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Volumes in the Dolores Archaeological Program include:

Dolores Archaeological Program: Field Investigation and Analysis – 1978, November 1983.

Dolores Archaeological Program: Synthetic Report 1978-1981, June 1984.

Dolores Archaeological Program: Studies in Environmental Archaeology, August 1985.

Dolores Archaeological Program: Anasazi Communities at Dolores: Early Small Settlements in the Dolores River Canyon and Western Sagehen Flats Area, May 1986.

Dolores Archaeological Program: Research Design and Initial Survey Results, June 1986.

Dolores Archaeological Program: Anasazi Communities at Dolores: Early Anasazi Sites in the Sagehen Flats Area, July 1986.

Dolores Archaeological Program: Anasazi Communities at Dolores: Middle Canyon Area, September 1986.

Dolores Archaeological Program: Final Synthetic Report, December 1986.

PART I

Chapter 1

OVERVIEW OF THE DOLORES ARCHAEOLOGICAL PROGRAM

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and David A. Breternitz

The Dolores Project is a water impoundment project under construction by the Bureau of Reclamation in southwestern Colorado, north of Mesa Verde National Park (fig. 1.1). A history of the development of the Dolores Project can be found in Madden and Weakly (1980). The Dolores Project Cultural Resources Mitigation Program was developed by the Bureau of Reclamation to mitigate the adverse impacts of construction on the cultural resources in the Dolores Project area. The DAP (Dolores Archaeological Program) has been responsible for the mitigation work since June of 1978 (Bureau of Reclamation Contract No. 8-07-40-S0562). The DAP consists of the University of Colorado, the primary contractor; a number of subcontractors, most notably Washington State University; and a variety of consultants. At the time this volume was prepared for final submission to the Bureau of Reclamation (October 1985), the contract was scheduled to be completed in December of 1985.

Congressional legislation and an executive order structure the mitigation of the Dolores Project. These include the Reservoir Salvage Act of 1960 (amended 74 Stat. 220, 16 U.S.C. 469), Section 106 of the National Historic Preservation Act of 1966 (amended 80 Stat. 915, 16 U.S.C. 470), Executive Order 11593, the Archaeological and Historic Preservation Act of 1974 (P.L. 93-291), and P.L. 96-301 (94 Stat. 832).

In 1978 the Bureau of Reclamation signed a Memorandum of Agreement with the President's Advisory Council and the Colorado State Historic Preservation Office to develop a data recovery program for cultural resources as part of the Dolores Project. At the same time, the Bureau of Reclamation entered into a Memorandum of Understanding with the Bureau of Land Management to provide for curation of the data and materials from the Dolores mitigation work and for construction of the Anasazi Heritage Center. The Anasazi Heritage Center is to house the data and materials from the DAP and other Dolores Project contracts for public interpretation and future research.

The products of the DAP consist of reports, a computer data base, field notes, field maps, photographs, and material collections. Some reports are available in published form, such as this volume, and almost all reports produced by the DAP are available through NTIS (National Technical Information Service). The DAP reports consist of descriptive site reports, designs and manuals, analytical reports, and synthetic reports. The computer data base, field notes, field maps, and material collections will be available for future research at the Anasazi Heritage Center located near Dolores, Colorado.

This volume is the final synthetic statement of the DAP. It specifically addresses the problem domains (Economy and Adaptation, Paleodemography, Social Organization, Extraregional Relationships, and Cultural Process) in the program's general research design (Kane et al. 1983), it summarizes the culture history of the area, and it reports the results of the program's efforts to model Anasazi cultural dynamics from A.D. 600 to 980. This chapter is intended to familiarize the reader with the program's history and its organization, the methods and techniques employed by the program, and the cultural resources of the Dolores Project.

SUMMARY OF DOLORES ARCHAEOLOGICAL PROGRAM HISTORY

The mitigation contract between the University of Colorado and the Bureau of Reclamation was signed on 6 June 1978; fieldwork began 6 days later. In an ideal situation, more time would have been allocated to program design and functions prior to beginning fieldwork; however, the needs of the Bureau of Reclamation for archaeological clearance took precedence in the first year of the program and continued to do so until 1983, when fieldwork was completed. There are both advantages and disadvantages to this sequence of events. Perhaps the major advantage is that the fieldwork never delayed construction; overall project costs were not increased through construction time losses and crisis management of the archaeological resources was avoided. A major disadvantage is that the lack of design and planning time at the initial stages of the program

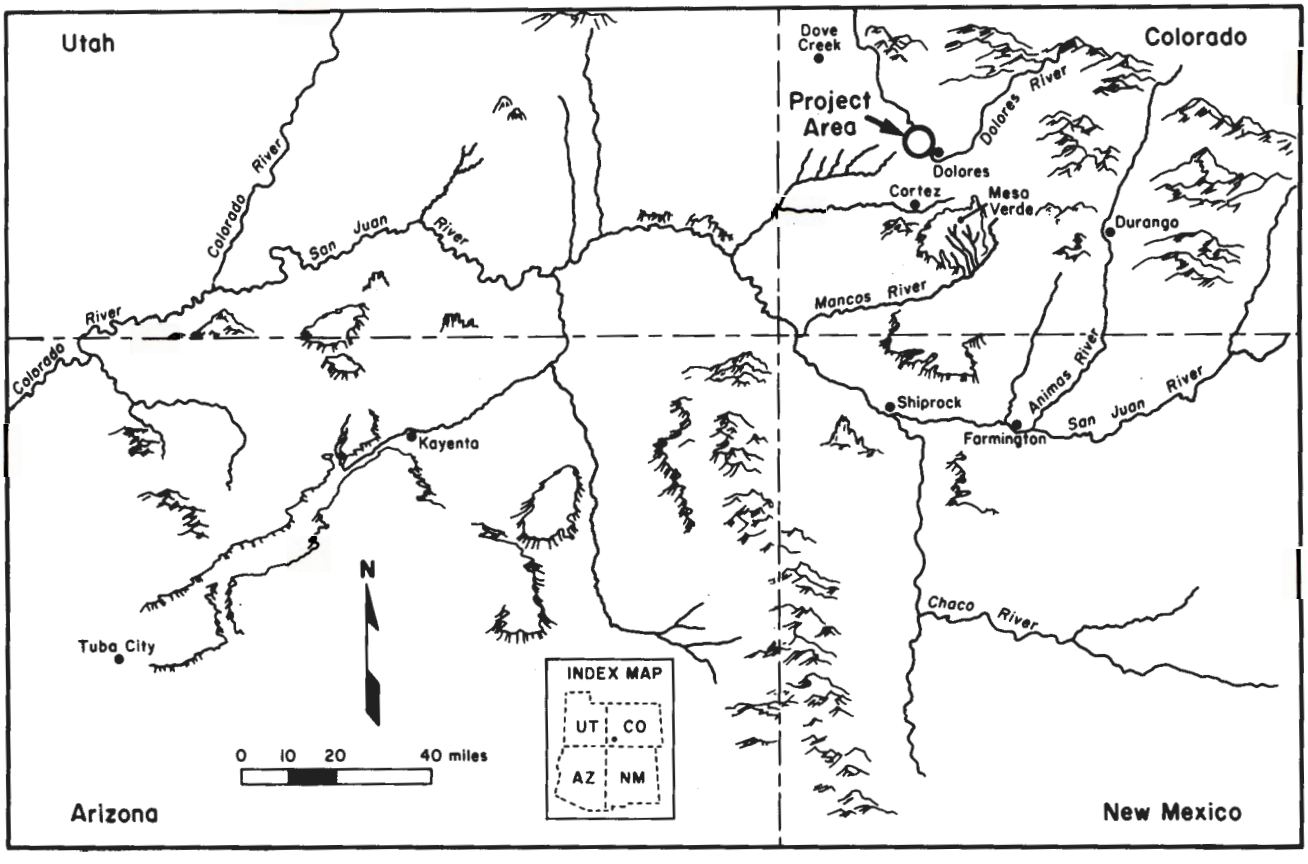

Figure 1.1 – Location of the Dolores Project area, southwestern Colorado.

caused a lag in the development of fieldwork and analytical programs that would recover data necessary to specifically address the problem domains of the general research design (Kane et al. 1983). Another major disadvantage was that some of the data collected during the early years of the program were not directly comparable with data collected once the theoretical goals of the DAP became better focused.

The original contract included provisions for both prehistoric and historic data recovery work. However, during the summer of 1978, site survey was the responsibility of the Bureau of Reclamation and the Young Adult Conservation Corps. The Youth Conservation Corp also maintained separate excavation crews. This division of labor between the contractor and the government proved to be a serious problem since it did not facilitate a well-integrated approach to data recovery. As a result, site survey operations were consolidated under the supervision of the DAP during the winter of 1978-1979 and the use of Youth Conservation Corps personnel for excavation was also placed under DAP supervision during the summer of 1979.

During the winter of 1978-1979, the first fieldwork reports were written, some of which appear in *Dolores Archaeological Program: Field Investigations and Analysis – 1978* (Dolores Archaeological Program 1983). During this period, the DAP systematics (Kane 1983; chap. 5) were developed, and the design of a series of computerized analysis and fieldwork forms was completed. Design of the computer forms required intensive effort because standardized provenience methods and analytical techniques had to be developed.

By the summer of 1979, the general research design as presented in the original Technical Proposal (RFP 40-S0562) (Breternitz and Kane 1978) had been expanded into the format that continued to guide DAP research for the remainder of the program (Kane et al. 1983). The general research design interpreted a framework of scientific inquiry intended to lead each researcher through similar theoretical and methodological steps for each problem domain. It was never assumed that all of the questions in the general research design could or should be addressed, but it was considered essential that all of the questions be structured by similar and

comparable method of inquiry. During the summer of 1979, the majority of the fieldwork and analysis computer forms were used for the first time. This was a somewhat painful experience because any amount of design work must be modified to fit the realities of archaeological fieldwork and analysis. The process of testing and revising the computerized forms involved monthly (sometimes weekly) modification of coding values and clarification of the variable and value definitions. The process of working with the computer forms was, however, instrumental in shaping the remainder of the program, because critical decisions were made about how to collect data that were comparable both from site to site, and from field season to field season. This was essential so that the data could be used not only during the life of the DAP but also by future researchers.

Over the winter of 1979-1980, the DAP discovered what it really meant to try to computerize what was already a massive data base that would continue to grow exponentially. Problems were encountered with managing the data in the computer and in retrieving the data in a meaningful format. At this point it became apparent that if the program was going to become so reliant on the use of computer data processing, then additional resources would have to be devoted to this task. Probably the most important lesson learned was that management of the DAP data base would require custom-program manipulation of the data, since available "canned" data base management systems (such as REX or System 2000) could not do the job with such a large data base. Planning the 1980 field season, which proved to be the largest in the history of the DAP, was not an easy task. However, substantial progress had been made by then in terms of how to consistently collect data in the field and in the laboratory.

The summer of 1980 brought passage of legislation (Public Law 96-301 [94 Stat. 832]) authorizing the Bureau of Reclamation to increase spending from 1 percent up to 4 percent of the total Dolores Project construction costs to mitigate the adverse effects of the Dolores Project on cultural resources in the project area.

Complete inventory survey of the Dolores Project pool area was also completed during the summer of 1980, and the mitigation design (Knudson et al. 1985) was developed to insure that an adequate sample of the cultural resources in the Dolores Project area was investigated. A temporal-functional matrix was constructed to array all of the resources in the pool area by time and by site function. A very important concept that came out of the mitigation design was the full site equivalent, or FSE, which quantifies the amount of labor required to recover the information from the components at any given site. The FSE concept and a temporal-functional matrix are useful because they more accurately reflect the complexity of an archaeological site by taking into consideration the size variation and the multiple occupations so common to Dolores area sites. Since site size and complexity are taken into account, the DAP avoided having to use sites as units of comparison and having to make the assumption that all sites are equal in information content.

During the summer of 1980, it also became apparent that the job of turning out high-quality reports was far greater than anticipated. Report production capabilities had progressed from a single typist working on an electric typewriter and 1 of the co-principal investigators serving as a part-time editor in 1978, to 2 word processors with operators and an editorial coordinator. However, even with these resources it was obvious that report production was badly bottlenecked. Steps taken to alleviate the problem included hiring a full-time editor and streamlining report outlines. Despite these efforts and those in the years to come, report preparation was a multivariate problem that required constant attention.

The winter of 1980-1981 brought renewed design work on managing the data base. Standardized computer output was programmed for excavated sites for use in descriptive site reports, and plans were laid for developing a mechanism to structure the data into the program's temporal and spatial units (Kane 1983 and chapter 5, this volume). The sheer volume of the data and the number of samples and artifacts already collected forced the DAP to re-evaluate both how the data were collected and how they were recorded. This involved modifying the field manual (Kane et al. 1981) and removing redundant or minimally useful information from the computer data files and from field and analysis forms. The changes that were made in the field manual are reflected in the excavation manual (Kane and Robinson 1984).

The historic studies portion of the DAP contract was terminated in May of 1981. This part of the contract had been plagued with problems since 1978, although in 1980 and 1981, the DAP had taken some promising steps to rectify the situation (Bloom 1984). The mitigation work on the historic resources was completed by the National Park Service (Kendrick 1982).

A major accomplishment during the spring of 1981 was the production of *Dolores Archaeological Program: Synthetic Report 1978-1981* (Dolores Archaeological Program 1984), which was the first example of the kind of results being produced by the DAP. The report was written in response to a directive from the Bureau of Reclamation and was intended to serve as a means for

making future budgetary decisions by the Bureau of Reclamation. The DAP modeling of Anasazi cultural dynamics also began to take shape as can be seen in Lipe (1984). The DAP modeling represented a conscious effort on the part of the program to focus its synthetic effort on the Cultural Process problem domain of the general research design (Kane et al. 1983). By this time it had become apparent just how finite project resources were going to be, and it was believed that focusing the program's efforts on modeling cultural process had the highest potential of making a substantial contribution to the program's mitigation goals, and to anthropological archaeology.

During the summer of 1981 inventory survey of the McPhee Reservoir takeline area was finally completed. This was a major milestone in the history of the DAP. The lack of information about the totality of the cultural resources in the Dolores Project area had been a hindrance to both the DAP and the Bureau of Reclamation in the areas of budgeting and overall planning. The completion of survey of the takeline area provided the needed information about the bulk of the resources that would be impacted by the Dolores Project.

A peer review board was also convened by the Bureau of Reclamation during the summer of 1981. The findings of the board were most useful to the DAP. Some of the board's recommendations had been recognized independently and had already been implemented by the DAP. Other recommendations provided essential insight from outside members of the archaeological profession and these recommendations were implemented as well.

Another major milestone at this time was the development of midlevel research designs by the program in the areas of additive and reductive technologies and in environmental archaeology and survey. The resulting documents (Blinman 1985; Phagan 1985; Petersen et al. 1985; Orcutt 1985a:93, 12) serve to link analysis with the general research design (Kane et al. 1983).

In general, 1981 was a critical year for the DAP. Production of the synthetic report (Dolores Archaeological Program 1984), peer review, and a much reduced field season during the summer allowed the program to assess its progress and to focus its efforts on obtaining the data necessary to meet the program's research goals.

Additional work was done during the winter of 1981-1982 in the area of theoretical design; progress was made on the model and related analysis. Mini-research designs (Blinman 1982; Gross 1982; Kane 1982; Orcutt 1982; Petersen et al. 1982; Phagan 1982; Schlanger 1982) were generated to further develop and articulate the variables in the program's general, systemic model (Lipe 1984).

The end of the summer of 1982 brought the first attempt to present the preliminary results of the DAP modeling for staff members. A seminar was held to disseminate the results that had been collected since the modeling effort had begun. The seminar was instrumental in shaping the remainder of the modeling, since it not only allowed the sharing of information but provided a mechanism for coordinating future work.

In the fall of 1982, a week-long seminar was held at Mesa Verde National Park to plan the modeling effort for the remainder of the program. A member of the peer review board, Jeffery S. Dean (University of Arizona) participated in and contributed to the seminar. The results of the seminar can be found in Lipe et al. (1983).

During the winter of 1982-1983 a major breakthrough in terms of report production was achieved; the computer was programmed to produce descriptive tables based on standardized site output for authors of site reports. This in itself was a major accomplishment, since it reduced some of the transcription problems associated with producing descriptive site reports. This effort toward streamlining report production was taken a step further through developing communications between the computer and the word processing system that had recently been purchased. This eliminated any possibility of data transcription errors in site report material culture tables (a major part of these reports), because the tables could be directly transferred from the computer to the word processors. Since most of the reporting effort at this time was in the area of site reports, this represented a critical stride in alleviating the report production bottleneck.

Fieldwork for the program was completed in the summer of 1983. Besides being a major milestone in and of itself, completion of the fieldwork allowed the DAP to focus its attention on synthetic studies and the modeling effort. Completion of the fieldwork also made it possible to complete plans for publication of DAP reports. The majority of the reports were still not in the publication process so that those that remained could be grouped into collections with common themes that were archaeologically meaningful. By this time, the program had begun work with the first galley and page proofs, and by November of 1983, the first publication, *Dolores Archaeological Program Field Investigations and Analysis – 1978* (Dolores Archaeological Program 1983), was available in print. The next collection, *Dolores Archaeological Program: Synthetic Report 1978-1981* (Dolores Archaeological Program 1984), was published in June of 1984.

By the summer of 1984, the majority of the temporal-spatial data base was available for synthetic work. Analysis and report writing continued until June of 1985. At the time this chapter was written (July 1985), editing of reports was scheduled to continue until termination of the contract on 31 December 1985. Transfer of data and materials to the Anasazi Heritage Center was to take place during the summer and fall of 1985.

ORGANIZATION OF THE DOLORES ARCHAEOLOGICAL PROGRAM

The organization of the Dolores Archaeological Program reflects both the complexity and the evolving nature of a large, long-term mitigation program. Table 1.1 is a list of Bureau of Reclamation and peer review board personnel that have been associated with the DAP. Table 1.2 through 1.6 reflect the organization of the DAP.

A detailed discussion of the program's organization from 1978 to 1981 can be found in Breternitz (1984:4-5). The discussion that follows and tables 1.2 through 1.6 summarize the organization of the DAP over the life of the program. The general configuration of the DAP, which, according to Mintzberg (1981), is similar to both a professional bureaucracy and an adhocracy.

Administrative Organization

The uppermost tier in the DAP organization is the senior staff. Over the years, as many as 8 and as few as 5 senior staff members (table 1.2) have been associated with DAP. The senior staff, and the program in general, has been headed by the senior principal investigator who retains ultimate authority for all aspects of the DAP. As specified in the contract with the Bureau of Reclamation, from 2 to as many as 4 co-principal investigators have been responsible for aspects of the program and have served as members of the senior staff. Other members of the senior staff have included a full-time technical performance manager and 2 part-time consulting managers. Since 1981, the senior staff has been composed of the senior principal investigator, 3 co-principal investigators, and a technical performance manager. As a group, the senior staff is the primary design and planning unit of the DAP.

The second tier in the DAP organization consists of the task specialists, who have been responsible for overseeing specific analytic and support areas. These individuals are responsible to the senior staff and, ultimately, to the senior principal investigator.

A third level of supervisory personel consists of assistant task specialists and crew chiefs who have been responsible for individual site excavations, site survey, and analysis. Crew members below this level have served as essential elements in DAP fieldwork and analysis.

More specific aspects of the DAP organization can be better understood by referring to tables 1.3 through 1.6 and to the following discussion.

Field Organization

Over the life of the program, the 2 co-principal investigators from Washington State University have alternately served as field directors for Washington State University investigations (table 1.3), in addition to fulfilling other responsibilities. A single co-principal investigator has been the field director for University of Colorado investigations and he has been assisted at various times by locality supervisors, staff archaeologists, or an assistant field director. From 1981 on, survey operations were the responsibility of the settlement archaeology task specialist.

Essential elements of the DAP field organization have been the crew chiefs and the crew members who have assisted them in individual site excavations and in site survey. In addition to their field supervision responsibilities, DAP crew chiefs have also been responsible for writing descriptive site reports and for writing administrative and analytical survey reports.

Analytical Organization

The major analytical areas of the DAP, additive technologies, environmental archaeology (formerly known as environmental studies), reductive technologies, and settlement archaeology (also known as survey), have all been headed by task specialists (table 1.4) for most of the life of the program. Each of these individuals is a specialist in their designated analytical area and each has been aided by an assistant task specialist or crew chief and by crew level people to accomplish the necessary tasks in each analytical area.

Support Organization

Additional DAP staff members are primarily responsible for administration, data coordination, data processing, laboratory operations, and report production (table 1.5).

An administrative assistant to the senior principal investigator has been responsible for budget preparation, payroll, bookkeeping, and general office work.

A technical performance manager (formerly known as data coordinator) has been responsible for overall coordination of data and communications between the

Table 1.1 – Bureau of Reclamation personnel and peer review board

Title Name	Affiliation	Tenure
Contracting officer		
Albert H. Pfiefle	Bureau of Reclamation, regional office	6/78 - 5/85
Donald J. Jolovich	Bureau of Reclamation, regional office	5/85 - 12/85
Dolores Project engineer (Contracting officer's representative)		
R.W. Radcliffe	Bureau of Reclamation, Cortez office	6/78 - 12/80
Dana B. Hill	Bureau of Reclamation, Cortez office	12/80 - 12/85
Bureau of Reclamation archaeologist		
Ward F. Weakly	Bureau of Reclamation, Denver office	6/78 - 9/85
Regional archaeologist		
Lou Madden	Bureau of Reclamation, Durango office	6/78 - 7/80
A. Wayne Prokopetz	Bureau of Reclamation, Salt Lake City office	4/80 - 12/85
Project archaeologist		
Thomas J. King	Bureau of Reclamation, Cortez office	10/78 - 12/85
Peer reviewer		
Jefferson Chapman	University of Tennessee	7/81 - 8/81
Jeffrey S. Dean	University of Arizona	7/81 - 8/81
Douglas W. Schwartz	School of American Research	7/81 - 8/81

senior staff and task specialists, subcontractors and consultants, and field and laboratory operations. Toward the end of the program, the technical performance manager has been responsible for report production.

DAP data processing has been the responsibility of a task specialist, with assistance from assistant task specialists or crew chiefs, in addition to various crew members. Since DAP data processing has been centralized for the majority of the program, this support group has been responsible for both the management of the computerized data base and retrieval of the data to meet the needs of researchers and report writers.

Laboratory operations have been supervised by a laboratory supervisor on the task specialist level. The laboratory supervisor has been assisted by an assistant task specialist (or crew chief) and a number of crew members over the life of the DAP. The primary function of this support group has been to process the materials from the field so that they have been ready for analysis, to insure the quality of fieldwork data and the temporal-spatial data base, and to provide cross-checking of data in reports.

Over the life of the program, the report production support group has been structured in several ways. This group initially consisted of a co-principal investigator and a typist. The growing needs of report production eventually required a report coordinator, an editor, several word processor operators, and several drafters. This group was then reorganized to include a task specialist, a report flow monitor, additional editors and assistant editors, word processor operators, drafters, and data checkers. Near the end of the program (1984), the technical performance manager was assigned the responsibility for overall report production. At this time, the report production group consisted of a task

Table 1.2 – Dolores Archaeological Program senior staff

Title Name	Affiliation	Tenure
Senior principal investigator		
David A. Breternitz	University of Colorado	6/78 - 12/85
Co-principal investigator		
Robert A. Bye, Jr.	University of Colorado	6/78 - 4/81
Allen E. Kane	University of Colorado	6/78 - 12/85
Timothy A. Kohler	Washington State University	8/80 - 12/85
William D. Lipe	Washington State University	6/78 - 12/85
Project manager		
Steven E. James	Woodward-Clyde Consultants	6/78 - 3/81
Operations analyst		
Ruthann Knudson	University of Idaho, Woodward-Clyde Consultants	8/80 - 5/81
Technical performance manager		
Christine K. Robinson	University of Colorado	8/80 - 12/85

specialist, a report-flow monitor, editors, assistant editors, word processor operators, and drafters. Data checking was made the responsibility of the laboratory supervisor and his staff in 1983.

Subcontractor and Consultant Organization

The organization of subcontractors and consultants in association with the DAP has been consistent in the majority of cases, but exceptions can be noted in table 1.6.

Another substantial lesson learned early in the program was that, if the program was going to make a commitment to consistent data collection, then most analytical work needed to be conducted at the DAP laboratory near Dolores, Colorado. As a result, some functions that had been carried out by subcontractors or consultants or by DAP personnel off-project, were subsequently moved to the DAP laboratory facility.

METHOD AND TECHNIQUE

General Program Orientation

The DAP is a data recovery program designed to compensate for the loss of cultural resources and the information those resources contain as a result of construction in the Dolores Project area. The DAP research effort has been guided by the mitigation design (Knudson et al. 1985), which is composed of the program's general research design (Kane et al. 1983) and the implementation design. The following discussion reviews several general concepts under which the DAP has operated; the general research design and the implementation design are then summarized.

Basic Concepts

Federal construction projects are legally required to implement programs to mitigate the effects of construction on cultural resources. Because the Dolores Project is a large Bureau of Reclamation water impoundment project, avoidance of cultural resources or preservation of resources in place has not been possible in most cases, although these alternatives have been used whenever possible. Investigation of selected cultural resources has been the primary mitigative option exercised by the DAP. Given this approach to alleviating the adverse impacts of construction on Dolores Project cultural resources, the DAP has made a commitment to not only collect raw data and specimens, but to disseminate the information that has been collected in written descriptive and synthetic reports.

The mitigation design (Knudson et al. 1985) has been generated to structure the mitigative efforts of the DAP, and this design serves as the basic planning document for the work that has been conducted by the DAP. The mitigation design outlines 3 functions that are associated with data recovery in the context of the Dolores Project. These functions are design, planning, and performance.

Table 1.3 – Dolores Archaeological Program field organization

Area Title Name	Affiliation	Tenure
Field operations		
Field director		
Allen E. Kane	University of Colorado	6/78 - 9/83
Timothy A. Kohler	Washington State University	6/79 - 9/80
William D. Lipe	Washington State University	6/82 - 9/83
Settlement archaeology (survey)		
Task specialist		
Janet D. Orcutt	University of Colorado	1/81 - 6/85
Assistant task specialist		
Douglas D. Dykeman	University of Colorado	5/79 - 6/80
Douglas A. Goulding	University of Colorado	6/80 - 7/84
Crew Chief		
Gay A. Ives	University of Colorado	5/79 - 8/83
Roger N. Walkenhorst	University of Colorado	5/80 - 9/83
Excavation		
Assistant field director		
Mark A. Stiger	University of Colorado	5/80 - 11/83
Locality supervisor (staff archaeologist)		
Daivd H. Greenwald	University of Colorado	5/79 - 10/80
Nancy J. Hewitt	University of Colorado	5/79 - 10/80
Field crew chiefs		
Charlotte L. Benson	University of Colorado	6/79 - 5/80
Gary A. Brown	University of Colorado	8/78 - 9/81
Joel M. Brisbin	University of Colorado	6/78 - 12/83
M. Edward Bussard	University of Colorado	7/78 - 9/79
Ross C. Fields	University of Colorado	6/80 - 6/81; 11/81 - 3/83
David H. Greenwald	University of Colorado	10/80 - 8/81
Raymond G. Harriman	University of Colorado	8/78 - 10/81; 6/82 - 9/82; 2/83 - 3/83
Nancy J. Hewitt	University of Colorado	6/78 - 5/79; 10/80 - 5/81
James H. Kleidon	University of Colorado	8/78 - 4/83
Kristin A. Kuckelman	University of Colorado	4/79 - 2/81; 5/81
Ricky R. Lightfoot	University of Colorado	1/84 - 4/84
John L. Montgomery	University of Colorado	6/79 - 8/79; 6/81 - 9/81
James N. Morris	University of Colorado	5/80 - 6/82; 10/83 - 6/85
Maxine M. Morris	University of Colorado	4/79 - 10/81
Gregory C. Nelson	University of Colorado	5/79 - 12/83
Christine K. Robinson	University of Colorado	6/79 - 5/80
Sarah H. Schlanger	University of Colorado	8/81 - 9/81; 10/83 - 1/85

Table 1.3 – Dolores Archaeological Program field organization – Continued

Area Title Name	Affiliation	Tenure
Judith A. Southward	University of Colorado	6/79 - 1/81
Joseph W. Studer	University of Colorado	6/79 - 1/80
Mark D. Varien	University of Colorado	5/83 - 8/83; 11/83 - 7/84
Richard H. Wilshusen	University of Colorado	4/79 - 5/81; 11/81 - 9/83
Craig F. Woodman	University of Colorado	6/79 - 7/80
Richard W. Yarnell	University of Colorado	4/79 - 11/82
Richard V. N. Ahlstrom	Washington State University	6/79 - 12/79; 8/80
Eric Blinman	Washington State University	6/79 - 3/81
Cory Dale Breternitz	Washington State University	11/78 - 5/81; 6/82
Karen Dohm	Washington State University	6/79 - 11/83;
Alice M. Emerson	Washington State University	7/78 - 5/82; 10/82
Melissa Gould	Washington State University	6/80 - 1/83; 2/84 - 3/84
G. Timothy Gross	Washington State University	8/80 - 5/81
Patrick Harden	Washington State University	6/80 - 8/81
Patrick F. Hogan	Washington State University	7/78 - 8/81
Donald Howes	Washington State University	6/80 - 5/82
Ricky R. Lightfoot	Washington State University	6/80;12/81 - 11/83; 5/84
James N. Morris	Washington State University	6/82 - 4/83
Sarah H. Schlanger	Washington State University	7/78 - 8/83; 9/84
Lynn E. Sebastian	Washington State University	6/79 - 4/81
Mark D. Varien	Washington State University	5/80 - 2/81; 6/82 - 7/83
Historic studies		
Task specialist		
Deborah A. Duranceau	University of Colorado	10/79 - 8/80
John P. Bloom	University of Colorado	12/80 - 5/81
Excavation crew chief		
John P. McCarthy	University of Colorado	6/80 - 8/80
Survey crew chief		
John R. Stien	University of Colorado	6/80 - 8/80
Hal Douglas Carr	University of Colorado	6/80 - 5/81
Oral history crew chief		
Adrian S. White	University of Colorado	6/80 - 5/81
Special studies		
Archaeomagnetic and magnetometer crew chief		
J. Holly Hathaway	Colorado State University	8/78 - 11/83

Table 1.4 – Dolores Archaeological Program analytical organization

Area Title Name	Affiliation	Tenure
Additive technologies		
Task specialist		
William A. Lucius	University of Colorado	10/78 - 8/81
Eric Blinman	University of Colorado	8/81 - 6/85
Assistant task specialist		
Scott E. Travis	University of Colorado	6/80 - 8/81
Crew chief		
Robert M. R. Waterworth	University of Colorado	6/80 - 9/83
C. Dean Wilson	University of Colorado	6/80 - 9/84
Environmental archaeology		
Task specialist		
Kenneth Lee Petersen	University of Colorado	8/81 - 7/85
Assistant task specialist		
Meredith H. Matthews (botany)	University of Colorado	1/81 - 12/84
Crew chief		
Vickie L. Clay (geology)	University of Colorado	7/78 - 8/79; 3/81 - 9/83; 8/84 - 10/84
Sarah W. Neusius (fauna)	University of Colorado	11/81 - 8/84
Environmental studies		
Task specialist		
Bruce Benz	University of Colorado	9/78 - 8/81
Historic studies		
Task specialist		
Deborah A. Duranceau	University of Colorado	10/79 - 8/80
John P. Bloom	University of Colorado	12/80 - 5/81
Reductive technologies		
Task specialist		
Roger A. Moore	University of Colorado	8/78 - 10/79
Carl J. Phagen	University of Colorado	10/79 - 6/85
Assistant task specialist		
T. Homer Hruby	University of Colorado	5/80 - 10/84
Crew chief		
Gail G. Snyder	University of Colorado	5/79 - 9/83
Phillip D. Neusius	University of Colorado	5/82 - 8/84
Settlement archaeology		
Task specialist		
Janet D. Orcutt	University of Colorado	1/81 - 6/85
Assistant task specialist		
Douglas D. Dykeman	University of Colorado	5/79 - 6/80
Douglas A. Goulding	University of Colorado	6/80 - 7/84
Crew chief		
Gay A. Ives	University of Colorado	5/79 - 8/83
Roger N. Walkenhorst	University of Colorado	5/80 - 9/85
Special analysis		
Crew chief		
Kenneth Lee Petersen (paleoclimatic reconstruction)	Washington State University	11/78 - 11/79
Carolyn R. Orth (ritual)	University of Colorado	6/80 - 10/82
Richard H. Wilshusen (architecture)	University of Colorado	9/83 - 8/84
Phyllis A. Wolf (storage)	University of Colorado	7/84 - 10/84

Table 1.5 – Dolores Archaeological Program support organization

Area Title Name	Affiliation	Tenure
Administration		
Administrative assistant		
Judith L. Burk	University of Colorado	8/78 - 5/84
Stacy A. Story	University of Colorado	5/84 - 8/85
Data coordination		
Technical performance manager		
Christine K. Robinson	University of Colorado	5/80 - 12/85
Data processing		
Task specialist		
Arthur L. Rohr	University of Colorado	5/80 - 8/82
Lynn L. Udick	University of Colorado	9/82 - 12/95
Crew chief		
Robert P. Ryan	University of Colorado	6/79 - 5/80
Jane A. Ward	University of Colorado	5/80 - 11/82
Dorin E. Steele	University of Colorado	4/80 - 7/85
Marcia G. Gross	University of Colorado	1/83 - 9/85
Laboratory processing		
Laboratory supervisor		
Paul J. Farley	University of Colorado	8/78 - 12/85
Assistant task specialist		
Louise M. Schmidlap	University of Colorado	5/79 - 12/85
Data check crew chief		
Gary A. Brown	University of Colorado	9/81 - 3/84
Laurie A. Whiting	University of Colorado	6/82 - 1/85
Photography crew chief		
Michael J. Hilton	University of Colorado	9/81 - 4/84
Photography		
Task specialist		
John P. Nylander	University of Colorado	4/79 - 10/81
Crew chief		
Bertand A. de Peyer	University of Colorado	6/78 - 6/79
Public relations		
Officer		
Alexis A. Hamilton	University of Colorado	9/81 - 4/83
Report production		
Technical performance manager		
Christine K. Robinson	University of Colorado	2/84 - 12/85
Task specialist		
G. Timothy Gross		5/81 - 9/85
Report coordinator		
Lora VanRenselaar		6/80 - 8/81

Table 1.5 – Dolores Archaeological Program support organization – Continued

Area Title Name	Affiliation	Tenure
Report flow monitor		
Alexis A. Hamilton	University of Colorado	8/80 - 9/81
Barbara J. Cullington	University of Colorado	10/81 - 12/85
Editor		
Rita Arnett	University of Colorado	5/82 - 12/85
Maureen C. Cavanaugh	University of Colorado	6/83 - 5/85
Ivy G. Doak	University of Colorado	8/83 - 8/84
Jane L. Epstein	University of Colorado	10/80 - 6/81
Mary C. Etzkron	University of Colorado	9/80 - 9/83; 1/85 - 12/85
Melissa Gould	University of Colorado	5/84 - 12/85
Linda P. Hart	University of Colorado	5/81 - 12/85
Nancy J. Hewitt	University of Colorado	10/82 - 3/84
Susan E. King	University of Colorado	4/84 - 12/84
Kristin A. Kuckelman	University of Colorado	10/83 - 11/83
Katherine S. Miller	University of Colorado	9/82 - 7/83
Lynn L. Udick	University of Colorado	9/81 - 9/82
Drafting crew chief		
Steven R. Dominquez	University of Colorado	6/79 - 10/80
Lee R. Schmidlap	University of Colorado	4/80 - 4/82
Thomas C. May	University of Colorado	8/79 - 12/85
Carla M. Hoehn	University of Colorado	11/84 - 12/85
Word Processor		
Rysta E. Frederick	University of Colorado	7/84 - 12/85
Carla M. Hoehn	University of Colorado	7/84 - 12/85
Thirza D. Kennedy	University of Colorado	6/80 - 7/84
Margaret G. Meador	University of Colorado	7/84 - 12/85
Cathy J. Watts	University of Colorado	7/81 - 7/84
Anne M. Wolley	University of Colorado	6/82 - 8/84

Design. – Responsibility for the design of DAP research has been delegated to the DAP by the Bureau of Reclamation, and all of the designs generated by the DAP have been subject to Bureau of Reclamation approval. Approval of DAP designs has largely been a function of construction schedules and budgetary constraints; the content of DAP designs traditionally has taken a lower priority.

DAP designs have structured the conceptual development of several levels of DAP research in the Dolores Project area. First, the mitigation design (Knudson et al. 1985) has structured the problem areas investigated by the program through the general research design (Kane et al. 1983). The rationale used to mitigate the adverse effects of construction on Dolores Project cultural resources is outlined in the implementation design. The second level of DAP research has been structured by midlevel research designs that cover certain categories of recovered data (e.g., ceramics, lithics, and environmental studies). The third category has been designed to enable the DAP to synthesize Dolores Project data through the use of explanatory models that are applicable to cultural systems in general, and that can be tested with Dolores Project data. All of these conceptual designs are available in written form and the majority are published (Kane et al. 1985).

Planning. – Planning functions have been shared by the Bureau of Reclamation and the DAP. The Bureau of Reclamation has established levels of effort to be expended by the DAP on Dolores Project area cultural resources based on construction schedules and funding levels. The DAP has responded by balancing Bureau of Reclamation constraints with designs, manuals, and time-personnel-management charts generated to meet the needs of the Bureau of Reclamation and the objective of the DAP to achieve scientific validity and to disseminate the majority of the information obtained from data recovery efforts.

Table 1.6 – Dolores Archaeological Program consultants and subcontractors

Category Primary personnel	Affiliation	Tenure
Archaeoastronomy		
John A. Eddy	University of Colorado	8/78
Archaeomagnetic dating		
Jeffrey L. Eighmy	Colorado State University	6/79 - 9/83
Dendrochronology		
William J. Robinson	Laboratory of Tree-Ring Research, University of Arizona	6/79 - 9/84
Editing		
Andrea Vierra	No affiliation	5/80 - 11/80
Faunal studies		
Steven D. Emslie	Center for Western Studies	7/78 - 5/81
Geology		
Frank C. Leonhardy	University of Idaho	5/79 - 6/80
Vance T. Holliday	University of Colorado	5/80 - 9/80
Lucy A. Piety	University of Colorado	5/80 - 9/80
Soil analysis		
Kenneth W. Decker	University of Minnesota	10/82 - 9/83
Historic studies		
Steven G. Baker	Centuries Research, Inc.	6/78 - 9/79
Duane A. Smith		
Lithics consultant		
Ruthann Knudson	University of Idaho	7/78 - 3/81
Obsidian dating		
Fred W. Trembour	U.S. Geological Survey	10/81 - 3/84
Obsidian sourcing		
Lee Sappington	University of Idaho	6/83 - 2/84
Petrographic analysis-ceramics		
Diane Kamilli	University of Colorado Museum	8/80 - 3/83
Physical anthropology		
Louisa B. Flander	University of Colorado	8/78 - 12/80
Ann Weiner Stodder	University of Colorado	1/81 - 6/85
Pollen analysis		
Linda J. Scott	Palynology Analysts	6/79 - 1/84
Projectile points		
Robert K. Vierra	Northwestern University	6/80 - 11/81
Project management		
Steven E. James	Woodward-Clyde Consultants	6/78 - 9/81
Radiocarbon dating		
	University of Georgia	78-79
	University of Texas	2/80
	Di-Carb	80
	Beta Analytic	80 - 6/85
Remote sensing		
Aerial photography		
	Thomas R. Mann & Associates	6/79 - 8/79
Magnetometer survey		
John W. Weymouth	University of Nebraska	9/78 - 9/82
Robert J. Huggins	Spectrum Geophysics	11/80 - 12/83

Some duplication of personnel listings exists between tables 1.1 and 1.6

Performance. – The performance function has been the responsibility of the DAP. The Bureau of Reclamation contracted with CASA (Complete Archaeological Services Associates) to mitigate the effects of construction of the linear features (canals and laterals) of the Dolores Project and the results of this work are not included in this volume. For those parts of the Dolores Project for which the DAP has had performance responsibilities, this function has included fieldwork, analysis, and reporting. All of this work has been monitored by the Bureau of Reclamation and has been subject to that agency's review and approval.

The Research Design

The basic framework of the general research design was presented in the original technical proposal (Breternitz and Kane 1978) accepted by the Bureau of Reclamation in 1978. Five problem domains were identified in this document: (1) Economy and adaptation; (2) Paleodemography; (3) Social organization; (4) Extraregional relationships; and (5) Cultural process. During late 1978 and 1979, this basic structure was expanded into a series of questions for each problem domain and the resulting document is a key element of the DAP mitigation design. The general research design has been published as Kane et al. (1983); a shorter version will be published with the mitigation design (Knudson et al. 1985).

In the current version of the general research design, the first 4 problem domains are broken down into a series of questions designed to lead researchers through a similar set of methodological steps for each problem domain. If each question could be answered, a relatively complete reconstruction of Dolores area prehistory would be available for the time periods represented in the project area. The fifth problem domain, cultural process, is also broken down into a series of questions, and addressing this problem domain builds on the results derived from the first 4 domains. The fifth problem domain also calls for the development (chap. 6) and testing (chaps.7 through 16) of processual models, and this has been the major focus of DAP synthetic efforts.

The general research design is the framework that has guided development of field and laboratory data recovery and procedures. Although it was never anticipated that all of the questions in the general research design could, or should, be addressed, the DAP data base is broad and data categories have not been excluded just because DAP researchers did not anticipate their utility to others. However, during 1981 the DAP did expend considerable effort to eliminate redundant data from the computer files and, based on a long, hard evaluation, the DAP also ceased collecting data deemed to be only minimally useful. It is not denied that this process probably did restrict the data base somewhat, but given the financial and scheduling constraints that have been encountered by the DAP, the advantages have outweighed the disadvantages. The resulting data set is still broadly based, very clean, and streamlined for maximum utility given the overall complexity of the cultural resources in the Dolores Project area.

The first 3 years of the DAP were primarily devoted to fieldwork, preliminary analysis of the recovered materials, and descriptive reporting. However, even at this early stage, attempts were made to address the general research design in descriptive reports, and even though some of the interpretations that address the general research design are no longer valid, the focus on the general research design facilitated the eventual synthesis of Dolores data.

Work on synthesizing Dolores Project data did not begin until late 1980 when the general model of Dolores cultural change was first developed (Lipe 1984). Work on developing the general model continued until early 1983. The general model, as it currently exists (chap. 6), is derived from a synthesis of literature about sociocultural systems and is applicable to virtually any system. The general model is composed of variables with predictions about the relationships between variables. As a result of the development of the general model, a set of time increments, referred to as periods in this volume, was developed to better reflect temporal variation in the project area. Periods are divided into subperiods as follows:

Period 1 (A.D. 600-720)
- Subperiod 1.1 (A.D. 600-660)
- Subperiod 1.2 (A.D. 660-700)
- Subperiod 1.3 (A.D. 700-720)

Period 2 (A.D. 720-800)
- Subperiod 2.1 (A.D. 720-760)
- Subperiod 2.2 (A.D. 760-780)
- Subperiod 2.3 (A.D. 780-800)

Period 3 (A.D. 800-840)
- Subperiod 3.1 (A.D. 800-820)
- Subperiod 3.2 (A.D. 820-840)

Period 4 (A.D. 840-880)
- Subperiod 4.1 (A.D. 840-860)
- Subperiod 4.2 (A.D. 860-880)

Period 5 (A.D. 880-920)
- Subperiod 5.1 (A.D. 880-900)
- Subperiod 5.2 (A.D. 900-920)

Period 6 (A.D. 920-980)
- Subperiod 6.1 (A.D. 920-940)
- Subperiod 6.2 (A.D. 940-980)

Period 7 (A.D. 980-1250)
- Subperiod 7.1 (A.D. 980-1025)
- Subperiod 7.2 (A.D. 1025-1100)
- Subperiod 7.3 (A.D. 1100-1175)
- Subperiod 7.4 (A.D. 1175-1250)

Periods, as well as phases and subphases, have been used to structure the data presentations (chaps. 2 through 15) in this volume. Both systems of presentation are valid, depending on the data being presented and the theoretical constructs used to formulate periods or phases and subphases. Periods are strictly time increments, while phases and subphases are based on organizational characteristics and may overlap in time (refer to the systematics discussion later in this chapter). For example, Blinman (chaps. 2, 12, and 14) uses periods because his data exhibit period variation. Phagan (chap. 3) uses the phase and subphase system to present his data because he felt that change in lithic data was not as rapid as change in ceramic data and that variability in lithic data was best represented by phase and subphase presentation.

As a result of the development of the general model, 2 specific models of Dolores sociocultural change were also developed. These are referred to as "the economic model" and "the social model" in the remaining chapters of this volume. In the economic model, economic responses are viewed as the forces that drive culture change; the social model recognizes sociopolitical developments as the primary source of change. While a good deal of debate has occurred among the program staff about how the economic and social models interrelate, it is generally recognized that they reflect parts of the general model and that the goal of generating 2 such models is to develop contrasting expectations that can be evaluated with Dolores area data. The reader is referred to Lipe (chap. 6) for additional information about the general, economic, and social models. Development of the social model has lagged behind the development of both the general and economic models. As a result, varying degrees of emphasis can be seen on the economic and social models in the chapters designed to evaluate DAP models (chaps. 7 through 16); quite often the variability in emphasis is a function of the amount of time available to evaluate the social model rather than an example of extreme bias.

The Implementation Design

The implementation design (Knudson et al. 1985) is the DAP's attempt to answer the thorny problem that confronts most contemporary archaeologists—" 'How many data are enough' to characterize the variability in and among populations of artifacts, ecofacts, features, and distributional characteristics of the same?" (Lipe and Kohler 1984). The implementation design has been generated to develop an explicit approach to answer the question. While recognized that it is the responsibility of the Bureau of Reclamation to assess the adequacy of mitigation on the Dolores Project cultural resources, the DAP felt the need to develop an anthropologically based approach to determine the level of work needed to defend the scientific adequacy of the samples recovered from those resources. Key concepts of the implementation design that are pertinent to this volume are the temporal-functional matrix, tracks, and the concepts of FSE (Full Site Equivalent) and crew weeks.

Temporal-functional matrix. – The temporal-functional matrix in the implementation design arrays selected Dolores prehistoric cultural resources by site type and by tradition, phase, and subphase (refer to the discussion on systematics later in this chapter); many resources are assigned to multiple units that reflect organizational units. Resources included in this matrix are an archaeologically significant grouping because they are considered to be a population that can be used for assessing the representativeness and the reliability of DAP data recovery efforts.

Tracks. – The intensity of DAP data recovery can be characterized along a continuum from nonintensive to intensive. The 4 tracks defined in the implementation design reflect stages along this continuum, with Track 4 reflecting the least intensive level of effort and Track 1 reflecting the most intensive level of effort. Variability in effort occurs within each track and work within the more intensive tracks may include work with less intensive tracks.

Track 4: This level of data recovery is basically reconnaissance investigation on the modern ground surface. Different types of mapping (e.g., plane table, aerial, magnetometer) may be conducted at this level of intensity. This track may also include environmental surveys to identify the distribution of resources.

Track 3: This level of data recovery is predicated on completion of some sort of Track 4 work. Track 3 work involves collection of artifacts and samples from the modern ground surface. Collection strategies may be judgmentally based, or may be based on probability sampling, and still others may be intensive recovery of all surface materials.

Track 2: Track 2 work is based on some level of completion of Track 4 and Track 3 work. Track 2 is the least intensive subsurface data recovery and is essentially a test excavation program that relies heavily on the judicious use of heavy equipment. Data recovery strategies may be judgmentally based or may be based on probability sampling. Varying amounts of materials may be collected depending on the data recovery strategy adopted. For instance, with a probability sampling strategy all the deposits encountered are screened; however, with a judgmental strategy, only those deposits that are clearly cultural in origin and are relatively uncontaminated by other cultural or postabandonment deposits are screened.

Track 1: This level of data recovery is the most intensive level of work and, again, assumes that some work has been conducted on the preceding 3 levels. There is a good deal of variability at this level of effort since the Dolores cultural resource base is both complex and varies considerably in size. On small sites, this level of effort may involve complete excavation. On a large site, Track 1 effort may involve recovery of only a fraction of the data contained in the site. Collection of artifacts and samples at Track 1 level is also dependent on the anticipated interpretability of the deposits from which such items were derived.

Full Site Equivalent and crew weeks. – The FSE (full site equivalent) was designed to account for the variability in size and complexity present in Dolores cultural resources. The FSE represents the amount of labor, calculated as a 10-person crew working 40 hours per week, that the DAP anticipates it would take to completely investigate any given site included in the temporal-functional matrix in the implementation design. All FSE figures, which were generated after 3 years of field experience in the Dolores Project area, assume a Track 1 level of investigation.

FSE figures for architectural sites are based on the number of household clusters (refer to systematics discussion later in this chapter) that are anticipated from evidence from the modern ground surface. On nonarchitectural sites, FSE figures are based on an estimation of the square meters that are within the defined limits of a site. In all probability, these FSE figures can be applied to the remainder of the Dolores cultural resource base since they are derived from the majority of the resources in the Dolores Project area.

"Crew weeks" refers to the actual labor expended by a 10-person crew mitigating the adverse effects of construction on Dolores cultural resources. An assessment of the FSE concept and the crew weeks expended on the Dolores cultural resource base is furnished later in this chapter.

Specific Research Efforts and Methods

Applying the Research Design

The general research design is a broad structure of inquiry designed to systematically cover 5 problem domains. The general research design has provided a basic framework within which more specific research areas have been identified, although it was never anticipated that all 5 problem domains could be treated equally. Two mechanisms have enabled the DAP to identify more specific research areas within the framework of the general research design. First, a synthetic report was produced in 1981, which was later published in 1984 (Dolores Archaeological Program 1984). Production of the synthetic report, which was written in response to a directive from the Bureau of Reclamation so that the agency could evaluate future budgetary allocations, allowed the DAP to assess its progress to date and identify those data categories most promising, as well as those categories that were lacking but were essential to the overall DAP efforts. Second, efforts to develop a model of cultural process of the DAP began about the time the production of the synthetic report took place. Development of this model (refer to chap. 6) and the expectations derived from the model have also allowed the DAP to identify fruitful research areas and those data needed to address these research areas.

The intent of this volume is to provide the final synthetic statement about the prehistory of the Dolores Project area and to address those parts of the 5 problem domains in the general research design that can be answered with DAP data. The following discussion will summarize how aspects of the general research design have been addressed over the life of the program.

As stated in the preceding section, the current general research design was well integrated into the program as early as 1979. Despite the fact that until 1981 DAP efforts were largely occupied by fieldwork, preliminary analysis, and descriptive reporting, addressing the general research design figured heavily into the early descriptive activities of the program. An emphasis on addressing the general research design in the descriptive aspects of the program continued throughout the tenure of the DAP. For example, site report authors have been encouraged to evaluate the data from individual sites and to point out those data that may be useful in resolving particular questions in the general research design. While a more comprehensive approach and more broadly based data have been necessary to resolve these questions, substantial contributions have been made toward addressing the general research design through base level description.

Task specialists in additive and reductive technologies, environmental archaeology, and survey have all addressed the general research design through midlevel research designs (Blinman 1985; Phagan 1985; Petersen et al. 1985; Orcutt 1985a) that link the respective data categories to the general research design. The linkages that have been established from any data category depend on the prevalence of the data category as well as the suitability of that data category for addressing specific problem domains. For example, both lithic and ceramic items have the potential to address Problem Domain 4, Extraregional Relationships. However, shell items occur in very low frequencies in the Dolores data base and the problems associated with interpreting this data category are substantial given both its size and the

information available about this data category in areas that are in proximity to the Dolores area. As a result, the midlevel research designs that include shell (Petersen et al. 1985; Phagan 1985) do not focus very heavily on this data category; attempts have been made to describe shell items, but interpreting these items and using them to address the general research design have not figured heavily into midlevel research designs.

Another way that the general research design has been addressed has been through studies that provide data for synthetic work. these studies are called "supporting studies" because they build on DAP descriptive work and are an intermediate interpretive step between description and synthesis of Dolores data. The majority of supporting studies conducted have been designed to facilitate the efforts to address Problem Domain 5 (Cultural Process) through the general model. Midlevel research designs (Blinman 1982, Gross 1982; Kane 1982; Orcutt 1982; Petersen et al. 1982; Phagan 1982, Schlanger 1982) link these supporting studies to the general model. Other supporting studies were designed to address specific parts of the general research design that reflected the strengths of the Dolores data base or that were deemed to be essential to program goals. Supporting studies have been conducted by both the DAP staff and independent researchers that were not supported by the contract with the Bureau of Reclamation.

Synthesizing the data from the Dolores Project has been a major goal of the DAP. The synthetic report (Dolores Archaeological Program 1984), which was produced in 1981, was the first attempt of the DAP to synthesize the data that had been collected during the first 3 years of the program. This report is the culmination of the Dolores Project synthetic efforts. Chapters 2, 3, 4, and 5 are intended to address the first 4 problem domains (Economy and Adaptation, Paleodemography, Social Organization, and Extraregional Relationships) in the general research design. Chapter 6 through 16 address the fifth problem domain (Cultural Process) through the general model.

Program Systematics

Three series of terms have been developed by the DAP to describe the functional, spatial, and formal placement of sites in the Dolores Project area. These are the site typology, the spatial series, and the formal, or chronological, series. A brief discussion of each of these series is included in the following discussion. Refer to Kane (1983, 1984, and chap. 5) for a more detailed presentation of these concepts.

Site typology. – The DAP site typology is a functional typology that recognizes that prehistoric occupation of sites in the Dolores area occurred along a continuum from a few minutes to several hundred years. Three site types have been developed to reflect this continuum; these are the limited activity locus, the seasonal locus, and the habitation. Architectural evidence visible from the modern ground surface is used to distinguish between the 3 types since most sites are known only from survey data.

Limited activity loci lack evidence of architecture and it is inferred that they were occupied for very short periods of time and were used for selected activities. Evidence for surface architecture, or rooms, is usually present at seasonal loci, these sites are inferred to have been used for longer periods of time than limited activity loci and for a larger number of activities. Although use of seasonal loci is not limited to climatic seasons, field houses are good examples of seasonal loci. Sites with more substantial surface architecture, or pitstructures, are classified as habitations. It is inferred that habitations were occupied more or less permanently during the year and that a full range of activities took place at habitations.

The DAP site typology was originally an intuitive construct (Kane 1983). However, Schlanger and Orcutt (1985) have been able to verify the validity of the original typology through their study of assemblages collected from the modern ground surface.

Spatial series. – The DAP spatial series consists of administrative and interpretive units. Examples of administrative units are sites, localities, and sectors.These units have been used to divide the project area into units that are manageable and to provide a common set of terms when referring to parts of the Dolores Project area.

The interpretive spatial units were originally based on Flannery's (1976) work on early Mesoamerican villages and have since been modified by the DAP (chap. 5). Interpretive spatial units are hierarchically organized beginning with the activity area. An activity area is inferred to represent space that was used by an individual or a small group for a single activity or group of selected activities. A central hearth in a room or pitstructure is an example of an activity area. Related activity areas are usually grouped into use areas. The open area between a row of rooms and a pitstructure is often identified as a use area because this open area can include hearths and other features indicate that many activities were conducted in the vicinity by more people than used an activity area. The space that is inferred to have been used by a household is called the household cluster in the interpretive spatial series. This is a complex concept because there is temporal variability in the way that architectural space was organized during the Dolores sequence. Early in the sequence (ca.

A.D. 600-760), the space inferred to have been used by a household consisted of a pitstructure with associated storage rooms to the north of the pitstructure. Later in the Dolores sequence (ca. A.D. 760-975), a household cluster usually consisted of three-room suites composed of 2 back storage rooms and a front living room to the north of pitstructures. Kane, in chapter 5 refers to these three-room suites as dwelling units. Pitstructures appear to have been shared facilities because they do not occur on a 1:1 ratio to the three-room suites. Rooms that cannot be confidently assigned to three-room suites are also inferred to be shared space. Groups of household clusters and the shared space associated with them are called interhousehold clusters in the interpretive spatial series. It is inferred that interhousehold clusters represent the space used by households that begin to cooperate around A.D. 760. The largest unit in the interpretive spatial series is the community cluster. Community clusters consist of 1 or more habitations composed of household clusters, interhousehold clusters late in the sequence, and the seasonal and limited activity loci associated with them. Early in the Dolores sequence, community clusters were dispersed and appear to have been loosely grouped into what Kane (1984:28) has called neighborhoods. Later in the sequence, community clusters more aggregated and were more focused around a central habitation.

Formal (chronological) series. – The formal series is also composed of hierarchical units that describe the organization and chronological placement of cultural resources in the Dolores Project area.

The smallest units in the formal series are the episode and the element. These units are not hierarchically related to one another, but they are hierarchically related to other units in the series. Episode represent brief, transitory use of the project area by groups smaller than households. Elements represent major construction events by households or interhouseholds and are usually equivalent to the uselife of structures in the project area.

Episodes and elements are assigned to subphases, phases, and traditions; however, it is possible that an episode or an element cannot be assigned to all 3 units. Subphases and phases are defined based on architectural and organizational characteristics and thus, they may overlap in time. Although these architectural and organizational characteristics have strong temporal correlates, dates of construction or use associated with an episode or an element are not enough to assign them to a subphase or phase. Tradition is a self evident unit that will be familiar to most readers.

Table 1.7 summarizes DAP phases and subphases by tradition. Two sets of dates are associated with the phases and subphases in the Anasazi Tradition. The first set of dates have been in place since 1981 when the prehistory of the project area was synthesized on an interim basis (Kane 1983, 1984) and all of the chapters in this volume that use phases and subphases, with the exception of chapter 5, were written using these dates. The second set of dates were Kane's versions of the first set and appear only in chapter 5.

Table 1.7 – Dolores Archaeological Program phases and subphases, by tradition

Tradition Phase Subphase	Date(s)
Paleo-Indian	Prior to 5000 B.C.?
Archaic	5000 B.C. – A.D. 500
Great Cut	2000 B.C. – A.D. 500
Anasazi	A.D. 1-1200
Cougar Springs	A.D. 1-600
Sagehen	A.D. 600-850 (A.D. 600-840)
Tres Bobos	A.D. 600-700
Sagehill	A.D. 700-780 (A.D. 700-780)
Dos Casas	A.D. 760-850 (A.D. 760-840)
McPhee	A.D. 850-975 (A.D. 840-1000)
Periman	A.D. 850-900 (A.D. 840-910)
Cline	A.D. 900-975 (A.D. 920-1000)
Grass Mesa	A.D. 880-925 (A.D. 870-910)
Sundial	A.D. 1050-1200 (A.D. 1000-1200)
Marshview	A.D. 1050-1200 (A.D. 1000-1200)
Escalante	A.D. 1125-1200 (A.D. 1120-1180)
Shoshoean	A.D. 1500-1800
Protohistoric	A.D. 1775-1870

Dates in parentheses are revisions from Kane (chapter 5).

Figure 1.2 correlates the periods presented in the research design section with the corresponding Anasazi Tradition phases and subphases and the Pecos Classification (Kidder 1927; Watson 1954). The phase and subphase dates in this figure correspond to the first sets of dates in table 1.7 since the majority of the chapters in this volume that deal with phases and subphases were written according to these dates.

The Data Base[1]

The DAP data base consists of computer files, hand written forms and notes, field maps and photographs. Because the data base is so massive, the majority of the data have been computerized in one form or another. The computerized data base has been managed by the DPG

[1]Substantial contributions to this section were made by Lynn L. Udick, Dorin E. Steele, and Marcia G. Gross, DAP, Dolores, Colorado.

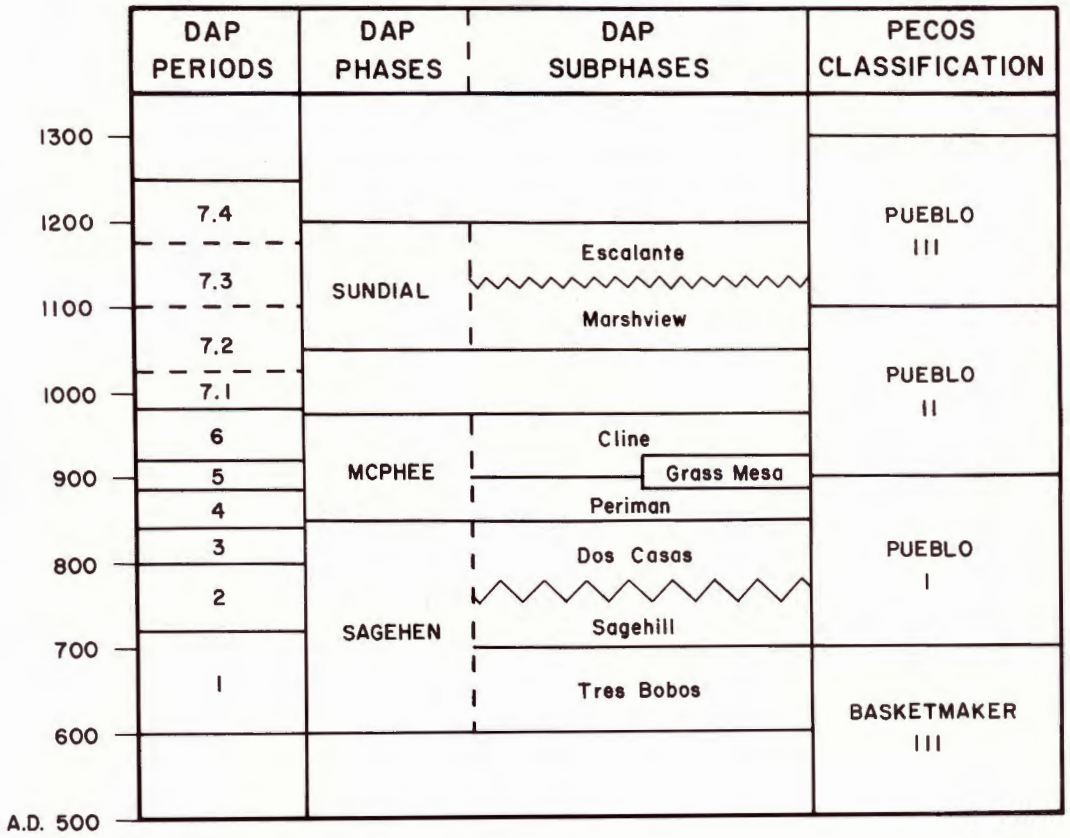

Figure 1.2 – Dolores Archaeological Program periods, phases, and subphases correlated with the Pecos Classification.

(Data Processing Group) throughout most of the program's life, and the methodology that has been used to manage the data base is one of the major contributions of the DAP, in addition to the data base itself. The DPG has had to meet the diverse data needs of researchers, report writers, editors, and curators associated with the program; this has involved data entry, editing, storage, and backup, as well as statistical data analysis and data report generation.

Several decisions made during the development of the computerized data base were critical to the overall success of the DAP data processing system. Perhaps the most important was the decision that all data recording forms, for both the field and laboratory, were to be designed for direct input into the computer. Although every form allows for verbal description, a standard set of explicitly defined variables and values for each variable are recorded on each form and codes for these have been input directly into the computer. Second, data processing has been a centralized function for the program. Requests for editing, programming, and data analysis have been submitted to and cataloged by the DPG; actual file maintenance and computer work has been done by trained DPG staff.

This has been essential since it has often been necessary to track down the source of a particular problem or duplicate analysis results after several years have transpired. Third, after several trials, it became apparent that no data base management system was available that could meet the DAP's data management needs, so the decision was made to develop custom programs to meet these needs. Fourth, since use of the Bureau of Reclamation mainframe was remote and the DAP has been one of the largest user's of this mainframe, the decision was made, and was approved by the Bureau of Reclamation, to purchase a large microcomputer so that some data processing work could be done onsite. Last, a forum, composed of the DPG, the Laboratory Supervisor, and the Technical Performance Manager was formed to review and coordinate requests from the computerized data base. This ensured that requests were appropriate given the structure of the data base and that the resulting output accurately reflected the original request.

Data structure. – To address the questions in the DAP general research design (Kane et al. 1983), many types of data had to be integrated into the DAP computerized data base. The heavy emphasis on statistical analysis by both the general research design and the implementation design (Knudson et al. 1985) has required that the data base be organized sequentially for processing.

The DAP spent considerable time and effort evaluating currently available DBMS's (Data Base Management System) to see if they were potentially suitable to the DAP data base and were efficient and cost effective. At the time the evaluation took place (1979), none of these systems (e.g., System 2000 or REX) could meet the anticipated needs of the data base. The amount of data exceeded the capacity of the DBMS's available at the time, and the fact that the files would be added to and continually edited until close to the end of the program also precluded the use of the DBMS's currently available. In addition, the cost of using any DBMS and having to reformat data into sequential files for statistical analysis or SPSS (Statistical Package for Social Sciences [Nie et al. 1975]) was prohibitive. Therefore, the DAP data base consists of sequential files that reflect the analytical system used. In addition, each file contains key variables by which each computerized file can be linked to another; special software has been written to link files.

Structure of the data files: The DAP data files consist of provenience information, data from analysis of material classes, inventory information, and temporal-spatial information.

The provenience file: The provenience file consists of a line of information for every FS (field specimen) number assigned in the field. Information entered into the file include the following: site number; FS number; steady unit type and number, which refer to both cultural units, such as rooms or pitstructures, and arbitrary units, such as grid squares and trenches; horizontal and vertical subdivisions within study units and features; assessments about the types and locations of deposits encountered; collection modes; and information about any features that were encountered. This file is a critical link in the data base since the variables state-county, site number, and FS number link this file to all other files in the data base.

The artifact files: All artifacts and samples are assigned to a material class and these structure artifact and sample files. Examples of artifact material classes are: ceramics, flaked lithics, fauna, and macrobotanical remains. Artifact files contain the results of preliminary or intensive analysis (Blinman et al. [1984]; Phagan and Hruby [1984]; Neusius and Canaday [1985]). These files range in size from 480 records in the shell file to over 100,000 records in the ceramics file. In most files a single record represents a single item; in several, including the fauna and ceramics files, each record represents a common lot of items.

The inventory files: Sequential files have also been built for inventory and data recording for all items coming into the laboratory during a field season, all samples taken in the field, all maps and photographs, all surveyed sites, and all dating samples with results.

The temporal-spatial master file: The temporal-spatial master file contains IF-statements that attach temporal and spatial information to provenience units from excavated sites. Proveniences that may be assigned temporal and spatial information range from a single FS, to a fill sequence within a structure, to an entire study unit. This file is based on program systematics and also includes the periods discussed earlier in the general research design section. The confidence and integrity values included with most of the temporal and spatial assignments comprise an essential part of this file.

Confidence values range from 0 to 4 and this variable rates the strength of the arguments used to make an assignment. For instance, a value of 4 represents the highest confidence possible and reflects assignments supported by multiple, independent lines of evidence. A value of 1 represents the lowest confidence and reflects an assignment for which no strong argument but a best guess has been made.

Integrity refers to the relative "purity" of an assignment and also ranges in value form 0 to 4. A value of 4 is the highest value and refers to assignments that represent undisturbed, sealed cultural surfaces or strata. A value of 1 reflects lowest integrity. Assignments in this category are disturbed deposits likely to contain considerable extraneous material but at least 50 percent of the material in them is believed to have belonged to the temporal or spatial unit.

Data storage and backup: All preliminary analysis files have been kept on disk storage in the mainframe computer for easy access since many of these files have been used on a daily basis for either editing or analysis. Intensive analysis files not in use have been kept on tape. Because of the extensive editing required to produce error-free files, and because it has been necessary to track sources of problems and verify or redo analyses, a weekly 52-tape backup system was installed in 1982. All data files have been written to tape on a weekly basis. After completion of all fieldwork and analysis, the data base contains over 375 000 records.

Hardware. – In 1978 work on the data base began with a single CRT terminal in the laboratory facility to communicate with the Bureau of Reclamation Central Computer Service in Denver. All processing and data storage took place on the Bureau of Reclamation CDC CYBER mainframe computer. A Dec LA printer was acquired in 1980 for receiving printed output.

By 1981 the DAP was the largest user of the Bureau of Reclamation CYBER and the size of the system was creating problems in Denver. A decision was made to purchase a large multi-tasking microcomputer for use at the DAP laboratory facility. In 1982 a Northern Telecom SYCOR 435, with a 10 megabyte hard disk, tape cartridge backup, dual floppy disk drives, and 2 CRTs was acquired. The data base remained on the Bureau of Reclamation CYBER and all analysis was done by remote job entry from the SYCOR. The major, persistent shortcoming of the DAP hardware has been inadequate and slow printer capacity.

Three dedicated data lines have been used to communicate with the CYBER in Denver. A 2400 baud synchronous line has been used for batch job entry. Two 1200 baud asynchronous lines have been used for time-share operations, including file editing and printing of output.

Also in 1982, 2 Micom word processors were added to the 2 existing Lanier word processors for the production of reports. These machines were tied into the data processing hardware so that massive data tables for reports have been directly transmitted to the word processors after being created on the CYBER. These tables could then be edited as needed and included in reports, without re-entering and proofing the data.

Software. – The diverse requirements from the DAP data base precluded the use of a single DBMS or a single combination of software already available and custom software written by the DPG.

Software acquired from outside: Three software packages acquired from outside the DAP have been used extensively in DAP analyses. These are:

SPSS (Statistical Package for the Social Sciences): SPSS (Nie et al. 1975) has been used extensively for many of the numerous and varied analyses required by researchers and report writers working with the data base. SPSS REPORT has been particularly useful for formatting faunal and macrobotanical data output because timing and the structure of these files precluded the writing of custom programs. The parametric and nonparametric statistical programs available with SPSS have been used in the majority of the analyses of the data base.

SYMAP: SYMAP (Dougenik and Sheehan 1977) has been used to map distributions of resources, site surface collections, artifact and botanical remains on structure floors, and agricultural potential.

Other statistical programs: Three programs have been acquired from J.J. Wood of Northern Arizona University. These are HCLUST, an item clustering program; GOWER, to computer Gower's coefficients; and EUCLID, to compute Euclidean distance.

In-house software: The programs discussed here are only a portion of the software written by the DPG, and they are selected to illustrate the building of the DAP data base from the time field information arrives in the laboratory, through inputting and editing of data, to analysis, and finally reporting. All of the software used by the DAP is available in a final data processing documentation report (Udick and Gross 1985).

Receiving programs: Records of all materials collected in the field are entered into the computer. A series of FORTRAN programs order the data and print out an inventory of all materials. The output has been used to cross-check field notes and analysis records to ensure the arrival and analysis of all field material.

Inputting programs: While most preliminary and intensive analysis data have been sent to a keypunching service in Denver for input, several kinds of data have been input onsite with screen-formatted input programs. These were written in TAL, the assembler-like language on the SYCOR microcomputer.

File listing programs: COBOL programs have been written for all data files to provide easy-to-use line dumps for data editing and review. These programs format the data in each file so that mistakes in each record can be easily identified.

Standard output: To provide authors of site reports with appropriate data for each site, large COBOL programs have been written for ceramic, flaked lithic tool, flaked lithic debitage, and nonflaked lithic tool material classes. Each "standard output" provides the results of preliminary artifact analysis by all provenience units designated at a site and it creates tables that tabulate selected variables by provenience units which, since 1982, have been directly transmitted to work processors for inclusion in site reports.

Photographic study packages: A COBOL program has been generated to produce a listing of all photographs taken in the field and laboratory. The output is sorted so researchers and report authors can quickly identify photographs that meet their needs.

Diversity indices: For researchers needing a measure of diversity, a FORTRAN program provides the Shannon-Wiener and Simpson's diversity indices, as well as an index of equitability.

Ceramic summary: This COBOL program provides a summary of count and weight of ceramic data by traditional provenience. This program has been essential for many of the dating arguments used by the DAP in assigning proveniences to temporal units.

Probability estimates: A series of FORTRAN programs estimates the frequencies of structures and artifacts where probabilistic excavation design was used at site (Kohler [1984, 1985]; Kohler and Gross [1984]).

Minimum number of individuals: For faunal data, a FORTRAN program has been written to estimate the number of individuals in each species represented in any provenience, or any temporal or spatial data grouping.

The "Big Link": While a COBOL linker has been written to link the provenience file with any other data file, a more flexible linkage has been required. The "Big Link" is a COBOL program written to combine up to 5 files that have common variables. The "Big Link" can create a new file of selected variables from any of the linked files.

Temporal-spatial programs: In most cases it has been possible to assign excavated proveniences to temporal units, such as tradition, phase, subphase and/or period, and to spatial units, such as activity and use areas, household and interhousehold clusters, and community clusters. Confidence and integrity assessments for assignments are also available and these were discussed in the temporal-spatial file section. The programs that run the temporal-spatial assignments are composed of COBOL programs that create a "megafile" that links all IF-statements in the temporal-spatial file with the provenience and any artifact file. This allows a researcher to ask very complex questions of the data base. For example, one could ask for all of the flaked lithic tools from pitstructure floors that are assigned to domestic use areas in Subperiod 2.2 with a confidence of 3 or 4 and an integrity of 3 or 4, or for all of the corn from macrobotanical samples collected from hearths that contained primary refuse from Period 4.1 in the Grass Mesa Community Cluster.

The megafiles created from the data base form the basis for most DAP synthetic results, and this discussion is intended to help the reader understand enough about how they have been used to evaluate the results in the remaining chapters of this volume. Since the data base was still being built while researchers were conducting analyses and writing reports, megafiles have been created several times during the life of the program to include new data and editing changes. This means decisions have had to be made about which megafile was used for any one study and when enough additions and changes had been made to warrant megafile re-creation, a very expensive process. As a result, some studies have used older versions of a megafile than others. In this volume, all of the chapters report results from megafiles that included all of the data base, but some variability exists in the versions of megafiles used. For instance, the faunal data reported in chapter 4 are current as of August 1984, while the other chapters were written with files that are current as of June 1985. The versions used will differ in the amount of editing conducted on them, but serious comparability problems between the 2 versions are not anticipated.

The way in which researchers grouped data from the megafiles varies considerably, and completely describing all of the ramifications of this variability is impossible without resorting to description on a case by case basis, which would not be appropriate here. The megafiles, and indeed the data base as a whole, are extremely complex and well controlled. Deriving a data group from the megafiles is most often a subtractive process. As a result, it is quite possible to generate a situation where a data set is too small to interpret. These factors have to be balanced so that data groups reflect the strengths of the data base and are large enough to say something meaningful. In this volume, the greatest variability in the way that data are grouped is in Matthews' section of chapter 4, where special IF-statements were added to requests from the macrobotanical megafile to add more provenieces from sites.

Data-check packages: To enable data-checkers to ensure accuracy of data in site reports, a COBOL program creates a standard package for each site. This includes a listing of all samples taken from the site, the dimensions of all features at the site, and all PL's (point locations) at the site sorted by provenience units.

Table-maker programs: COBOL programs have been written to create standard-output-formatted data summary tables for any data set from the flaked lithic tool, flaked lithic debitage, nonflaked lithic tool, and faunal artifact files. These tables can be transmitted to the word processors.

Column-switching programs: As report writers and editors worked with the standard output tables produced for the larger, more complex sites, they found a need to rearrange, and in some cases, delete columns from these tables. To relieve the burden this placed on the word processing staff, a COBOL program was written to permit adding, deleting, rearranging, and subtotaling columns within standard output tables before they were sent to the word processors.

Acquisition of Field Data

Surficial Studies

Because over 1000 sites are in the Dolores Project area and only a small number could be intensively excavated or sampled, information obtained from the modern ground surface has been extremely important. Data acquisition from the modern ground surface correspond to Track 3 and 4 investigations.

The techniques employed to recover data from the modern ground surface have varied over a span of 10+ years and this has created problems that will be discussed further in the cultural resource section. Techniques employed by the DAP include inventory survey, probability survey, and magnetometer survey.

Inventory survey is designed to provide 100 percent coverage of zones that will be directly impacted by construction. Inventory survey meets or exceeds the Bureau of Reclamation Class III survey standards. Most of the DAP inventory survey work has been guided by the survey manual (Bohnenkamp et al. 1984).

Survey using probability sampling techniques has been employed to obtain coverage of areas not scheduled to be covered by inventory survey. Specific techniques used for probability surveys can be found in Schlanger (1985a) and Schlanger and Harden (1985).

Magnetometer survey of selected sites has been a very successful technique for the DAP. Magnetometer survey has been undertaken to complement inventory survey and to aid in the identification of subsurface features prior to excavation. Magnetometer survey has greatly increased the ability of the DAP to predict the location of structures and whether or not they are burned. It has been a very cost effective technique in that as more knowledge was gained, fewer hours had to be spent in the field assessing both the location and the size of structures; trenching procedures could proceed on the basis of magnetometer maps alone. Further information on magnetometer survey can be found in Huggins (1983), Burns et al. (1983, 1984), Huggins and Weymouth (1981a, 1981b, 1983).

Excavations

Acquisition of data below the modern ground surface, Track 1 or 2 level of investigation, has been conducted selectively. The DAP has had to balance data needs required by the general research design (Kane et al. 1983) with the Bureau of Reclamation practical needs; construction schedules, land ownership and extent of inventory survey have all been factors that have had to be taken into consideration.

Track 1 or 2 levels of investigation have been guided by 2 manuals; the field manual (Kane et al. 1981) guided fieldwork in the early years of the program, and the excavation manual (Kane and Robinson 1984) was used from 1981 until the completion of fieldwork in 1983. The manuals are similar, the major difference being that the excavation manual streamlines fieldwork and makes sampling procedures more explicit.

The goals of Track 2 excavations are to sample or test a given site, and this has involved the use of heavy equipment whenever possible. Track 1 excavations have involved more hand work but heavy equipment has also been used when possible. Both tracks emphasize exposure of structures and features and collection of artifacts and samples from the best contexts possible. The decision about which track to use at a site has been influenced by both research and practical considerations. Track 1 work can involve the complete excavation of a small site or opening up selected areas for more intensive work at a large, complex site.

Recording of excavation data has been done using a set of standardized field forms intended to focus the excavator's attention along similar lines. Parts of all of the forms are coded for direct input into the computer, and space is also provided for verbal description. The forms have been supplemented with photographs and maps.

The sheer magnitude of the artifacts and samples collected from excavations has caused the DAP to make decisions that limit what has been collected to sensitive proveniences that maximize the information collected. As a result, most excavated matrix has not been screened; exceptions are probability samples and structure floors, features, and midden deposits where the preservation is good and the deposits are relatively uncontaminated. The collection mode for every excavated provenience is recorded on each artifact bag and is a coded variable on the field form.

Two concepts have also been generated to structure the collection of artifacts and samples from excavation. The first is the concept of item versus assemblage mode collection (Kane and Robinson 1984), which pertains to artifact collections. Item mode collection procedures are geared toward diagnostic artifacts; contexts from which artifacts collected in this manner are fills that were not culturally deposited. Assemblage mode collections are either total collections or samples of contexts such as culturally deposited fills, cultural surfaces, and features. The second concept is the abandonment mode (Kane and Robinson, 1984, 1980) and it pertains to macrobotanical and pollen sampling. The concept assumes a scale of preservation is present in Dolores area structures that is related to the way they were abandoned. Macrobotanical and pollen sampling has been explicitly geared toward

structures abandoned and quickly sealed off from postabandonment filling or later cultural contamination.

Dating excavated proveniences has been an important priority for the DAP. Tree-ring dating, archaeomagnetism, and C-14 dating have been the techniques that have been used most often. A summary of the absolute dates from excavated proveniences is provided in appendix A.

Dating proveniences by tree-rings has not been as successful as anticipated, because samples analyzed by the Laboratory of Tree-Ring Research, University of Arizona, have largely consisted of ponderosa pine that is immature and does not have enough rings to produce dates.[2] Archaeomagnetism has been an important technique used by the DAP and the results have helped to refine the archaeomagnetic curve for the Southwest (Hathaway et al. 1983). Results from Carbon-14 dating have not been helpful (Gross 1983).

THE DOLORES PROJECT CULTURAL RESOURCE BASE

Dolores Project features consist of the McPhee Dam and Reservoir, the Great Cut Dike, buffer lands around the reservoir, and a distribution system composed of smaller reservoirs, canals, and laterals (fig. 1.3). The reservoir is also called the pool and encompasses 4470 acres (1809 ha) and will contain 381 000 acres ft of water; the maximum elevation of the pool is 6924 ft (2112 m). The buffer lands around the reservoir or pool are called the takeline. The takeline encompasses an additional 11 507 acres (4657 ha) above the maximum pool line. Figure 1.4 shows the pool and takeline in relation to the Escalante Sector, which is an administrative unit defined by the DAP (Kane 1984:24). Also shown in figure 1.4 are localities, which are smaller administrative units that make up the Escalante Sector (Kane 1984:24).

Dolores Project features can be classified into 2 categories depending on how much construction will impact these features. Primary impact areas are those lands directly affected by construction activities; the reservoir or pool is an example of a primary impact area. Secondary, impact areas are lands outside of primary impact areas and are not modified by construction; lands serviced by new irrigation systems are an example of secondary impact areas.

The DAP has been directed by the Bureau of Reclamation to focus mitigation efforts on primary impact areas. Further, because the pool and takeline areas are continuous and all of the cultural resources are considered to be known, with the exception of some of the resources located on the steep canyon walls of the Dolores River (this area was randomly sampled), the DAP has focused most of its mitigative and interpretive efforts on these 2 project features. The resources that are located in linear primary impact areas, such as canals and laterals (fig. 1.3), have not received as much attention since fully interpreting their spatial distribution and their relationship to the resources within the takeline is difficult.

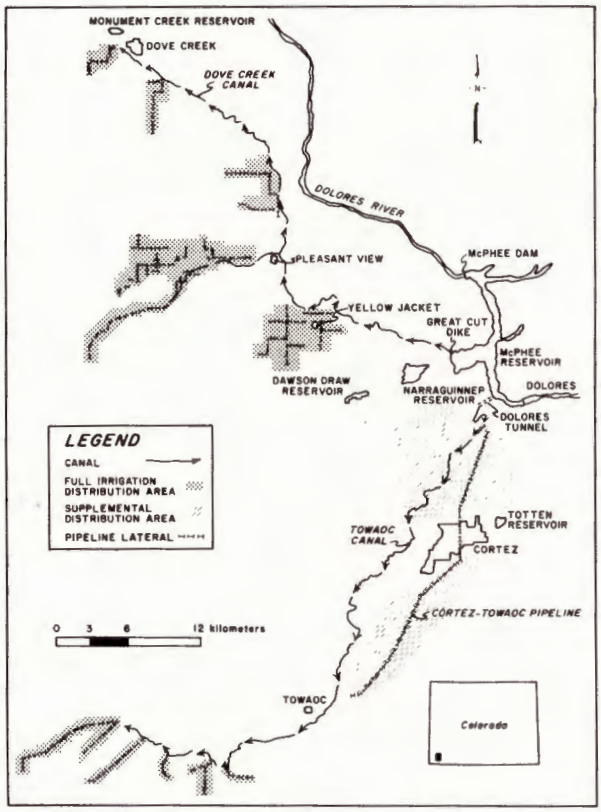

Figure 1.3 – Dolores Project features.

When the mitigation program began in 1978, the extent of the cultural resources that would be impacted by the Dolores Project was largely unknown, although the significance of the resource base had been recognized from pre-DAP surveys (Breternitz 1974). Archaeological surveys associated with the Dolores Project began as early as 1954-1955 when Dr. Joe Ben Wheat from the University of Colorado recorded Grass Mesa Village (Site 5MT23). Government funding of survey work related to the project began in 1972 when the University of Colorado contracted with the National Park Service-Midwest Archaeological Center. This reconnaissance covered part of the McPhee Reservoir area and results

[2]William Robinson, Laboratory of Tree-Ring Research, University of Arizona, personal communication.

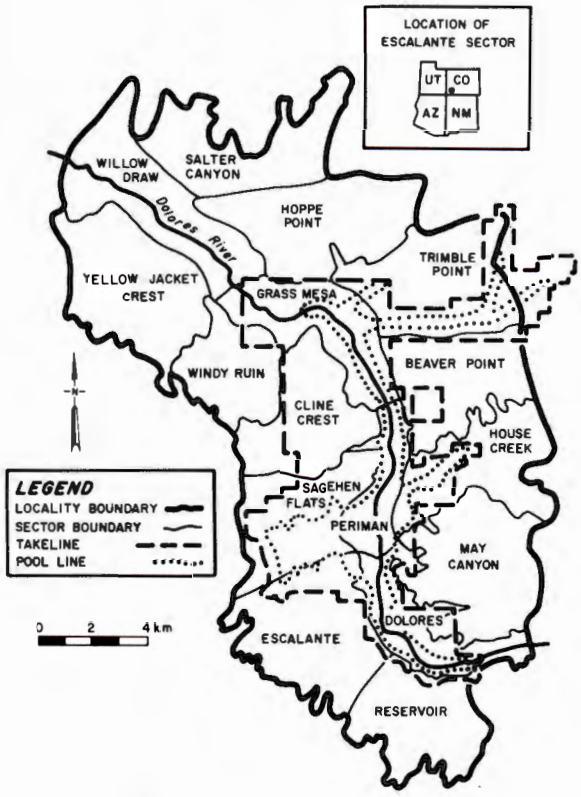

Figure 1.4 – The Escalante Sector.

are reported in Breternitz and Martin (1973). Other surveys funded by the government during the 1970's covered some ancillary features of the reservoir and other parts of the Dolores River valley (Kane 1975a, 1975b, 1977; Toll 1974, 1977). Although these surveys were useful, many of the data collected are of limited utility since coverage of key project features, such as the pool and takeline, was spotty and because most artifact collections were judgment, or "grab," samples geared toward diagnostic artifacts.

Survey efforts were resumed in 1978 under the supervision of the Bureau of Reclamation; DAP assumed responsibility for survey in 1979. Inventory survey of the pool area (Orcutt and Goulding 1985) was completed in 1980 and the takeline survey was completed in 1981. Survey of selected ancillary features continued until 1983. In addition, probabilistic surveys (Schlanger and Harden 1985; Schlanger 1985a) were conducted in 1979, 1980, and 1982 by Washington State University in the Cline Crest, Grass Mesa, Beaver Point, Trimble Point, Hoppe Point, Windy Ruin, and Yellowjacket Localities (fig. 1.4). The probability surveys were conducted to obtain coverage of areas in the Escalante Sector not scheduled for inventory survey.

The Nature of the Total Resource Base

Table 1.8 summarizes all of the cultural resources recorded in conjunction with the Dolores Project as of 1983, when DAP fieldwork was completed; data are presented by survey project and by location in relation to the takeline. The Bureau of Reclamation intends to conduct additional surveys that will add to the overall Dolores Project data base. Table 1.9 arrays all of the resources by site type and general temporal units. Assignment of resources to the site type variable in table 1.9 is based on architectural characteristics (Kane 1983) and, in some cases, on a discriminant function based on artifact variables designed by Schlanger and Orcutt (1985) to test Kane's original intuitive site typology. Since the DAP phase scheme is based on organizational characteristics more easily recognized in excavation data, the Survey Group did not assign resources to phases and subphases in the survey computer file from which table 1.9 was derived. Instead, sites were assigned to the more generalized temporal units reflected in table 1.9. These temporal units are based on the Pecos Classification and on general knowledge about the resources in the Mesa Verde Region. Resources were assigned by the Survey Group to these temporal units on the basis of architecture and types of ceramics, manos, metates, and projectile points present in surface collections (Ives and Orcutt 1982).

Although tables 1.8 and 1.9 both indicate a total of 1626 sites has been recorded, the nature of these resources is more complex than indicated on either table. For example, although table 1.9 does give some indication of those resources that have multiple components, the true complexity present is masked because each site is assigned to a single cell in the table. Resources that contain more than 1 site type or contain hidden components not detectable from survey data are not reflected in table 1.9.

The importance of table 1.9 is that it does reflect the temporal and functional assignments of the resources in the project area. As indicated in table 1.9, the majority of the resources are either untyped or are unknown in terms of site type. Of those that are typeable, the majority are limited activity loci, followed by habitations, and then seasonal sites. The majority of the resources could not be assigned to a temporal unit. Of those that could be assigned to a temporal unit, the most have been assigned to Pueblo I or Basketmaker III through Pueblo I. These general trends are the basis on which the DAP made mitigation decisions. Using the rationale that since the resource base reflects substantial Basketmaker III and Pueblo I occupations and that habitations and, to a certain extent seasonal sites, are most interpretable, the DAP focused mitigative efforts on these kinds of resources. This is not to say that the DAP ignored other resources. The point is the DAP attempted to mitigate resources in proportion to their temporal and functional occurrence within the project area.

Table 1.8 – Known cultural resources in the Dolores Project area as of 1983

Survey project	Within Dolores Project takeline	Outside Dolores Project takeline	Total
Pre-1978 surveys*	159	397	556
1978 BREC/YACC survey†	148	9	157
DAP – CU survey	576	177	753
DAP – WSU survey	44	84	128
Miscellaneous surveys	6	26	32
Total	933	693	1626

* Breternitz and Martin (1973); Toll (1974); Kane (1975a, 1975b, 1977).
† Dykeman et al. (1981).
BREC – Bureau of Reclamation.
YACC – Young Adult Conservation Corps.
DAP – Dolores Archaeological Program.
CU – Colorado University.
WSU – Washington State University.

Additional information on the totality of Dolores Project cultural resources can be found in the DAP survey computer file, in the paper records housed at the Anasazi Heritage Center, in the paper records at the Colorado State Historic Preservation Office, and in King (1980, 1981, 1982, 1983, and 1984).

Cultural Resources in the Escalante Sector

The following data presentation is focused on the Escalante Sector (fig. 1.4), an administrative unit defined by the DAP (Kane 1984:24). The Escalante Sector includes the Dolores Project pool, takeline, and the probabilistic surveys conducted by Washington State University. The Escalante Sector was chosen for more indepth presentation for 2 reasons. First, the resources in this sector are the basis for the vast majority of the mitigative and interpretive efforts of the DAP. Second, the data from the Escalante Sector, particularly those data from the takeline, represent the most consistent and complete data set available.

Table 1.10 arrays the cultural resources in the Escalante Sector by site type and by general temporal unit. Both variables and the means by which resources were assigned to them are identical to those in table 1.9. Consideration of only those resources in the Escalante Sector reduces the site set to 1074, although the complexity of the resources is not completely represented, which is a function of the nature of survey data and the method of presentation in the table. As reflected in table 1.10, the majority of the resources in the Escalante Sector are limited activity loci, followed by habitations, followed by seasonal sites. The majority of the resources could not be placed into a temporal unit. Of those that could be placed into a temporal unit, most are Pueblo I or Basketmaker III through Pueblo I. These patterns are consistent with those recognized when the entire data base is arrayed in the same manner.

Orcutt and Goulding (1985) have evaluated the McPhee Reservoir, or pool, data base and their findings are probably applicable to the larger takeline area. Orcutt and Goulding identify 2 major problems with the data base. The first is related to the representativeness of the pool or larger takeline area as a sampling unit. Orcutt and Goulding do not consider the McPhee Reservoir area to be a representative sampling unit when compared to the rest of the region because of the geographic break, termed the Sagehen Flats (fig. 1.4), in the western wall of the Dolores River canyon. They note that this kind of physiographic feature does not occur anywhere else between the source of the Dolores River and the Disappointment Valley. However, Orcutt and Goulding indicate this problem is partially offset by the survey work conducted on ancillary features outside the pool area and by the probabilistic surveys conducted by Washington State University. The second problem is related to variability in data collection procedures in surveys conducted over a long period of time. Orcutt

Table 1.9 – All recorded sites in the Dolores Project area, by site type and the Pecos Classification

Pecos Classification	Site type										Total	
	Untyped		Limited activity		Seasonal		Habitation		Unknown			
	N	% total	N	% total	N	% total	N	% total	N	% total	N	% total
Indeterminate	158	9.7	253	15.6	35	2.2	2	0.1	11	0.7	459	28.2
Archaic	2	0.1	2	0.1							4	0.2
Basketmaker II	1	0.1									1	0.1
Basketmaker III	22	1.4	18	1.1	10	0.6	9	0.6	1	0.1	60	3.7
Pueblo I	79	4.9	52	3.2	60	3.7	74	4.6	8	0.5	273	16.8
Pueblo II	81	5.0	18	1.1	13	0.8	13	0.8	1	0.1	126	7.7
Pueblo III	5	0.3									5	0.3
Post-Anasazi	1	0.1	1	0.1							2	0.2
Basketmaker III-Pueblo I	128	7.9	51	3.1	41	2.5	66	4.1	4	0.2	290	17.8
Pueblo I-Pueblo II	52	3.2	15	0.9	16	1.0	34	2.1	2	0.1	119	7.3
Pueblo II-Pueblo III	68	4.2					3	0.2			71	4.4
Basketmaker III-Pueblo II	30	1.8	6	0.4			10	0.6	1	0.1	47	2.9
Pueblo I-Pueblo III	28	1.7	1	0.1			3	0.2			32	2.0
Archaic-Pueblo III	3	0.2									3	0.2
Indeterminate Anasazi	33	2.0	42	2.6	20	1.2					98	6.0
Paleo, Pueblo I					1	0.1					1	0.1
Archaic, Pueblo I			2	0.1							2	0.1
Archaic-post-Anasazi			1	0.1							1	0.1
Indeterminate Anasazi, post-Anasazi			1	0.1							1	0.1
Pueblo II, post-Anasazi	2	0.1	3	0.2			1	0.1			6	0.4
Archaic, Pueblo II			1	0.1			1	0.1			2	0.2
Archaic-Pueblo I	1	0.1	2	0.1			1	0.1			4	0.2
Paleo-Pueblo II			1	0.1							1	0.1
Paleo-Pueblo I			1	0.1							1	0.1
Basketmaker III-Pueblo III	14	0.9									14	0.9
Pueblo I, post-Anasazi	1	0.1									1	0.1
Basketmaker III, Pueblo III	1	0.1									1	0.1
Pueblo I, Pueblo II, post-Anasazi							1	0.1			1	0.1
Total	710	43.7	471	29.0	196	12.1	219	13.5	30	1.8	1626	100.0

Table 1.10 – All recorded sites in the Escalante Sector, by site type and the Pecos Classification

Pecos Classification	Site type										Total	
	Untyped		Limited activity		Seasonal		Habitation		Unknown			
	N	% total	N	% total	N	% total	N	% total	N	% total	N	% total
Indeterminate	66	6.1	247	23.0	34	3.2	2	0.2	10	0.9	359	33.4
Archaic	2	0.2	2	0.2							4	0.4
Basketmaker III	3	0.3	18	1.7	10	0.9	9	0.8	1	0.1	41	3.8
Pueblo I	31	2.9	52	4.8	60	5.6	74	6.9	8	0.7	225	20.9
Pueblo II	4	0.4	18	1.7	13	1.2	13	1.2	1	0.1	49	4.6
Pueblo III	1	0.1									1	0.1
Post-Anasazi	1	0.1	1	0.1							2	0.2
Basketmaker III-Pueblo I	17	1.6	51	4.7	41	3.8	66	6.1	4	0.4	179	16.7
Pueblo I-Pueblo II	4	0.4	15	1.4	16	1.5	34	3.2	2	0.2	71	6.6
Pueblo II-Pueblo III	4	0.4					3	0.3			7	0.7
Basketmaker III-Pueblo II	11	1.0	6	0.6			10	0.9	1	0.1	28	2.6
Pueblo I-Pueblo III	1	0.1	1	0.1			3	0.3			5	0.5
Archaic-Pueblo III	1	0.1									1	0.1
Indeterminate Anasazi	12	1.1	42	3.9	20	1.9	1	0.1	2	0.2	77	7.2
Paleo, Pueblo I					1	0.1					1	0.1
Archaic, Pueblo I			2	0.2							2	0.2
Archaic-post-Anasazi			1	0.1							1	0.1
Indeterminate Anasazi, post-Anasazi			1	0.1							1	0.1
Pueblo II, post-Anasazi			3	0.3			1	0.1			4	0.4
Archaic, Pueblo II			1	0.1			1	0.1			2	0.2
Archaic-Pueblo I	1	0.1	2	0.2			1	0.1			4	0.4
Paleo-Pueblo II			1	0.1							1	0.1
Paleo-Pueblo I			1	0.1							2	0.1
Basketmaker III-Pueblo III	6	0.6									6	0.6
Pueblo I, post-Anasazi	1	0.1									1	0.1
Pueblo I, Pueblo II, post-Anasazi							1	0.1			1	0.1
Total	166	15.5	465	43.3	195	18.2	219	20.4	29	2.7	1074	100.0

and Goulding point out that the problem is most severe with surface collected artifacts; the problem is not as severe with other data categories and this is probably the result of long term involvement of University of Colorado trained personnel in surveys associated with the Dolores Project. Although the DAP attempted to alleviate some of the data collection variability in the survey data set, a complete solution to this problem was not possible. Sites recorded prior to the DAP or early in the history of the program could not be completely rerecorded or recollected to current standards (Bohnenkamp et al 1984). However, some attempt was made to re-record or recollect selected sites judged to be essential to the program mitigative or research goals.

Table 1.11 arrays the resources in the Escalante Sector by surface collection mode and by percent of site collected. Surface collection mode is documented in Bohnenkamp et al. (1984). The number of judgmentally collected resources largely reflects sites recorded before the DAP or recorded early in the history of the program; this collection mode was designed to obtain diagnostic artifacts. In some cases, judgmental collection was used to augment a representative sampling technique with diagnostic artifacts. The transect collection mode was used primarily in 1979 and the procedure involved collecting all material within 1-m-wide units transecting a site. The point-located mode was used very little and involved plotting artifacts in relation to the site datum. The grid collection mode involved establishing a site grid and either collecting every other unit or, if fewer than 50 units, collecting all the grid units established. The no collection mode refers to situations where it was not possible to collect surface materials and bring them back to the DAP laboratory facility for analysis. In these cases, a modified version of DAP preliminary artifact analysis was conducted in the field. The quadrat collection mode refers to square units that measured 2 m, 4 m, 8 m, or multiples of 8 m on each side. The quadrat collection mode was designed to collect no fewer than 100 artifacts per quadrat and no more than 500 artifacts; the lower and upper artifact limits were based on DAP's best estimate of the number of artifacts needed as a representative sample from a given site. The 100-percent collection mode refers to cases where 100 percent of the artifacts were collected from the site. Percent of site collected is the survey group's best estimate of how much of the site was surface collected given the limitations of site definition based on survey.

Table 1.11 illustrates the problems that can be encountered when dealing with surveys that span a number of years. Although most surface collections consist of complete collections that represent 91-100 percent of the site, judgment collections where no data are available to evaluate the percentage of the site that was collected are next in frequency. Probably the most important point that table 1.11 illustrates is that variability in survey collections can severely hamper efforts to get at base-level questions such as functional and temporal placement of resources and that undertaking such an effort requires planning for the time and effort needed to at least partially offset this problem.

It is encouraging that the correlation between surveyors trained in the same manner and their recording of non-artifactual variables is consistent enough to make their data useable (Orcutt and Goulding 1985).

The way that the DAP alleviated some of the problems with variability in recording the survey data base was to use a subtractive process based on the Escalante Sector that eliminated those resources not easily interpreted or manipulated. The DAP also made a commitment to this end by conducting additional studies to help tie down functional and temporal placement of the resources in the Dolores Project area. Schlanger and Orcutt (1985) not only tested and verified Kane's (1983) original intuitive site typology based on architecture; they were also able to generate a way to assign site function to resources that lacked architectural evidence on the basis of artifact variable.

Another critical study conducted is Blinman's (1984) work that calibrates ceramic change in the project area. Blinman began with contexts that were absolutely dated by tree-ring samples. Based on these results, he proceeded to evaluate contexts that could be dated on the basis of architecture and were inferred to be relatively uncontaminated by earlier or later cultural deposits or by postabandonment processes. By examining these contexts and conducting additional independent research on red wares (Blinman 1983), he was able to correlate percentages of ceramic types and attributes with specific time increments. This work proved invaluable for solving many dating problems both for survey and excavated contexts.

Table 1.12 summarizes data from the habitations in the takeline area; these data form the basis for the results presented in chapters 8 and 10. These data further illustrate the complexity of the resources in the Dolores Project area. Habitations were assigned to period in table 1.12 based on Blinman's (1984) calibration of ceramics in the project area. A comparison of the column labeled "No. sites" and the column labeled "No. rubble mounds" illustrates there is not a one-to-one correlation between the 2 attributes. The "No. of sites" column is the number of site numbers assigned to habitations in the takeline area. Sites with occupations dating to more than 1 period can appear on the table more than once and sites of unknown age have been apportioned to periods given the overall temporal pattern in the project area. The rubble mound column

Table 1.11 – All recorded sites in the Escalante Sector, by collection mode and percent of site collected

Collection mode	Percent of site collected																		Total	
	Inapplicable		Less than 1 percent		1 to 10 percent		11 to 25 percent		26 to 40 percent		41 to 60 percent		61 to 75 percent		76 to 90 percent		91 to 100 percent		No data			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Inapplicable	56	5.2																	1	0.1	57	5.3
Judgement	4	0.4			6	0.6	9	0.8	4	0.4	7	0.7			1	0.1	8	0.7	357	33.2	396	36.9
Transect					21	2.0	7	0.7	1	0.1			1	0.1			1	0.1	1	0.1	32	3.0
Point located	1	0.1			1	0.1	1	0.1													3	0.3
Grid							2	0.2	1	0.1	11	1.0			1	0.1	31	2.9			46	4.3
No collection							1	0.1									1	0.1			2	0.2
Quadrat			20	1.9	88	8.2	29	2.7	6	0.6	1	0.1	1	0.1			10	0.9	7	0.7	162	15.1
100 percent					1	0.1											365	34.0			366	34.1
No data																			2	0.2	2	0.2
Combined systematic					5	0.5			1	0.1							2	0.2			8	0.7
Total	61	5.7	20	1.9	122	11.4	49	4.6	13	1.2	19	1.8	2	0.2	2	0.2	418	38.9	368	34.3	1074	100.0

Table 1.12 – Habitations in the Dolores Project takeline area

Period		No. sites	No. rubble mounds Project takeline	No. households
1	A.D. 600-720	16	19	34
2	A.D. 720-800	66	81	216
3	A.D. 800-840	38	56	216
4	A.D. 840-880	66	160	629
5	A.D. 880-920	39	88	438
6	A.D. 920-980	7	7	30
7.1	A.D. 980-1025	7	11	52
7.2	A.D. 1025-1100	8	17	106
7.3	A.D. 1100-1175	5	5	12
Total		252	444	1733

Source: Data compiled from Orcutt (1985b:appendix A).

reflects the number of actual rubble mounds within each site; rubble mounds have been apportioned to periods in a manner similar to that for sites.

Table 1.12 points out the problem of simply counting sites to get an accurate idea about the Dolores cultural resource base. The source of the problem is related to site definition based on inventory survey. For example, villages such as Grass Mesa Village (Site 5MT23), Rio Vista Village (Site 5MT2182), and House Creek Village (Site 5MT2320) were given a single site number while each individual rubble mound (Sites 5MT4475, 5MT4476, 5MT4477, 5MT4478, 5MT4479, 5MT4480, 5MT4621, 5MT4622, 5MT4623, 5MT4624, 5MT4625, 5MT4725, 5MT5103, 5MT5104, 5MT5105, 5MT5106, 5MT5107, 5MT5108, and 5MT5388) in McPhee Village was given an individual site number. At the time site designations were given to the rubble mounds at McPhee Village, it was not known that they represented parts of a single village.

The situation is further complicated if the inference used to construct the column labeled "No. households" in table 1.12 are correct. This column reflects the number of individual households inferred to have occupied each rubble mound by period. The figures in the column are based on Schlanger's (1985b) conversion figure, where 50 m^2 of rubble converts to 1 household. According to Schlanger, this conversion figure is conservative and is based on excavation data with an allowance for rubble scatter built into the figure.

From the data presented thus far, it is clear that assessing the nature of a cultural resource base by simply counting sites misrepresents the size and complexity of the resource base. Also, evaluating the adequacy of mitigation effort by comparing the total number of sites to the number of sites where mitigative efforts have taken place misrepresents both the resource base and the mitigative efforts.

The Dolores Archaeological Program Excavated Data Base

The excavation data base further illustrates the complexity of the cultural resources in the Dolores Project area. Figure 1.5 illustrates the location of the excavated resources in the project area. Table 1.13 presents the final temporal and functional assignments for excavated resources. Table 1.13 will conflict with some of the site abstracts in appendix B and this difference is a function of the time lag between the writing of site reports and the final changes in temporal and spatial assignments during the summer of 1985.

Element and episode numbers in table 1.13 are assigned by site number and represent the smallest increments of time recognized in the Dolores Project archaeological record. Elements are inferred to represent major construction events, such as pitstructure construction, by household groups. Episodes are inferred to represent smaller, more transitory activities, such as a burial event, by groups smaller than a household. Tradition is a self evident assignment and will be familar to most readers. Phase and subphase assignments are based on organizational characteristics that rely heavily on architecture; phases and subphases are assigned temporal increments that may overlap. Period assignments were derived from absolute dates where possible but, as can be seen from appendix A, not as many absolute dates as desired were obtained from the excavated data base. In cases where absolute dates were not available, period assignments were made by constructing a dating argument based on Blinman's (1984) ceramic calibration,

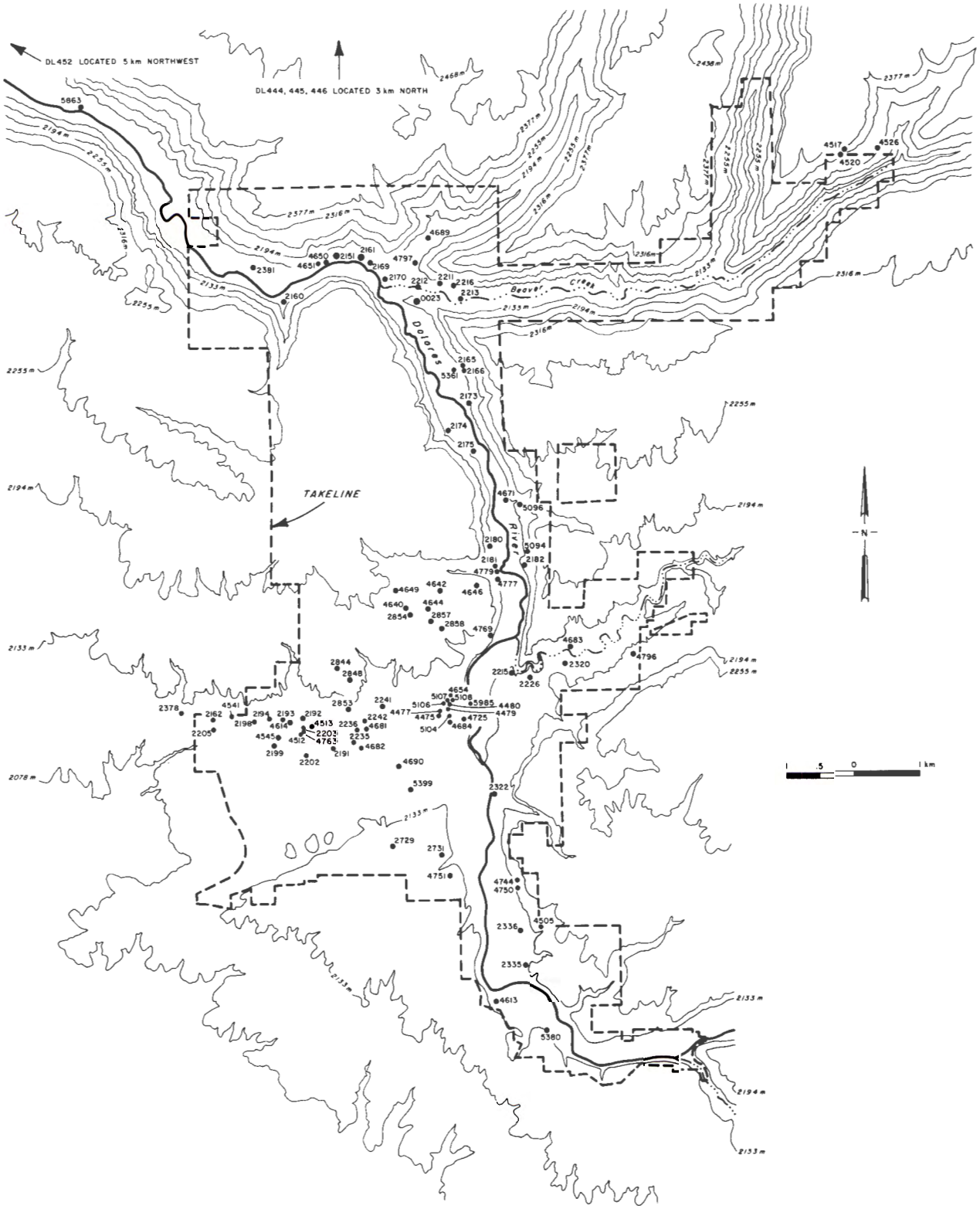

Figure 1.5 – Location of excavated sites in the Dolores Project area.

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Grass Mesa Village 5MT23	Element 1	Anasazi/Sagehen/Sagehill	720-800	Habitation/small hamlet	6	83.3
	Element 2	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	100	88.0
	Element 3	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	2	100.0
	Element 4	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	7	42.9
	Element 6	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	2	100.0
	Element 7	Anasazi/McPhee/Grass Mesa	900-920	Habitation/large hamlet	117	92.3
	Element 8	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	35	100.0
	Element 9	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	1	100.0
	Element 10	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	1	100.0
	Element 11	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	1	100.0
	Element 12	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	4	75.0
	Element 13	Anasazi/late Sagehen-early McPhee/unknown	720-880	Habitation/unknown	0	0.0
	Element 14	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	77	100.0
	Element 16	Anasazi/McPhee/unknown	840-920	Habitation/unknown	3	0.0
	Element 19	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	21	100.0
	Element 21	Anasazi/Sagehen/Dos Casas	780-820	Habitation/small hamlet	37	100.0
	Element 23	Anasazi/Sagehen/Dos Casas	720-840	Habitation/small hamlet	4	75.0
	Element 25	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	11	100.0
	Element 26	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	0	0.0
	Element 27	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	2	100.0
	Element 28	Anasazi/Sagehen/Dos Casas	780-840	Habitation/small hamlet	16	100.0
	Element 30	Anasazi/McPhee/unknown	840-920	Habitation/unknown	4	100.0
	Element 31	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	21	100.0
	Element 32	Anasazi/McPhee/Periman	860-880	Habitation/village	72	97.2
	Element 33	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	30	86.7
	Element 34	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	1	100.0
	Element 35	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	10	80.0
	Element 36	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	66.7
	Element 37	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	4	100.0
	Element 40	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	2	100.0
	Element 38	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	100.0
	Element 39	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	100.0
	Element 41	Anasazi/Sagehen/Dos Casas	780-840	Habitation/small hamlet	6	83.3
	Element 42	Anasazi/McPhee/Grass Mesa	880-920	Habitation/village	19	84.2
	Element 43	Anasazi/Sagehen/Sagehill	780-840	Habitation/small hamlet	4	100.0
	Element 44	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	1	100.0
	Element 45	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	1	100.0
	Element 46	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	4	100.0
	Element 47	Anasazi/Sagehen/unknown	720-840	Habitation/unknown	0	0.0
	Element 48	Anasazi/McPhee/unknown	840-920	Habitation/unknown	2	100.0
	Element 49	Anasazi/late Sagehen-early McPhee/unknown	720-880	Habitation/unknown	0	0.0
	Element 50	Anasazi/Sagehen/Dos Casas	720-840	Habitation/small hamlet	5	100.0
	Element 51	Anasazi/late Sagehen-early McPhee/unknown	800-880	Habitation/unknown	16	93.8
	Element 52	Anasazi/late Sagehen-early McPhee/unknown	800-980	Habitation/unknown	6	100.0
	Element 53	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	16	100.0
	Element 54	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	2	100.0
	Element 56	Anasazi/McPhee/Periman	840-860	Habitation/village	7	100.0
	Element 57	Anasazi/McPhee/Periman	860-880	Habitation/village	36	97.2
	Element 58	Anasazi/Sagehen/Sagehill	760-780	Habitation/small hamlet	13	76.9
	Element 59	Anasazi/McPhee/Grass Mesa	880-900	Habitation/village	36	83.3
	Element 60	Anasazi/McPhee/Grass Mesa	880-900	Habitation/village	73	91.8
	Element 61	Anasazi/McPhee/Grass Mesa	880-900	Habitation/village	20	100.0
	Element 62	Anasazi/McPhee/unknown	800-880	Unknown/unknown	0	0.0
	Element 63	Anasazi/McPhee/unknown	720-880	Unknown/unknown	1	100.0
	Element 64	Anasazi/Sagehen/Dos Casas	720-840	Habitation/small hamlet	3	66.7
	Element 65	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	6	100.0
	Element 66	Anasazi/Sagehen/Sagehill	600-800	Habitation/small hamlet	14	92.9
	Element 67	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	3	100.0
	Element 68	Anasazi/Sagehen/Dos Casas	720-840	Habitation/small hamlet	24	83.3

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Grass Mesa Village (cont'd)						
5MT23	Element 69	Anasazi/Sagehen/Sagehill	600-800	Habitation/small hamlet	7	85.7
	Element 70	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	25	92.0
	Element 71	Anasazi/McPhee/Periman	820-860	Habitation/village	149	91.3
	Element 72	Anasazi/McPhee/Periman	860-880	Habitation/village	342	94.7
	Element 73	Anasazi/McPhee/Periman	880-900	Habitation/village	392	80.1
	Element 74	Anasazi/McPhee/Grass Mesa	880-920	Habitation/village	87	85.1
	Element 76	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	11	81.8
	Element 78	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	1	100.0
	Element 79	Anasazi/Sagehen/Dos Casas	720-780	Habitation/small hamlet	0	0.0
	Element 80	Anasazi/Sagehen/Dos Casas	780-840	Habitation/village	11	100.0
	Element 81	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	3	100.0
	Element 82	Anasazi/McPhee/Periman	840-880	Habitation/village	17	100.0
	Element 83	Anasazi/McPhee/Periman	880-920	Habitation/village	125	97.6
	Element 84	Anasazi/McPhee/Periman	840-880	Habitation/village	19	94.7
	Element 85	Anasazi/McPhee/Grass Mesa	880-920	Habitation/village	4	100.0
	Element 86	Anasazi/McPhee/Periman	860-880	Habitation/village	5	100.0
	Element 87	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	7	100.0
	Element 88	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	2	100.0
	Element 89	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	16	100.0
	Element 90	Anasazi/Sagehen/Dos Casas	760-800	Habitation/small hamlet	5	60.0
	Element 91	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	5	100.0
	Element 92	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	100.0
	Element 93	Anasazi/McPhee/Grass Mesa	880-920	Habitation/large hamlet	4	100.0
	Element 94	Anasazi/McPhee/Grass Mesa	880-920	Habitation/large hamlet	13	92.3
	Element 95	Anasazi/McPhee/Grass Mesa	880-920	Habitation/unknown	7	85.7
	Element 96	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	2	100.0
	Element 97	Anasazi/Sagehen/Dos Casas	720-800	Habitation/small hamlet	7	100.0
	Element 98	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	66.7
	Element 99	Anasazi/McPhee/Grass Mesa	880-920	Habitation/small hamlet	3	100.0
LeMoc Shelter						
5MT2151	Element 1	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	9	100.0
	Element 2	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	121	79.3
	Element 3	Anasazi/McPhee/Periman	840-880	Habitation/small hamlet	73	89.0
	Element 4	Anasazi/McPhee/Grass Mesa	880-900	Seasonal locus/field house	41	78.0
	Episode 1	Anasazi/McPhee/Grass Mesa	880-900	Limited activity/unknown	35	8.6
	Episode 2	Anasazi/McPhee/Grass Mesa	940-980	Limited activity/unknown	67	82.1
	Episode 3	Anasazi/Sundial/Marshview	980-1025	Limited activity/unknown	109	65.1
*5MT2160	Element 1	Anasazi/McPhee/unknown	720-840	Seasonal locus/field house	14	0.0
Prince Hamlet						
5MT2161	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	6	100.0
	Element 2	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	8	100.0
	Element 3	Anasazi/McPhee/Periman	840-880	Habitation/large hamlet	10	100.0
	Element 4	Anasazi/McPhee/Periman	880-900	Habitation/large hamlet	315	55.2
	Episode 1	Anasazi/Sundial/unknown	980-1175	Limited activity/unknown	0	0.0
Lone Pine Hamlet						
5MT2162	Element 1	Anasazi/Sagehen/Tres Bobos	700-720	Habitation/small hamlet	7	71.4
	Element 2	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	2	0.0
	Element 3	Anasazi/Sundial/Marshview	1025-1175	Seasonal locus/field house	2	0.0
*5MT2165	Element 1	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	2	0.0
*5MT2166	Element 1	Anasazi/Sagehen/Sagehill	660-700	Habitation/small hamlet	27	0.0
*5MT2169	Element 1	Anasazi/McPhee/Periman	720-800	Habitation/small hamlet	53	0.0
*5MT2170	Element 1	Anasazi/Sagehen/Tres Bobos	720-800	Habitation/small hamlet	22	0.0
*5MT2173	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	2	0.0

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Los Cuartos House						
5MT2174	Element 1	Anasazi/Sagehen/Dos Casas	820-840	Seasonal locus/field house	7	42.0
*5MT2175	Episode 1	Anasazi/Sagehen/unknown	600-1250	Limited activity/unknown	2	0.0
*5MT2180	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	9	0.0
Hamlet de la Olla						
5MT2181	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	43	32.6
	Element 2	Anasazi/McPhee/Periman	840-920	Seasonal locus/field house	53	15.1
	Episode 1	Anasazi/McPhee/unknown	840-980	Limited activity/mortuary	1	100.0
Rio Vista Village						
5MT2182	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	6	100.0
	Element 2	Anasazi/Sagehen/Dos Casas	780-820	Habitation/small hamlet	109	99.1
	Element 3	Anasazi/Sagehen/Dos Casas	800-820	Habitation/small hamlet	67	29.9
	Element 4	Anasazi/McPhee/Periman	840-860	Habitation/village	59	100.0
	Element 5	Anasazi/McPhee/Periman	860-880	Habitation/village	119	69.7
	Element 11	Anasazi/Sagehen/Sagehill	720-840	Habitation/small hamlet	1	100.0
	Element 12	Anasazi/Sagehen/Dos Casas	820-840	Habitation/large hamlet	4	50.0
	Element 13	Anasazi/McPhee/Periman	840-860	Habitation/village	129	72.1
	Element 14	Anasazi/McPhee/Grass Mesa	860-900	Habitation/large hamlet	18	83.3
	Element 21	Anasazi/Sagehen/Dos Casas	820-860	Habitation/small hamlet	5	80.0
	Element 22	Anasazi/McPhee/Periman	860-900	Habitation/village	302	86.1
	Element 23	Anasazi/McPhee/Grass Mesa	880-900	Habitation/small hamlet	30	86.7
	Element 31	Anasazi/McPhee/Periman	860-900	Habitation/village	65	41.5
Little House						
5MT2191	Element 1	Anasazi/McPhee/Periman	840-860	Seasonal locus/field house	165	30.9
	Episode 1	Anasazi/McPhee/Periman	860-880	Limited activity/camp	2	50.0
Pheasant View Hamlet						
5MT2192	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	320	36.2
	Episode 1	Anasazi/McPhee/unknown	800-880	Limited activity/mortuary	1	100.0
	Episode 2	Anasazi/McPhee/unknown	800-880	Limited activity/mortuary	1	100.0
Dos Casas Hamlet						
5MT2193	Element 1	Anasazi/Sagehen/Dos Casas	760-780	Habitation/small hamlet	256	21.1
	Element 2	Anasazi/Sagehen/Dos Casas	760-800	Habitation/small hamlet	297	68.0
Casa Bodega Hamlet						
5MT2194	Element 1	Anasazi/Sagehen/Sagehill	720-840	Habitation/small hamlet	308	19.5
	Element 2	Anasazi/Sagehen/Dos Casas	820-860	Seasonal locus/unknown	56	48.2
Sagehill Hamlet						
5MT2198	Element 1	Anasazi/Sagehen/Sagehill	700-760	Habitation/small hamlet	231	21.6
Horse Bone Camp						
5MT2199	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/camp	2	100.0
	Episode 2	Anasazi/Sagehen/unknown	800-840	Limited activity/unknown	174	24.7
Sheep Skull Camp						
5MT2202	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/storage	407	13.8
	Episode 2	Anasazi/McPhee/unknown	920-980	Limited activity/unknown	46	0.0
Casa Roca						
5MT2203	Element 1	Anasazi/McPhee/Cline	920-940	Seasonal locus/field house	121	49.6

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Moonlight House						
5MT2205	Element 1	Anasazi/McPhee/Periman	880-900	Seasonal locus/field house	62	22.6
*5MT2211	Element 1	Anasazi/Sagehen/Dos Casas	800-840	Habitation/small hamlet	3	0.0
*5MT2212	Episode 1	Anasazi/Sagehen/unknown	600-800	Limited activity/unknown	1	0.0
	Episode 2	Anasazi/Sundial/unknown	920-1250	Limited activity/unknown	0	0.0
*5MT2213	Element unknown	Anasazi/Sagehen/Sagehill	720-800	Seasonal locus/unknown	11	0.0
Sundance Pueblo						
5MT2215	Element 1	Anasazi/Sundial/Escalante	1025-1100	Seasonal locus/unknown	189	43.9
	Episode unknown-other site	Anasazi/Sagehen/unknown	600-1250	Unknown/unknown	150	38.0
*5MT2216	Element 1	Anasazi/Sagehen/unknown	600-920	Habitation/small hamlet	0	0.0
	Element 2	Anasazi/Sundial/unknown	920-1250	Seasonal locus/unknown	0	0.0
Dovetail Hamlet						
5MT2226	Element 1	Anasazi/Sagehen/Dos Casas	820-860	Habitation/small hamlet	149	49.7
	Episode 1	Anasazi/McPhee/Periman	880-920	Limited activity/unknown	0	0.0
Marshview Hamlet						
5MT2235	Element 1	Anasazi/Sundial/Marshview	1100-1175	Seasonal locus/unknown	244	10.2
	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/camp	3	33.3
	Episode 2	Anasazi/Sundial/Marshview	1100-1175	Limited activity/mortuary	1	100.0
	Episode 3	Anasazi/Sundial/Marshview	1100-1175	Limited activity/camp	2	50.0
Horsefly Hamlet						
5MT2236	Element 1	Anasazi/Sagehen/Dos Casas	760-800	Habitation/small hamlet	104	5.8
	Episode 1	Unknown/unknown/unknown	Unknown	Limited activity/unknown	48	6.3
	Episode 2	Anasazi/Sundial/Marshview	980-1175	Limited activity/unknown	0	0.0
Southview House						
5MT2241	Element 1	Anasazi/Sundial/Marshview	1100-1175	Seasonal locus/field house	146	56.8
	Episode 1	Anasazi/Sagehen/Dos Casas	800-840	Limited activity/unknown	497	7.2
Ridgeline Camp						
5MT2242	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/camp	82	14.6
	Episode 2	Archaic/Great Cut/n.a.	Pre-600	Limited activity/camp	98	19.4
	Episode 3	Anasazi/Sagehen/Dos Casas	780-800	Limited activity/unknown	143	14.0
	Episode 4	Anasazi/McPhee/Cline	920-1250	Limited activity/unknown	0	0.0
House Creek Village						
5MT2320	Element 1	Anasazi/McPhee/Periman	860-900	Habitation/village	430	47.2
	Element 11	Anasazi/Sagehen/Dos Casas	840-860	Habitation/small hamlet	0	0.0
	Element 12	Anasazi/McPhee/Periman	860-900	Habitation/village	3	0.0
	Element 21	Anasazi/Sagehen/Dos Casas	800-840	Habitation/large hamlet	9	88.9

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
House Creek Village (cont'd)						
5MT2320	Element 22	Anasazi/McPhee/Periman	820-860	Habitation/village	76	85.5
	Element 31	Anasazi/Sagehen/Dos Casas	820-860	Habitation/large hamlet	0	0.0
	Element 32	Anasazi/McPhee/Periman	860-900	Habitation/village	1	0.0
	Element 61	Anasazi/McPhee/Periman	860-900	Habitation/village	1	0.0
	Element 71	Anasazi/McPhee/Periman	800-920	Habitation/village	1	0.0
Squawbush Hamlet						
5MT2322	Element 1	Anasazi/McPhee/Periman	820-860	Habitation/village	22	36.4
*5MT2335	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	9	0.0
Kin Tl'iish						
5MT2336	Element 1	Anasazi/Sagehen/Dos Casas	780-840	Habitation/small hamlet	62	100.0
	Element 2	Anasazi/McPhee/Periman	820-880	Habitation/small hamlet	18	61.1
	Element 3	Anasazi/McPhee/Periman	840-860	Habitation/small hamlet	118	90.7
	Element 4	Anasazi/McPhee/Cline	920-980	Habitation/large hamlet	22	86.4
	Episode 1	Anasazi/Sundial/Marshview	940-1025	Limited activity/mortuary	0	0.0
	Episode 2	Anasazi/Sundial/Marshview	940-1025	Limited activity/mortuary	2	100.0
	Episode 3	Anasazi/Sundial/Marshview	940-1025	Limited activity/mortuary	0	0.0
Poco Tiempo Hamlet						
5MT2378	Element 1	Anasazi/Sagehen/Tres Bobos	660-700	Habitation/small hamlet	12	100.0
	Element 2	Anasazi/Sagehen/Tres Bobos	700-760	Habitation/small hamlet	115	88.7
	Episode 1	Anasazi/unknown/unknown	720-1250	Limited activity/mortuary	0	0.0
	Episode 2	Anasazi/unknown/unknown	720-1250	Limited activity/mortuary	0	0.0
*5MT2381	Element 1	Anasazi/Sagehen/Sagehill	720-800	Habitation/small hamlet	3	0.0
Paintbrush House						
5MT2729	Element 1	Anasazi/Sundial/Marshview	1025-1175	Seasonal locus/unknown	130	46.9
Casa de Nada						
5MT2731	Element 1	Unknown/unknown/unknown	Pre-600 or post-1250	Seasonal locus/unknown	223	100.0
	Episode 1	Unknown/unknown/unknown	Pre-600 or post-1250	Limited activity/unknown	1	100.0
	Episode 2	Anasazi/unknown/unknown	840-980	Limited activity/unknown	2	100.0
Charred House						
5MT2844	Episode 1	Anasazi/Sagehen/Sagehill	720-800	Limited activity/storage	26	11.5
Rusty Ridge Hamlet						
5MT2848	Element 1	Anasazi/Sagehen/Tres Bobos	660-720	Habitation/small hamlet	24	83.3
	Element 2	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	80	5.0
	Episode 1	Anasazi/Sagehen/Dos Casas	800-820	Limited activity/mortuary	1	0.0
Deer Hunter Hamlet						
5MT2853	Element 1	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	2	50.0
	Element 2	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	38	10.5
	Episode 1	Anasazi/unknown/unknown	800-840	Limited activity/mortuary	1	100.0
Aldea Sierritas						
5MT2854	Element 1	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	62	51.6
	Element 2	Anasazi/Sagehen/Sagehill	780-800	Habitation/small hamlet	505	57.8
	Episode 1	Anasazi/Sagehen/Dos Casas	800-820	Limited activity/unknown	1	100.0
Cansado Camp						
5MT2857	Element 3-other site	Anasazi/Sagehen/Dos Casas	800-820	Habitation/large hamlet	16	0.0

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Apricot Hamlet						
5MT2858	Element 1	Anasazi/Sagehen/Tres Bobos	660-700	Habitation/small hamlet	328	32.6
	Element 2	Anasazi/Sagehen/Sagehill	700-720	Seasonal locus/unknown	23	100.0
	Episode 1	Anasazi/McPhee/Periman	800-880	Limited activity/unknown	0	0.0
McPhee Pueblo						
5MT4475	Element 1	Anasazi/Sagehen/Dos Casas	820-840	Habitation/large hamlet	0	0.0
	Element 2	Anasazi/Sagehen/Dos Casas	840-860	Habitation/large hamlet	0	0.0
	Element 3	Anasazi/McPhee/Periman	860-880	Habitation/village	171	98.2
	Element 4	Anasazi/McPhee/Periman	880-920	Habitation/village	575	91.0
	Element 5	Anasazi/McPhee/Cline	920-940	Habitation/village	236	91.1
	Element 6	Anasazi/McPhee/Cline	940-980	Habitation/village	303	75.2
Masa Negra Pueblo						
5MT4477	Element 1	Anasazi/McPhee/Periman	860-880	Habitation/village	92	100.0
	Element 2	Anasazi/McPhee/Periman	880-920	Habitation/village	468	73.5
	Element 3	Anasazi/McPhee/Cline	920-980	Habitation/large hamlet	68	70.6
Aldea Alfareros						
5MT4479	Element 1	Anasazi/McPhee/Periman	860-900	Habitation/village	605	61.5
Paintbrush Pueblo						
5MT4480	Element 1	Anasazi/McPhee/Periman	860-880	Habitation/village	81	77.8
	Element 2	Anasazi/McPhee/Periman	880-920	Habitation/village	57	64.9
	Element 3	Anasazi/Sundial/Marshview	920-1250	Seasonal locus/unknown	0	0.0
*5MT4505	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	3	0.0
Cascade House						
5MT4512	Element 1	Anasazi/Sagehen/Dos Casas	800-840	Seasonal locus/unknown	372	25.0
Lee Side Camp						
5MT4513	Element 1	Anasazi/Sagehen/unknown	600-840	Habitation/small hamlet	1	0.0
	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	4	0.0
	Episode 2	Anasazi/Sagehen/unknown	600-920	Limited activity/unknown	0	0.0
	Episode 3	Anasazi/Sundial/unknown	920-1250	Limited activity/unknown	0	0.0
*5MT4517	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	6	0.0
*5MT4520	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	4	0.0
*5MT4526	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	6	0.0
Jeddito Camp						
5MT4541	Element 1	Anasazi/Sundial/Marshview	980-1175	Habitation/small hamlet	159	0.0
	Episode 1	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/unknown	0	0.0
Tres Bobos Hamlet						
5MT4545	Element 1	Anasazi/Sagehen/Tres Bobos	600-660	Habitation/small hamlet	629	58.7
	Episode 1	Anasazi/Sagehen/unknown	600-800	Limited activity/mortuary	0	0.0
	Episode 2	Anasazi/Sundial/Marshview	980-1025	Limited activity/unknown	0	0.0
Pozo Hamlet						
5MT4613	Element 1	Anasazi/Sagehen/Sagehill	700-720	Habitation/small hamlet	193	10.4
	Episode 1	Anasazi/McPhee/Periman	920-1250	Limited activity/unknown	1	0.0
Prairie Dog Hamlet						
5MT4614	Element 1	Anasazi/Sagehen/Sagehill	700-760	Seasonal locus/unknown	20	95.0
	Element 2	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	498	27.3
Sunflower Hamlet						
5MT4640	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	35	0.0

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Desecho Camp						
5MT4642	Episode 1	Anasazi/unknown/unknown	720-880	Limited activity/unknown	36	0.0
Windy Wheat Hamlet						
5MT4644	Element 1	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	53	100.0
	Element 2	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	38	81.6
	Element 3	Anasazi/Sagehen/Dos Casas	800-820	Habitation/large hamlet	755	61.5
*5MT4646	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	3	0.0
Roadside Camp						
5MT4649	Episode 1	Anasazi/Sagehen/unknown	720-880	Limited activity/unknown	8	0.0
Hanging Rock Hamlet						
5MT4650	Element 1	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	3	100.0
	Element 2	Anasazi/McPhee/Periman	860-880	Habitation/large hamlet	155	63.2
	Episode 1	Anasazi/McPhee/Periman	880-980	Limited activity/unknown	1	100.0
Calmate Shelter						
5MT4651	Element 1	Anasazi/Sagehen/Sagehill	720-840	Habitation/small hamlet	14	0.0
	Element 2	Anasazi/Sundial/unknown	1025-1250	Seasonal locus/field house	3	0.0
Beaver Trap Shelter						
5MT4654	Element 1	Anasazi/McPhee/Periman	860-900	Habitation/village	1	100.0
	Element 2	Anasazi/McPhee/Cline	900-980	Habitation/village	15	80.0
	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	6	83.3
	Episode 2	Anasazi/Sagehen/unknown	720-920	Limited activity/unknown	1	100.0
	Episode 3	Anasazi/Sundial/unknown	1025-1175	Limited activity/camp	1	0.0
	Episode 4	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/camp	4	100.0
	Episode 5	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/camp	7	85.7
	Episode 6	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/camp	6	83.3
	Episode 7	Historic/historic/n.a.	Post-1250	Limited activity/camp	6	66.7
Periman Hamlet						
5MT4671	Element 1	Anasazi/Sagehen/Dos Casas	780-800	Habitation/small hamlet	0	0.0
	Element 2	Anasazi/Sagehen/Dos Casas	800-820	Habitation/small hamlet	934	47.6
	Element 11	Anasazi/Sagehen/Dos Casas	800-820	Habitation/small hamlet	492	36.6
	Element 12	Anasazi/Sagehen/Dos Casas	780-840	Habitation/small hamlet	145	14.5
	Element 13	Anasazi/McPhee/Periman	820-880	Seasonal locus/field house	13	46.2
	Episode 1	Unknown/unknown/unknown	Post-1250	Limited activity/unknown	1	100.0
Hawk House						
5MT4681	Element 1	Anasazi/Sagehen/unknown	720-880	Seasonal locus/field house	90	37.8
Climbing Cactus Camp						
5MT4682	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	0	0.0
	Episode 2	Anasazi/Sundial/unknown	920-1250	Limited activity/unknown	75	0.0
Singing Shelter						
5MT4683	Element 1	Anasazi/Sagehen/Tres Bobos	600-800	Unknown/unknown	1	0.0
	Element 2	Anasazi/Sagehen/Sagehill	720-780	Habitation/small hamlet	1	0.0
	Element 3	Anasazi/Sagehen/Dos Casas	820-840	Habitation/small hamlet	178	97.8
	Element 5	Anasazi/Sundial/Marshview	1025-1175	Seasonal locus/field house	48	45.8
	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	2	100.0
	Episode 2	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/unknown	0	0.0

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Chindi Hamlet						
5MT4684	Element 1	Anasazi/Sagehen/Tres Bobos	660-700	Habitation/small hamlet	101	99.0
	Element 2	Anasazi/Sagehen/Tres Bobos	660-700	Habitation/small hamlet	259	39.0
	Episode 1	Anasazi/Sagehen/Dos Casas	800-880	Limited activity/mortuary	1	100.0
	Episode 2	Anasazi/Sagehen/Dos Casas	800-880	Limited activity/mortuary	1	0.0
	Episode 3	Anasazi/Sagehen/Dos Casas	800-880	Limited activity/mortuary	1	0.0
Kangaroo Camp						
5MT4690	Episode 1	Archaic/Great Cut/n.a.	Pre-600	Limited activity/unknown	128	0.0
Tres Chapulines Pueblo						
5MT4725	Element 1	Anasazi/McPhee/Periman	840-860	Habitation/village	19	15.8
	Element 2	Anasazi/McPhee/Periman	860-880	Habitation/village	20	5.0
	Element 3	Anasazi/McPhee/Periman	880-900	Habitation/village	32	12.5
*5MT4744	Element unknown	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	9	0.0
Pinyon House						
5MT4751	Element 1	Anasazi/Sundial/Marshview	1100-1175	Seasonal locus/unknown	123	22.8
*5MT4760	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	4	0.0
Faraway House						
5MT4763	Episode 1	Anasazi/unknown/unknown	720-920	Limited activity/storage	95	7.4
*5MT4769	Element unknown	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	8	0.0
*5MT4777	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	7	0.0
Dos Piedras Camp						
5MT4779	Episode 1	Anasazi/Basketmaker III-Pueblo I/unknown	840-880	Limited activity/unknown	22	13.6
	Episode 2	Anasazi/Basketmaker III-Pueblo I/unknown	600-980	Limited activity/unknown	36	0.0
Quasimodo Cave						
5MT4789	Episode 1	Anasazi/Sundial/unknown	920-1250	Limited activity/storage	56	48.2
*5MT4796	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	21	0.0
Cougar Springs Cave						
5MT4797	Element 1	Archaic/Cougar Springs/n.a.	Pre-600	Limtied activity/unknown	108	62.0
*5MT5094	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	3	0.0
*5MT5096	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	7	0.0
Willow Flat Pueblo						
5MT5104	Element 1	Anasazi/McPhee/Periman	860-880	Habitation/village	2	100.0
	Element 2	Anasazi/McPhee/Periman	880-900	Habitation/village	140	30.7
Weasel Pueblo						
5MT5106	Element 1	Anasazi/McPhee/Periman	840-880	Habitation/village	37	100.0
	Element 2	Anasazi/McPhee/Periman	880-900	Habitation/village	242	86.0
	Element 3	Anasazi/Sundial/Marshview	1025-1175	Seasonal locus/unknown	18	77.8
	Element 4	Anasazi/Sundial/Marshview	1100-1250	Seasonal locus/unknown	18	61.1

Table 1.13 – Temporal-spatial assignments for the Dolores Archaeological Program excavated data base – Continued

Site name Site No.	Element/ episode No.	Tradition/phase/ subphase	Period (A.D.)	Site type/subtype	No. of FS's	Percent of FS's troweled or screened
Pueblo de las Golondrinas						
5MT5107	Element 1	Anasazi/Sagehen/Sagehill	760-780	Habitation/small hamlet	4	75.0
	Element 2	Anasazi/Sagehen/Dos Casas	800-840	Habitation/village	17	76.5
	Element 3	Anasazi/McPhee/Periman	840-880	Habitation/village	253	81.0
	Element 4	Anasazi/McPhee/Periman	880-900	Habitation/village	23	30.4
	Episode 1	Anasazi/Sundial/unknown	1025-1100	Limited activity/unknown	0	0.0
Golondrinas Oriental						
5MT5108	Element 1	Anasazi/McPhee/Periman	860-880	Habitation/village	1	0.0
	Element 2	Anasazi/McPhee/Periman	880-900	Habitation/village	204	84.8
	Episode 1	Anasazi/unknown/unknown	880-1250	Unknown/unknown	1	0.0
*5MT5361	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	2	0.0
Star Bead Shelter						
5MT5380	Episode 1	Anasazi/unknown/unknown	920-1250	Limited activity/unknown	0	0.0
	Episode 2	Protohistoric/Beaver Point/n.a.	Post-1250	Limited activity/mortuary	10	80.0
Los Atavios						
5MT5399	Episode 1	Protohistoric/Beaver Point/n.a.	Post-1250	Other/other	3	33.3
Nuthatch Hamlet						
5MT5863	Element 1	Anasazi/Sagehen/Sagehill	720-760	Habitation/small hamlet	23	82.6
	Element 2	Anasazi/Sagehen/Dos Casas	820-880	Habitation/village	28	0.0
	Element 3	Anasazi/McPhee/Periman	840-880	Habitation/village	27	0.0
Standing Pipe Hamlet						
5MT5985	Element 1	Anasazi/unknown/unknown	600-840	Habitation/small hamlet	3	33.3
	Episode 1	Anasazi/McPhee/unknown	600-880	Limited activity/mortuary	1	100.0
Lone Aspen Camp						
5DL444	Episode 1	Anasazi/Sagehen/camp	600-840	Limited activity/unknown	18	100.0
	Episode 2	Anasazi/unknown/unknown	800-880	Limited activity.unknown	6	83.3
	Episode 4	Unknown/unknown/unknown	Post-1250	Seasonal locus/unknown	20	100.0
* 5DL445	Episode 1	Anasazi/unknown/unknown	600-1250	Limited activity/unknown	3	0.0
* 5DL446	Episode 1	Unknown/unknown/unknown	Unknown	Limited activity/unknown	4	0.0
River Rat Rockshelter						
5DL452	Episode 1	Anasazi/McPhee/unknown	920-1250	Limited activity/unknown	11	54.5

* These sites were not given names.
FS's – Field specimens.
n.a. – Not applicable.

and architectural and stratigraphic relationships. The site type column is based on Kane's architectural typology (1983). The subtype assignments associated with site type are defined in Kane (1983:19-23, chap. 5). Small hamlets are composed of 1 to 3 household clusters. Large hamlets incorporate 4 to 8 household clusters and several pitstructures interpreted to be shared facilities. Villages usually consist of more than 20 household clusters arranged in 5 or more roomblock units. Field houses consist of small clusters of living and storage units probably associated with agricultural activities. Field houses probably served as bases away from habitations. Mortuary refers to burial events. Camps refer to nonarchitectural sites occupied for short periods of time. The total number of collection units or FS (field specimen) numbers per unit and the percentage of those units subjected to screening or troweling collection modes are presented last in table 1.13; screened or troweled contexts are those that represent DAP assemblage mode collections (Kane and Robinson 1984). These are controlled collections because they represent a known volume or areas from well defined archaeological contexts.

Table 1.14 presents the labor expended on the Dolores Archaeological Program excavated data base. Table 1.14 list the general location of the cultural resources mitigated at a Track 1 or 2 level of investigation. The column labeled "full site equivalent" is the best estimate of the labor that would be necessary to fully investigate any given site in the excavated data set. One FSE (full site equivalent) is equal to the labor output of one 10-person crew for a 40-hour work week. FSE values were calculated for all of the resources in the Dolores Project pool area and for Reach 1 of the Dove Creek Canal (Knudson et al. 1985) because the DAP could not convince the Bureau of Reclamation of the value of the FSE estimation, given the Bureau of Reclamation's concern about the DAP collecting redundant information. The "Crew weeks expended" column in table 1.14 is an accounting of the amount of time actually spent by a 10-person crew working a 40-hour work week for each site in the Dolores Project excavated data set.

Summary of Mitigation Efforts on the Dolores Archaeological Program Excavated Data Base

King (1984:5) indicates that 33 percent of the resources in the pool area have been mitigated and 19 percent of the resources in the pool have been intensively investigated. King's percentages are derived by counting sites and calculating the appropriate percentages. However, if the number of FSE's and crew weeks are compared for the pool area, the number of crew weeks expended composes about 12 percent of the FSE's at sites subjected to a Track 1 or Track 2 level of investigation.

Table 1.14 – Labor expended on the Dolores Archaeological Program excavated data base

Site No.	General project location	Full site equivalent	Crew weeks expended
5MT23	Pool	1550	95
5MT2151	Pool	16	11
5MT2160	Pool	4	<1
5MT2161	Pool	38	9
5MT2162	Takeline	14	<1
5MT2165	Pool	10	<1
5MT2166	Pool	10	<1
5MT2169	Pool	10	<1
5MT2170	Pool	10	<1
5MT2173	Pool	5	<1
5MT2174	Pool	2	<1
5MT2175	Pool	4	<1
5MT2180	Pool	4	<1
5MT2181	Pool	18	2
5MT2182	Pool	252	34
5MT2191	Pool	4	3
5MT2192	Takeline		8
5MT2193	Takeline		9
5MT2194	Takeline		3
5MT2198	Takeline		5
5MT2199	Takeline		1
5MT2202	Pool	10	5
5MT2203	Pool	3	3
5MT2205	Takeline		<1
5MT2211	Pool	16	<1
5MT2212	Pool	10	<1
5MT2213	Pool	11	<1
5MT2215	Pool	10	6
5MT2216	Pool	18	<1
5MT2226	Pool	12	2
5MT2235	Pool	10	7
5MT2236	Pool	22	<1
5MT2241	Pool	5	2
5MT2242	Takeline		5
5MT2320	Takeline		14
5MT2322	Pool		<1
5MT2335	Pool	4	<1
5MT2336	Pool	76	14
5MT2378	Outside takeline	15	3
5MT2381	Takeline		<1
5MT2729	Takeline		1
5MT2731	Takeline		<1
5MT2844	Takeline		<1
5MT2848	Takeline		<1
5MT2853	Takeline		<1
5MT2854	Takeline		12
5MT2857	Takeline		<1
5MT2858	Takeline		6
5MT4475	Pool	310	31
5MT4477	Pool	106	16
5MT4479	Pool	14	13

Table 1.14 – Labor expended on the Dolores Archaeological Program excavated data base – Continued

Site No.	General project location	Full site equivalent	Crew weeks expended
5MT4480	Pool	110	8
5MT4505	Takeline		<1
5MT4512	Pool	8	10
5MT4513	Takeline		<1
5MT4517	Outside takeline		<1
5MT4520	Takeline		<1
5MT4526	Outside takeline		<1
5MT4541	Takeline		<1
5MT4545	Takeline		5
5MT4613	Pool	12	<1
5MT4614	Pool	12	6
5MT4640	Takeline		<1
5MT4642	Takeline		<1
5MT4644	Takeline		12
5MT4649	Takeline		<1
5MT4650	Pool	30	5
5MT4651	Pool	10	<1
5MT4654	Pool	5	<1
5MT4671	Pool	40	31
5MT4681	Pool	4	3
5MT4682	Pool	6	<1
5MT4683	Pool	32	13
5MT4684	Pool	14	4
5MT4690	Pool	3	<1
5MT4725	Pool	66	3
5MT4744	Takeline		<1
5MT4751	Takeline		2
5MT4760	Pool	10	<1
5MT4763	Pool	1	<1
5MT4769	Pool	8	<1
5MT4777	Pool	5	<1
5MT4779	Takeline		<1
5MT4789	Pool	2	<1
5MT4796	Pool	10	<1
5MT4797	Pool	8	2
5MT5094	Pool	6	<1
5MT5096	Pool		<1
5MT5104	Pool	16	1
5MT5106	Pool	56	4
5MT5107	Pool	60	17
5MT5108	Pool	46	2
5MT5361	Pool	4	<1
5MT5380	Takeline		<1
5MT5399	Takeline		<1
5MT5863	Outside takeline		1
5MT5895	Takeline		<1
5DL444	Outside takeline		<1
5DL445	Outside takeline		<1
5DL446	Outside takeline		<1
5DL452	Outside takeline		<1

When the total number of FSE's for the pool area is considered, N = 4582 (Knudson et al. 1985), then the total amount of crew weeks expended amount to about 8 percent of the pool FSE's. These figures differ radically from King (1984:5) and the reader will have to assess the value of each approach. The point is that most methods used to assess mitigative efforts employ methods that simplify rather than express the complexity of a resource base. The DAP has attempted to generate a mechanism that more accurately represents the resource base and the mitigative effort expended on that resource base.

ORGANIZATION OF THIS VOLUME

This volume consists of 4 parts. This chapter, part I, is an overview of the DAP. It includes a brief history of the program and a summary of DAP organization. Part II consists of 3 chapters (additive and reductive technologies and environmental archaeology) that address the problem domains in the general research design from the viewpoint of material culture. Part III is a summary of the culture history of the Dolores area that also addresses the problem domains in the general research design. Because the DAP made a conscious decision to focus its efforts on the Culture Process problem domain of the general research design, part IV of this volume centers around the program's effort to model Anasazi culture change from A.D. 600 to 980. The main body of the volume is followed by 4 appendixes. Appendix A consists of a listing of all of the absolute dates from sites excavated by the DAP. Appendix B contains abstracts from all of the reports that describe site excavations. Appendix C is a complete bibliographic listing of all reports, published papers, meeting papers, theses and dissertations produced by, or in conjunction with, the program. Appendix D discusses an alternative approach to resource mix.

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PART II

Chapter 2

ADDITIVE TECHNOLOGIES GROUP FINAL REPORT

Eric Blinman

INTRODUCTION

The ATG (Additive Technologies Group) has been responsible for analyses of prehistoric worked vegetal and ceramic materials recovered during the excavations and surveys of the DAP (Dolores Archaeological Program). These analyses have included supportive and intensive studies as well as the generation of inventories and basic descriptive data in support of field reports. Data have been gathered within the broad framework of the DAP research design (Kane et al. 1983) and the more specific ATG research design (Blinman 1983a). Analysis procedures, definitions, and evaluations of reliability of the resultant data sets are provided in the ATG laboratory manual (Blinman et al. 1984).

Worked Vegetal Materials

This category of materials is extremely diverse. It includes any artifact (culturally modified item) that is neither ceramic, stone, or bone. While the vast majority of these artifacts are vegetal in material class, some are only partially vegetal, and a few consist partially or wholly of hair or feathers. These items are rare in DAP collections due to their usually perishable nature and to the generally unfavorable conditions for preservation of perishable materials within the archaeological contexts of the Dolores Project area.

Worked vegetal materials were identified as such either in the field or in the laboratory. Those items requiring immediate efforts to stabilize their condition were given cursory examinations and characterizations and were turned over to Bureau of Land Management personnel for conservation. Items that were judged to be relatively stable were transmitted from the field to the Botanical Studies Section of the Environmental Studies Group for material identification and inventory. An identification number (sometimes referred to as an RV number) was assigned to each unique worked vegetal item at the time of this analysis by the ATG and was reported to the Botanical Studies Section. This number and a brief descriptive label are appended to data lines in the botanical data file that describe the material component or components of the item.

After the completion of botanical analysis and after stabilization where required, worked vegetal materials were turned over to the ATG for description. Description consisted of observations of artifact form and technology of manufacture. Due to the diversity of this artifact category and the relative scarcity of worked vegetal items, the only computerized data are the brief descriptive labels in the botanical data file. The ATG descriptions exist as written records and are curated by the Bureau of Land Management, Anasazi Heritage Center.

Ceramic Materials

Ceramic materials consist of fired pottery, other artifacts of clay, and clay as a raw material. These materials constitute the largest single class of artifacts recovered by the DAP, and they have been the primary focus of ATG effort. After field recovery, ceramic materials were cleaned in the processing lab and transmitted to the ATG. Inventory analysis (preliminary analysis) was completed, data were computerized, and materials were submitted to the Bureau of Land Management for curation. Subsequent to inventory analyses, subsets of ceramic materials were recalled from Bureau of Land Management storage for intensive analyses in support of specific research projects required as part of the DAP and ATG research designs.

Inventory analysis consisted of recording selected resource attributes, aspects of production technology, traditional typological affiliation, artifact form, and measures of quantity (counts and weights). Although explicitly sherd based in design, considerable effort was also expended to identify and, in some cases, to reconstruct vessels within the sherd collections. Emphasis was placed on those aspects of pottery useful for studies of exchange and for support of chronological inferences. Data were computerized to facilitate manipulation for descriptive

field reports, for inventory control, and for the design of intensive analyses. Editing and modification of preliminary analysis data have been continuous throughout the course of the DAP, resulting in more accurate data but also producing occasional inconsistencies between reports of early and late vintages.

Intensive analyses have fallen into 4 broad categories. Calibrations of ceramic change have provided basic support for the ceramic dating inferences used in descriptive reporting and DAP synthetic studies. Functional studies have used DAP reconstructible vessels as a basis for inferring subsistence technology and organization. Production studies have: (1) collected data on clay resource availability within the Dolores Project area; (2) characterized resources, unfired clays from archaeological contexts, and finished ceramics; and (3) evaluated technological and social aspects of pottery manufacture. Finally, studies of exchange have attempted to address questions of social and economic interactions on the basis of patterns of clay and temper occurrences in archaeological collections.

WORKED VEGETAL MATERIALS

Worked vegetal materials represent a residual class of artifacts, and these materials are both scarce and diverse. Although more than 300 items fall into this artifact class, their numbers are relatively insignificant compared with the DAP artifacts of ceramic and stone materials (more than 1 million). The descriptions that follow are based on complete analyses of 283 items. Descriptions of the remaining items were incomplete at the time data were assembled for this volume as a result of scheduling conflicts between conservation, botanical analysis, and ATG analysis. The scarcity of worked vegetal materials is directly related to the generally poor conditions for preservation of perishable materials characteristic of most sites in the Dolores area. Rockshelters suitable for habitation are rare in the Dolores Project area, and most habitation sites are in open settings. As a result, the majority of worked vegetal materials encountered by DAP excavations are preserved only as carbonized fragments. Several relatively dry rockshelters have been excavated, but only 2 of these sites have yielded significant amounts of uncarbonized items.

The diversity of the worked vegetal materials is, in part, the consequence of their residual nature in relation to the analytic systems devised for the more abundant material classes of artifacts (Phagan and Hruby 1984; Blinman et al. 1984). Worked vegetal materials include items that are undeniably cultural in origin (e.g., basketry), materials not modified but undoubtedly cultural, based on their archaeological context (e.g., grass linings of cysts), and materials whose modification is minimal or equivocal (e.g., "shaped" sticks). Occasional faunal materials (e.g., modified feathers) are also included for a lack of a more appropriate administrative pigeon-hole.

This diversity of materials and forms has precluded a consistent descriptive approach for the entire material class. Instead, analysis has focused on individual description of form, technology, and material, with an effort to maintain consistency of observations between similar items. This approach has been most successful for large subsets of the class (e.g., cordage and basketry classes). The contents of these larger subsets are most amenable to comparisons with other Southwestern archaeological collections, and these subsets will be emphasized in this summation.

Basketry

Approximately half of the worked vegetal materials are woven or are raw materials probably intended for use in weaving. Most of these represent rigid or semirigid forms (basketry [Adovasio 1977:1]) with few items flexible enough to be considered textiles (Kent 1983:7). Three classes of basketry can be defined on the basis of gross technique (plaiting, coiling, and twining), and all three classes are represented in DAP collections. In addition, netting is considered within the basketry category.

Plaited Basketry

This class of basketry includes those weaves in which all elements can be described as active (Adovasio 1977:99). In all DAP examples, elements of the weave simply cross each other, with no material or size differentiation between the 2 weave directions. Plaiting in DAP collections is executed exclusively in yucca leaves or leaf strips (primarily *Yucca bacatta* but some examples could be *Yucca angustissima*), and plaited items exhibit a restricted number of weaves and forms. Twill plaiting (2/2 interval) is the most common variety of weave (18 examples), with only a few items (3 examples) of simple plaiting (1/1 interval, or checker weave). In 2 specimens, the weave interval could not be determined due to poor preservation. In only 1 case was the element crossing significantly different than 90°. Form edges are present in 16 examples, and are predominantly simple 90° self selvages. Single examples of coiled and braided 90° self selvages are present, as are several examples of twining reinforcement of selvages.

Two plaited forms are definitely present in the DAP collections, and other forms may be present. Six definite and 5 probable sandals have been recovered from

2 rockshelters (Sites 5MT2151 and 5MT4683). None of the examples is carbonized, and a wide range of completeness and workmanship is represented (figs. 2.1 and 2.2). Mean element width varies from 2.1 to 15.7 mm, and although most sandals are executed with a 2/2 interval twill as the dominant plaiting pattern, 1 example is irregular. Loops of yucca leaf strips or yucca fiber cordage at the selvage or through the body of the weave appear to have served as anchor points to tie the sandals to the foot. Wear was relatively extensive on the examples. All of the sandals are attributable to the relatively small-scale post-A.D. 920 occupation of the Dolores Project area and are associated with seasonal or small habitations.

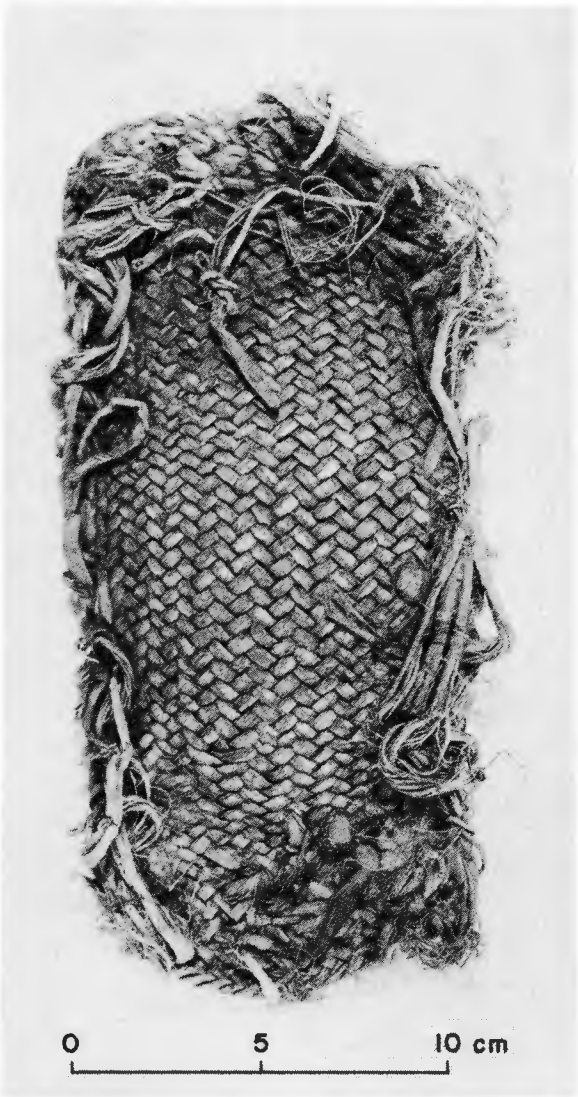

Figure 2.1 – Fine plaited yucca leaf sandal (RV 9) from Singing Shelter (Site 5MT4683) (DAP 160004).

The second definite plaited form is a single ring basket (RV 39) recovered from Pitstructure 10 at Grass Mesa Village (Site 5MT23). This ring basket (fig. 2.3) was preserved by the burning of the structure and its contents, and the basket is part of a relatively large assemblage of basketry that dates to A.D. 870-880 (Lightfoot et al. 1985). The yucca strips (mean width 4.8 mm) are plaited within a wooden (unidentified Dicotyledoneae) ring and the selvage is reinforced with at least 1 row of twined yucca strips. A shift in the plaiting interval from 2/2 to 2 rows of 3/2 constitutes an intentional band design through the center of the basket. When found, the basket supported a pile of shelled corn and a small Moccasin Gray jar.

The remaining plaited items in the DAP assemblage are too fragmentary to classify as to specific form. Many of these examples are similar to 1 or more of the sandals in element width or selvage characteristics, and they could be examples of that form. However, plaiting is a common technique used for matting (Adovasio 1977:122), and the fragment characteristics are compatible with this form as well. None of the selvage examples is similar to the ring basket, and none of the indeterminate items is likely to be from this type of form. Dates for these indeterminate fragments range from A.D. 660 to A.D. 920, but most are from A.D. 840-920 contexts.

In addition to the plaited basketry, 14 examples of yucca leaves or strips were recovered that could be either raw material for plaited basketry or disassociated elements from plaited items. Half of these examples were recovered from deposits of the 2 rockshelters, are uncharred, and appear to be raw material. The remainder are charred, and though some raw material may be represented, the individual items tend to be small and more of the examples appear to be disassociated from once complete plaited forms.

Coiled Basketry

Coiled basketry is the most abundant of the basketry classes, with 56 examples in DAP collections. Coiled forms are constructed by sewing a continuous horizontal, or foundation, element in concentric rings or coils (Adovasio 1977:53). Individual examples range from nearly complete, but carbonized and poorly preserved, specimens to specimens represented only by 1 or more sewing elements recovered from flotation samples. None of the DAP examples was recovered from rockshelter deposits, and all are charred. More than half of the items are too fragmentary to describe the type of foundation used, and 4 techniques of close coiling used in DAP coiled basketry consist of rods of squawbush (*Rhus aromatica*) wood and a single example of rabbitbrush (*Chrysothamnus*) wood.

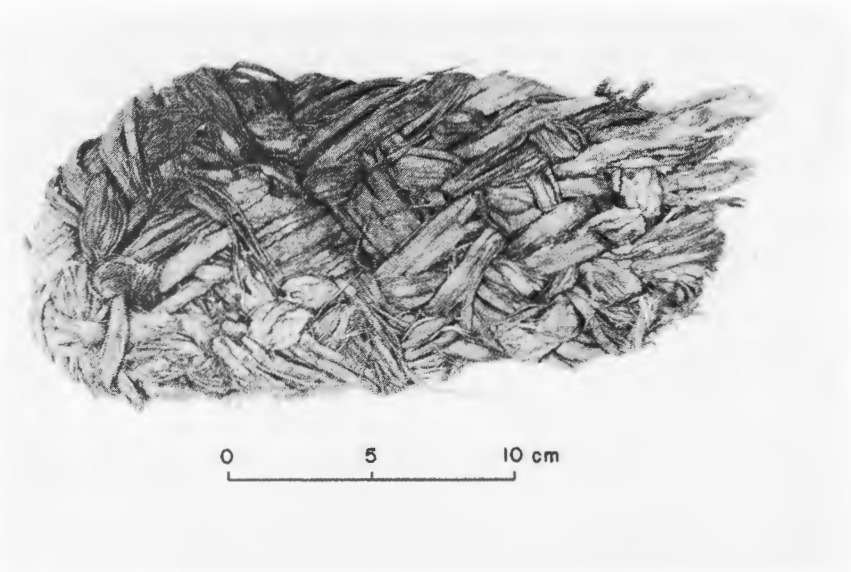

Figure 2.2 – Coarse plaited yucca leaf sandal (RV 18) from Singing Shelter (Site 5MT4683) (DAP 160003)

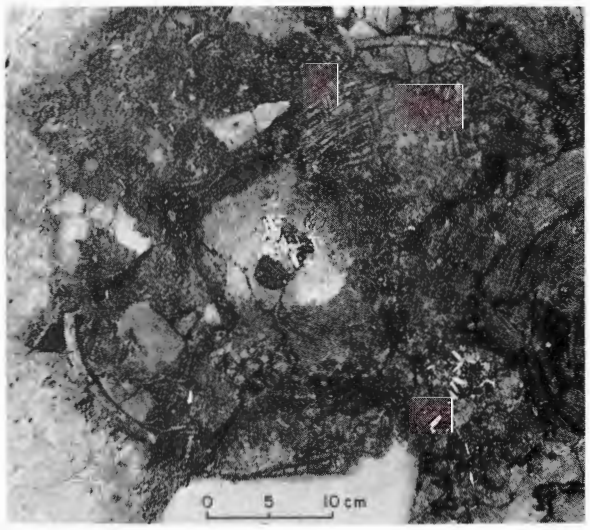

Figure 2.3 – Plaited ring basket (RV 39) from Pitstructure 10, Grass Mesa Village (Site 5MT23). Intact portions of the ring can be seen in the upper right and lower left corners of the photograph, and the largest area of preserved plaiting is visible in the upper right. Ears of corn and portions of a large coiled basketry bowl are also visible (DAP 161703).

Welts consist of yucca leaf strips or rarely of retted yucca fiber cordage, and the rare bundles consist of retted yucca fiber. Sewing elements are almost exclusively prepared from squawbush stems. The single exception is a basket represented by 2 thin strips of yucca leaf that have the curvature and length associated with broken fragments of coiled basketry sewing elements.

Although 4 types of coiling are represented in the collection (fig. 2.4), 22 of the 26 specimens that could be analyzed are of a single type. These specimens have a bunched foundation of 2 rods and a welt. The rods are usually split squawbush stems and are usually not decorticated. Most of the welts are thin strips of yucca leaf, but a thin 2-ply yucca fiber cord may have been used in 1 specimen. The foundations are joined by simple, noninterlocking, unsplit stitches that usually encircle, but occasionally pierce, the welt of the previous coil. Coil height ranges from 3.2 to 7.0 mm (mean = 5.4 mm), stitch width ranges from 1.2 to 2.0 mm (mean = 1.7 mm), and stitch frequency ranges from 1.8 to 6.4 stitches/cm (mean = 4.6 stitches/cm). Preserved and observable splices of the sewing elements are rare due to the fragmentary nature of the specimens, but moving ends are commonly bound under, and fag ends are either bound under or clipped short. Splice techniques of coiled basket weavers are described as being highly individualistic (Adovasio 1977:90), but too few observations can be made on individual specimens to evaluate splice variation within the DAP collection.

Two DAP specimens have a bunched two rod and bundle foundation (fig. 2.4). In both cases, the rods are split squawbush stems and the bundle is retted yucca fiber. Stitches are simple, noninterlocking, and unsplit, and each stitch pierces the bundle of the preceding coil. Mean coil heights for the 2 examples are 4.5 and 5.2 mm, mean stitch widths are 1.1 and 1.4 mm, and mean stitch frequencies are 5.1 and 7.1 stitches/cm. Splices are observable on only 1 specimen; both moving and fag ends are bound under.

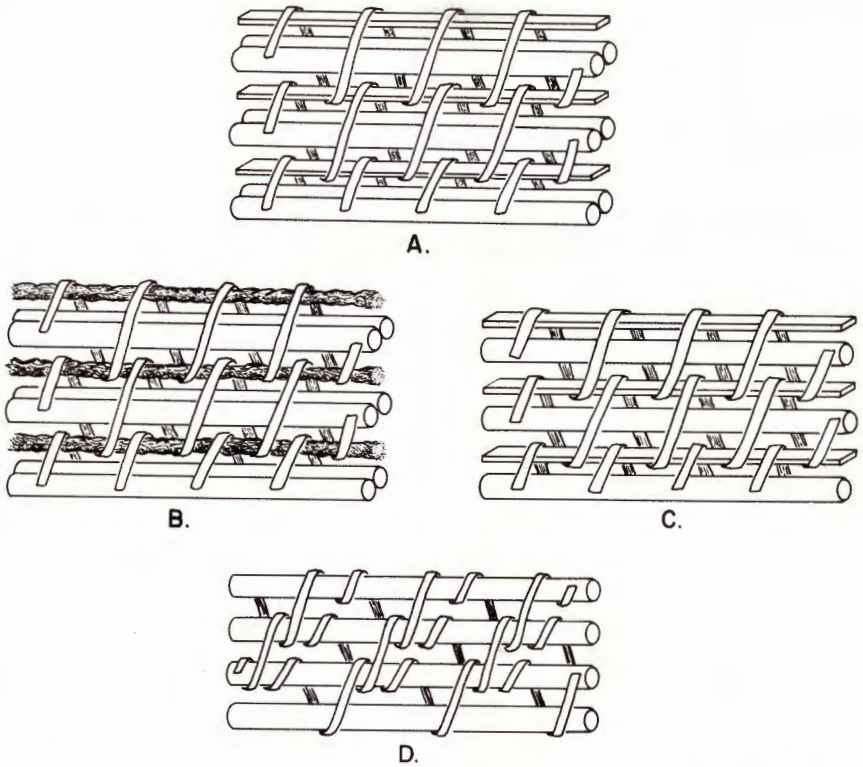

Figure 2.4 – Styles of foundations and stitching patterns in Dolores Archaeological Program coiled baskets: (a) two rod and welt, noninterlocking stitch; (b) two rod and bundle, noninterlocking stitch; (c) single rod and welt, noninterlocking stitch; and (d) single rod, interlocking stitch and wrap.

The remaining 2 coiling types (fig. 2.4) are represented by a single specimen each. One is based on a single rod and welt foundation. Stitches are simple, noninterlocking, unsplit, and encircle the rod of the preceding coil. Mean coil height is 6.0 mm, mean stitch width is 2.3 mm, and there are 2.7 stitches/cm. One fag end is visible and is bound under. The last coiling type is based on a single rod foundation with unsplit interlocking stitches that alternate encircling the previous foundation rod and wrapping the current foundation rod. Mean coil height is 3.5 mm, mean stitch width is 2.7 mm, and there are 2.5 stitches/cm. No splices are visible on this specimen.

Coiled basketry forms are difficult to reconstruct for DAP collections due to the fragmented nature of the remains. In 8 cases, sufficient portions of baskets were preserved to described the relative relationship between basket base and wall. In 3 cases, no clear distinction could be made between base and wall of the items, suggesting they were shallow bowls in form. Two of the items appear to have been 30 cm or greater in original diameter, and one may have been 15 cm in diameter. In 5 cases, a juncture between base and wall could be identified based on changes in the rate of coil curvature from the center of the specimen outward, suggesting a deep or steep-sided bowl form. Estimated base diameters were 15 cm, 20 cm, and 20-30 cm for 3 specimens; one relatively well preserved specimen had an 11-cm-diameter base and an 8-cm-high wall, and no estimate could be made for the base diameter of the fifth item. In all cases where form could be identified, the foundation types other than 2 rod and welt were used to create deep bowl forms.

The temporal distribution of DAP coiled baskets spans the A.D. 660-980 period, but most were recovered from contexts dating between A.D. 860-920. Two rod and welt foundations are ubiquitous throughout the entire period, and all of the minority foundations occur in a single assemblage (Pitstructure 10 at Site 5MT23) dating to A.D. 870-880. The preponderance of 2 rod and welt foundations in DAP collections is compatible with the temporal patterns in coiled basketry technology perceived by Morris and Burgh (1941:13), assuming that 2 rod and welt foundations were subsumed within their 2 rod and bundle category.

Morris and Burgh perceived a tendency for stitch width to vary through time, with the finer stitch widths occurring in later (Pueblo III) assemblages (1941:12). This, coupled with the claim that basketry is "as precise a time

marker as any other artifact class" (Adovasio and Gunn 1977:139), prompted an investigation into temporal variation within technological aspects of the DAP coiled basketry assemblage. The only measurements consistently observable within the DAP specimens were mean coil height, mean stitch width, and mean stitch frequency (3 of the 4 motor skill measurements used in previous studies of variation in coiled basketry from ethnographic and archaeological collections [Adovasio and Gunn 1975:73, 1977:140]). These measurements were assembled for all DAP 2 rod and welt foundation baskets, the measurements were grouped by time period, and the data were submitted to a discriminant analysis (SPSS [Klecka 1975]).

Two cases were assigned to the A.D. 660-720 period, 1 case was assigned to the A.D. 720-800 period, 6 cases were assigned to the A.D. 840-880 period, and 6 cases were assigned to the A.D. 880-920 period. These samples are small and the temporal representation is discontinuous, but the data do provide a test of the potential resolution of temporal change in these attributes. *F* statistics and the significance of the differences between the temporal groups are presented in table 2.1. The only 2 groups for which the observed differences are unlikely to be due to chance are the A.D. 660-720 and 720-800 periods. A plot of the discriminanat scores of the cases for functions 1 and 2 is presented in figure 2.5, and the scatter characteristics reinforce the minimal nature of the distinctions evident in the *F* statistics. Classification based on the discriminant functions resulted in assignment of only 33.3 percent of the cases to their correct groups.

Interpretation of the results of the discriminant analysis is limited somewhat by the small samples involved, but no suggestion of precise temporal resolution is inherent in the variation in the motor skill measurements taken. This implies that: (1) no temporal variation occurs in the measured attributes; (2) the variation is not significant at the scale of the time intervals used to group the DAP collections; or (3) the temporal variation is too inconsistent to be distinguished with the small samples available from DAP collections.

Analyses by Adovasio and Gunn (1975, 1977) suggested that individual weavers and their skill levels may provide another possible source of variation in the measured attributes. Spatially coherent groups of coiled baskets from excavations at Antelope House in Canyon de Chelly, Arizona, were validated by discriminant analysis, supporting the contention that the spatial groups represented the products of discrete weavers or groups of weavers that shared motor habits (presumable as a result of learning patterns of interaction frequency). The conditions of preservation of coiled baskets in DAP collections tend to result in cluster samples, with the recovery of multiple items from single structure floors. This allows the baskets

Table 2.1 – *F* statistics and significances of differences between temporal groupings of 2 rod and welt coiled baskets.

Time period (A.D.)	660-720	720-800	840-880
720-800	3.72 (0.06)		
840-880	2.72 (0.11)	0.95 (0.42)	
880-920	2.70 (0.12)	0.90 (0.44)	0.08 (0.93)

Probabilities are expressed in parentheses below *F* values. Probabilities reflect the likelihood that the observed differences between the groups could be the result of chance, given the variability observed within the groups being compared. Differences are regarded as potentially significant if the listed probability is less than 0.10.

to be grouped as assemblages that are contemporary, and the spatial association within a structure allows their interpretation as the property, if not the handiwork, of individuals or households.

The motor skill data from the DAP coiled baskets were used in a second discriminant analysis, but this time the data were grouped by structure provenience. Two of the structures contained single 2 rod and welt baskets, 2 structures contained 2 such baskets, and 3 structures contained 3 baskets. *F* statistics and significances for the differences between the groups are presented in table 2.2. Five of the 21 possible pairings of groups have a probability of less than 0.1 of being different solely on the basis of chance. This does not represent a strong discrimination of proveniences, but is stronger than the differences identified between the temporal groupings.

The scatter plot of the 2 discriminant function scores for the cases (fig. 2.6) portrays the cases and the centroids for the groups. Although overlap is evident, a much better separation of the groups occur than was true of the temporal scatter plot (fig. 2.5). Subsequent classification results based on the discriminant functions produced correct classifications 66.7 percent of the time, also somewhat better than the temporal functions. These results (moderately successful discrimination) are similar to those achieved in the analysis of the Antelope House basketry (Adovasio and Gunn 1975, 1977).

These findings demonstrate that basketry items used within a single household context will tend to be more similar to each other than they will be to basketery items from other households. This probably reflects the association of a household assemblage with a single weaver

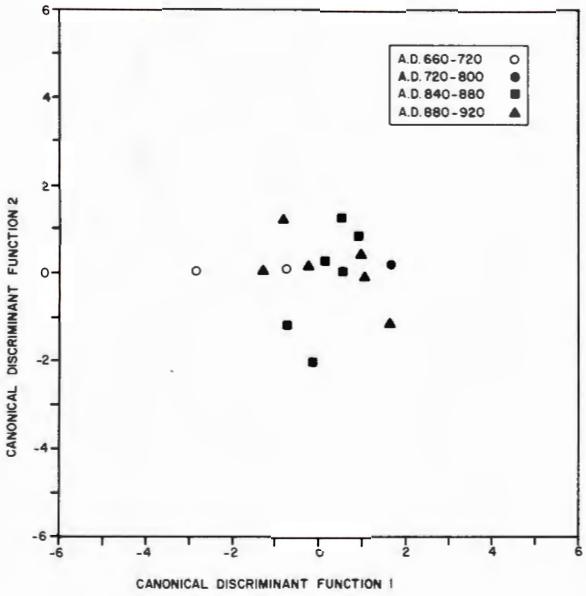

Figure 2.5 – Discriminant scores for 2 rod and well coiled baskets grouped by time period.

or with a group of weavers that share motor patterns and aesthetic principles. However, the extension of these results to the discrimination of individual or related weavers within a collection of basketry whose provenience and contemporaneity is unknown does not appear to be warranted. The most similar provenience groupings (where groups consist of 2 or more baskets) are from Pitstructure 10 at Grass Mesa Village and from Pitstructure 7 at McPhee Pueblo (Site 5MT4475). These structures are separated in time by approximately 20 years and in space by approximately 6.5 km.

Twined Basketry

Twined basketry is represented in DAP collections by 37 fragments. All but 3 examples are carbonized, and the 3 uncarbonized fragments are the only examples of twining from either of the rockshelters. Original forms of twined items can only be identified in 5 instances due to fragmentation and poor preservation. These forms include 1 mat, 3 pieces of a feather blanket, and what appears to be part of a twined sandal. The remaining 32 examples of twining are all from flexible items (cordage warps and wefts) and could be derived from mats, sandals, or possibly bags.

The single mat (RV 41) was recovered from Pitstructure 44 at Grass Mesa Village, and dates within the A.D. 880-900 period. It is unique in construction characteristics relative to the remaining DAP twined materials, consisting of a double warp of reed (*Phragmites*) culms, held together by rows of S-slant twining at 16.5-mm intervals. The weft elements are 2-ply, Z-spin, S-twist cordage of retted yucca fiber. The original size of the mat is unknown and no selvages were preserved. No other open twining or twining of reed warps is present in DAP collections, and none of the other examples of twining in DAP collections can be interpreted as representing mats.

The 3 feather blanket fragments were recovered from LeMoc Shelter (Site 5MT2151), and their interpretation is probable but not definite. Two of the fragments consist of short yucca-strip or fiber cores wrapped with feathers and bound with yucca leaf strips. The remaining fragment consists of a short length of 4-ply, Z-spin, S-twist yucca fiber cordage wrapped with feathers and bound with yucca strips. Although none of the fragments was charred, none was longer than 3 cm when found, and no twining elements were associated with the feather-wrapped cords. The interpretation of these items as parts of a twined feather blanket is based on their similarity to descriptions of feather blanket warps from other areas of the Southwest (Guernsey 1971:93, Rohn 1971:113; Kent 1983:fig 7g). They could represent portions of feather cord woven into some other form (e.g., a sock [Rohn 1971:fig. 132]). One of the three examples may date to the ninth century A.D., but the degree of disturbance of the rockshelter deposits makes the temporal affiliation of all of the fragments uncertain.

The single possible twined sandal fragment (RV 2) was recovered from Pitstructure 1 at Chindi Hamlet (Site 5MT4684) and is dated to the last decades of the seventh century A.D. (Tucker 1983). The item is charred and fragmentary, and what remains of the surface of the weave has been obscured by burning. Enough is visible at the fragment edges to classify it as close twined on single warps of 3-ply, Z-spin, S-twist yucca cordage (1.6 mm diameter). The weft elements appear to be single-ply yucca fiber (0.8 mm diameter), but the direction of spin cannot be determined. Side selvages are continuous, and the preserved end selvage appears to consist of warps folded back into the third or fourth weft row from the end. The interpretation of this item as a sandal is based on the width of the item and the location of an irregularity on the surface near the end selvage that may represent the remains of a toe strap.

The remaining 32 examples of twining are too small to identify their original forms. However, all of the remaining fragments are close twined and are composed of yucca fiber cordage warps and wefts. S-slant twining (16 cases) is more than twice as common as Z-slant examples (6 cases), and the majority of the items have 2-ply warps (24 items) and single-ply wefts (21 items). Most of the 2-ply cordage (14 cases) is based on Z-spun

Table 2.2 – *F* statistics and significances of differences between structural groupings of 2 rod and welt coiled baskets

Provenience	Site 5MT23 Pitstructure 10	Site 5MT23 Pitstructure 44	Site 5MT2193 Pitstructure 1	Site 5MT4475 Pitstructure 7	Site 5MT4477 Pitstructure 2	Site 5MT4684 Pitstructure 4
Site 5MT23, Pitstructure 44	1.71 (0.25)					
Site 5MT2193, Pitstructure 1	0.67 (0.54)	0.62 (0.57)				
Site 5MT4475, Pitstructure 7	0.12 (0.89)	1.59 (0.27)	1.02 (0.41)			
Site 5MT4477, Pitstructure 2	1.91 (0.22)	1.73 (0.25)	2.46 (0.16)	1.18 (0.36)		
Site 5MT4684 Pitstructure 4	4.18 (0.06)	4.09 (0.07)	4.29 (0.06)	2.50 (0.15)	0.07 (0.93)	
Site 5MT5107, Pitstructure 2	5.21 (0.04)	1.52 (0.28)	2.75 (0.13)	3.85 (0.07)	1.14 (0.37)	2.67 (0.14)

Probabilities are expressed in parentheses below *F* values. Probabilities reflect the likelihood that the observed differences between the groups could be the result of chance, given the variability observed within the groups being compared. Differences are regarded as potentially significant if the listed probability is less than 0.10.

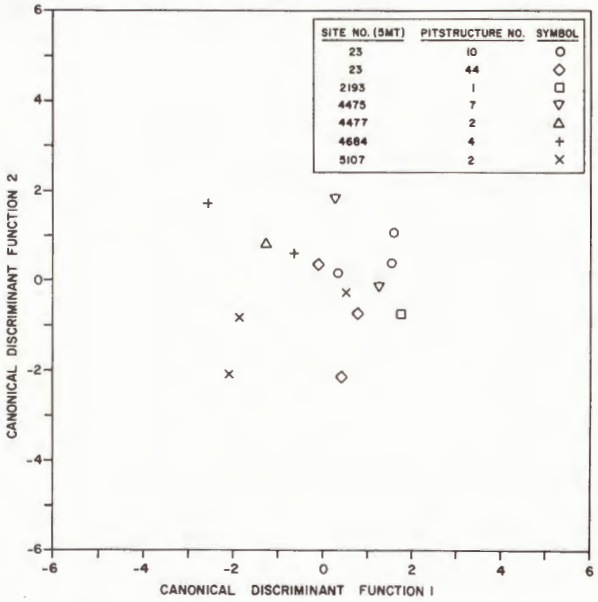

Figure 2.6 – Discriminant scores for 2 rod and welt coiled baskets grouped by structure provenience.

plies, while the single-ply wefts are predominantly S-spun (14 cases). Size of the warp and weft elements is determined by ply of the cordage used (mean diameters of single-ply [1.2 mm] and double-ply [1.8 mm] cords are the same for both warps and wefts). The temporal distribution of these twined fragments spans A.D. 660-920, with the majority derived from 2 A.D. 660-700 pitstructures at Chindi Hamlet.

Netting

Although the inclusion of these items under basketry may be questioned due to their flexible nature, they are similar in both material and flexibility to some of the twined basketry fragments described above. Only 3 netted items have been identified in DAP collection, and although their forms are indeterminant, they are probably all fragments from flexible bags. Each of the 3 is unique to a degree, but all appear to be knotless netting or looping (Rohn 1971:122; Kent 1983:47-51). A small fragment of unburned (presumably human) hair netting (fig. 2.7) was recovered from LeMoc Shelter, but the fragment cannot be dated with confidence due to the disturbed nature of the deposits. Two small pieces of yucca fiber cordage netting (RV's 11 and 14) were recovered from surficial deposits at Grass Mesa Village and are likely to predate A.D. 900. The first piece (RV 11) consists of tightly looped, 2-ply, S-spin, Z-twist yucca fiber cordage (fig. 2.8). Although the form cannot be identified, it is likely to have been a bag similar to those illustrated by Kent (1983:figs. 15 and 16). The second item (RV 14) consists of a small ring of cordage through which 15 cordage strands have been looped and then secured with an extremely fine row of twining. This appears to be the base or start of an open net bag that would have been completed with subsequent rows of cordage loops.

Felted Material

One example of matted or felted material (RV 12) was recovered from Pitstructure 10 at Grass Mesa Village.

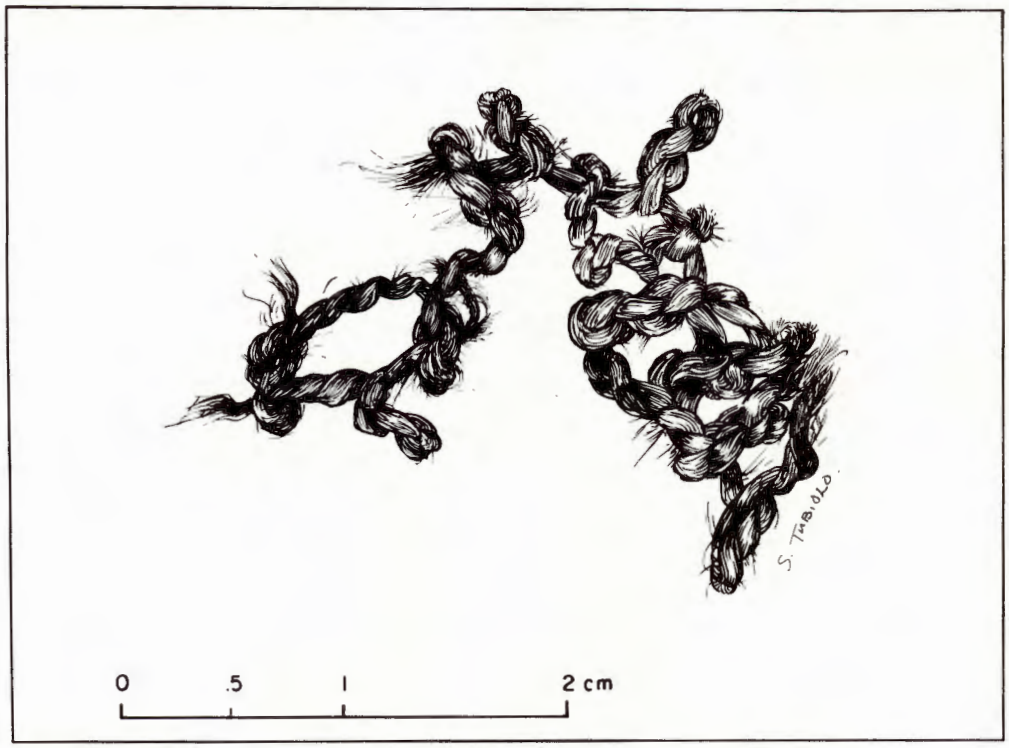

Figure 2.7 – Fragment of hair netting (RV 11) from LeMoc Shelter (Site 5MT2151).

The appearance of the fiber mass is unlike the appearance of quids or other bundles of retted fiber that occur in DAP collections. The item consists of a charred mass of 2 types of fibers that cross and intertwine without a specific orientation. Some of the fibers appear to be retted yucca, and the others were identified (with low confidence) as cotton (*Gossypium*). The interpretation of the material as part of a basketry or textile item is problematic because it was not associated with any stitching or cordage, but the appearance of a felted material is similar to that used in a felted pouch from Long House at Mesa Verde National Park (Osborne 1980:337, fig. 414).

Cordage

The second largest category of worked vegetal materials in DAP collections includes twine, braids, and miscellaneous bindings. Forms can be identified for some of these items, but most of the items represent disassociated fragments from larger basketry, textile, or other forms. All of these items are similar in material in that they are portions of or have been prepared from yucca leaves.

Twine

Twine is the largest subset of this class of materials, with 40 examples in DAP collections. All examples are based on retted yucca fiber, and all but 4 strands are preserved by charring. Most of the classifiable specimens are 2-ply (N = 25) or 3-ply (N = 3). Six examples were recovered in which multiple strands of 2-ply twine were twisted together to form larger cords. Five of these consisted of two 2-ply strands, and one consisted of three 2-ply strands. Mean diameter of the 2-ply strands is 2.8 mm, the mean for 3-ply twine is 3.2 mm, and the multiple-twist strands range between 4 and 7 mm in diameter.

Spin and twist directions for the twine are nearly equally represented. S-spin yarns are slightly more common (N = 19) than Z-spin yarns (N = 15) in the collection, and due to the presence of some strands of multiple-twist cordage with both S-spin and Z-twist, initial S-twists are slightly more common (N = 18) than initial Z-twists (N = 15). All but one of the multiple-twist cords was finished with a Z-twist. This relatively equal representation of spin and twist directions is unlike the tendency for single directions to predominate in other Mesa Verde region collections (Rohn 1971:table 13; Osborne 1980:table 21). However, several of the individual DAP site collections are dominated by single spin and twist directions.

All of the twine fragments are relatively short and their functional forms are indeterminate. One piece was tied

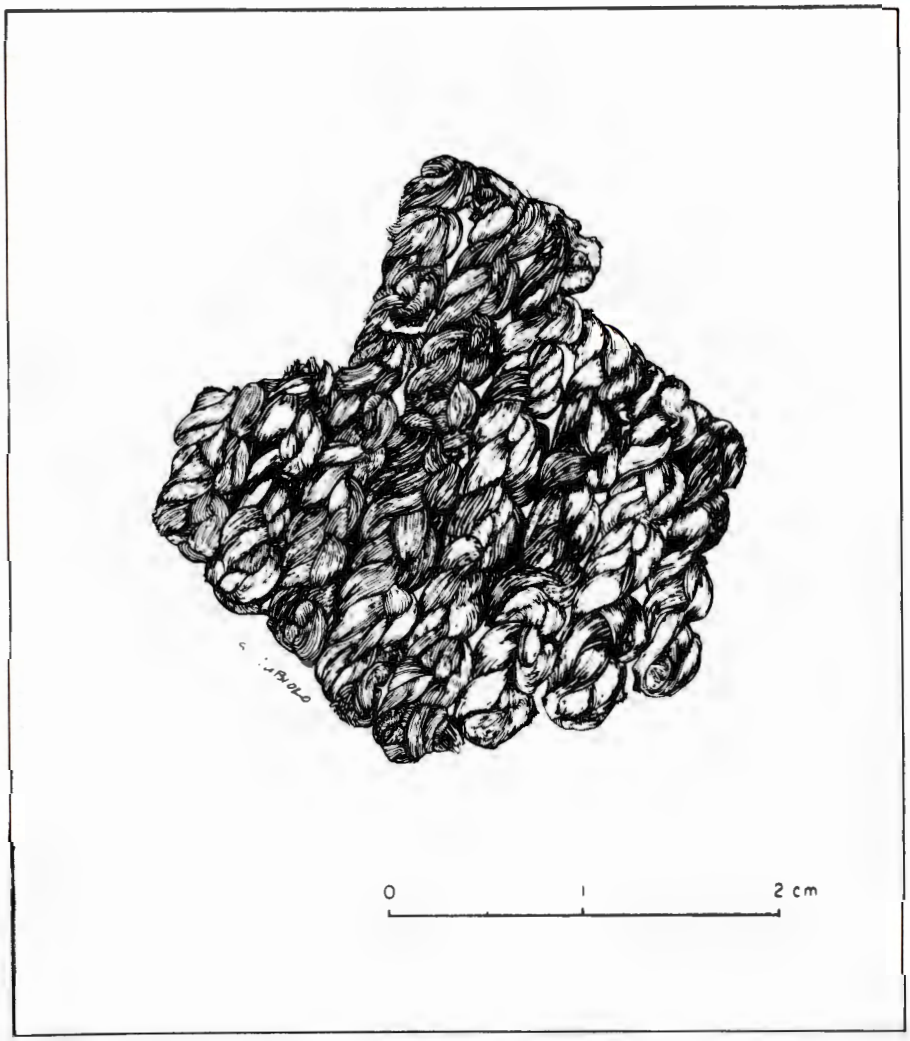

Figure 2.8 – Fragment of yucca cordage netting (RV 11) from Grass Mesa Village (Site 5MT23).

into a figure-eight knot, but the remaining examples were not manipulated. Mean diameter of the 2-ply twine fragments (2.8 mm) is slightly larger than the mean diameter of the 2-ply cordage used in twined basketry items (1.8 mm). This implies that most of the pieces of twine are not disassociated from twined basketry items. Supporting this contention is the predominance of Z-span plies in the basketry cordage as opposed to the relatively equal representation of Z- and S-spun plies in the 2-ply twine. However, cordage pieces may relax their twists somewhat when disassociated from a twined item, effectively enlarging their apparent diameter.

Braids

Braids are relatively rare in DAP collections and fall into 2 size classes. Four pieces of three strand braid have been identified. Two of these are woven from retted and S-spun fiber, 1 is woven of fiber but the characteristics cannot be determined, and 1 consists of woven leaf strips. The fiber braids range from 3.8 to 5.5 mm in diameter, and the leaf strip braid is flat and is 9 mm across. All of these are charred and fragmentary, and no form can be identified.

Three larger braids were all recovered from Pitstructure 210 at Rio Vista Village (Site 5MT2182). Their condition is poor, but each consists of at least 4 and probably 6 elements woven into a rectangular braid. The individual elements are 2-ply, Z-spin, S-twist cordage (3 to 4 mm diameter), and the finished braids range from 7.4 by 14.3 mm to 14.2 to 17.5 mm in cross section. Each braid appears to have been at least 2.5 m in length based on field observations, but only short sections were preserved well enough to recover for laboratory examination. Each

braid terminates at 1 end with a loop, but opposite end terminations could not be identified. In 1 case, the loop is complete, is about 6.5 cm long, is formed by braiding strands back into the body of the braid, and the loop is penetrated by the braid, forming a noose. The loops on the remaining specimens can be identified as such but are incomplete. The characteristics of the best preserved specimen are similar to the descriptions of several braids recovered by Guernsey and Kidder in northeastern Arizona (1974:79-80, plate 32). These complete specimens are described as snares and are interpreted as functioning in the capture of larger game. Extension of this interpretation to the Pitstructure 201 examples is speculative but reasonable.

Miscellaneous Bindings

In addition to the examples of prepared twine and braids, 14 examples of more expedient bindings are present. These consist of yucca leaves or leaf strips that have been knotted and presumably used to hold other materials together. Some of these bindings retain the circular forms (e.g., posts or bundles) around which they were wound, but most are simply fragments that retain knots as evidence of their use. Most of these materials would be described as potential raw materials for plaited basketry if they were not knotted or twisted. Square knots are the most common among the bindings, with single examples of granny, overhand, figure eight, and half hitch. All but 1 of the binding strips were recovered uncharred from the 2 rockshelters, and some may date to occupations after A.D. 920.

Assemblages of Worked Vegetal Materials

Although preserved perishable items are rare in DAP archaeological contexts, the necessary conditions for preservation (burning or dry deposits) tend to result in the recovery of clusters of items. Burned materials are usually confined to structure interiors, and the materials tend to be de facto refuse (Schiffer 1971:160). This category includes items that were deliberately abandoned prior to structure collapse (often worn out or low value items) and functional items, the destruction of which (as a result of set or accidental fires) entailed an economic loss to the associated household or households. Regardless of the systemic context represented, containment within a structure implies both a temporal and functional relationship between the items within a cluster.

Unburned materials are preserved in any dry deposits and thus are not restricted to structure interiors. Few of the unburned items in DAP collections are associated with structures, and most appear to be from primary or secondary refuse contexts as opposed to de facto refuse contexts. As such, contemporaneity is difficult to establish, and confidence in broader dating resolution is dependent upon the amount of disturbance associated with site occupations or historic looting. Unfortunately, the 2 dry rockshelters that have produced the majority of the unburned vegetal artifacts in the DAP collections have experienced both prehistoric and historic disturbance, and both have been the locus of post-A.D. 900 as well as pre-A.D. 900 occupations (unlike most of the open sites excavated by the DAP). Thus, most of the unburned materials are ambiguous in temporal affiliation.

Assemblages of Perishable Materials in Burned Structures

Although structure burnings can preserve worked vegetal material, such preservation is at best incomplete. Charring of individual items may be partial, resulting in total combustion of portions or in decay of uncharred portions. Charred specimens are fragile and are susceptible to physical damage during structure collapse as part of the burning process and during disturbance subsequent to structure collapse. Postdepositional disturbance includes archaeological recovery efforts, and many specimens could be noted or briefly described in the field, with only samples of the specimen surviving for laboratory examination. Similarly, a large number of worked vegetal materials are derived from soil samples (e.g., from hearth fills) and consist of minute fragments. As a result of these factors, assemblages of burned perishable materials are incomplete at best.

Thirteen DAP structures are associated with four or more worked vegetal items (including worked wood and miscellaneous materials not considered basketry or cordage). Occurrences of classes of basketry and cordage (bindings) in these structures are listed in table 2.3. Coiled basketry, cordage, and twined basketry classes are equally ubiquitous, occurring in 8 of the 13 structures. All structures with twined items include at least 1 flexible, twined item based on cordage warps and wefts, and if these are included in the cordage evaluation, cordage (in 1 form or another) occurs in 10 of the 13 structures. Plaited items are rare relative to the other basketry types, and looped and felted items occur in only 1 assemblage. Braids occur in 3 structures, but braided snares are only represented in 1 of these. Bindings are present in only 2 structures.

The numbers of types of materials associated with any given structure are very limited. In all but 1 case, structures are associated with 4 or fewer of the basketry and cordage types. This is not unexpected for those structures from which relatively few worked vegetal items were recovered. However, the mean number of individual basketry and cordage items is 7.9 for these 13 structures. This tendency for multiple occurrences of singly basketry or cordage types may be due to fragmentation of originally single items in a few cases, but

Table 2.3 – Occurrences of basketry and cordage types in structure assemblages containing 4 or more worked vegetal items

Site No.	Pitstructure No.	Basketry type					Cordage type		
		Plaiting	Coiling	Twining	Netting	Felting	Twine	Braid	Binding
5MT23 (N = 26)	10	+	+	+	+	+	+		+
5MT23 (N = 7)	44		+	+				+	
5MT2182 (N = 3)	1		+	+					
5MT2182 (N = 3)	201							+	
5MT2858 (N = 4)	1	+					+		+
5MT4475 (N = 11)	7		+	+			+		
5MT4475 (N = 12)	9	+		+			+	+	
5MT4477 (N = 5)	1		+						
5MT4477 (N = 10)	2		+				+		
5MT4644 (N = 13)	1			+			+		
5MT4684 (N = 12)	1	+		+			+		
5MT4684 (N = 20)	4		+	+			+		
5MT5107 (N = 7)	2	+	+						

Sample sizes reflect basketry and cordage items only.

in most instances the uniqueness of individual items is suggested by slight differences in attributes or large spatial distances between the finds. Multiple occurrences are also unlikely to be due to preferences of individual households for particular technologies because of the limited functional replacement potential between the classes of worked vegetal material. Therefore, variation in types of materials present is probably a result of both the vagaries of preservation and the selection of materials for discard in the cultural contexts of de facto refuse.

The single exceptional structure assemblage is from Pitstructure 10 at Grass Mesa Village, which has at least 1 item representing each class except braids. This diversity is based on a sample of 28 items, all but 2 of which are basketry or cordage. The conditions of destruction of Pitstructure 10 appear to be catastrophic in that nearly all of the material culture associated with the structure floor was usable or perhaps was even in use at the time of structure destruction (Lightfoot et al. 1985). This includes whole pottery vessels, corn (both shelled and on the ear), and the worked vegetal materials discussed here.

In addition to the diversity of technological classes represented within the Pitstructure 10 assemblage, considerable variety occurs within classes. The 3 minority types of coiled basketry foundations in DAP collections are based on specimens from this structure, and at least 4 deep or steep-sided coiled basketry bowl forms are present in addition to 3 shallow bowl forms. Plaiting is represented by a ring basket and by 6 fragments of at least 2 types of forms (although none of the forms can be specified). Only single items of twining, netting, and felting are present. Cordage present includes examples of 2-ply twine and a knotted yucca leaf strip.

The richness of this assemblage is due in part to the intensity of the fire that destroyed the strucure and in part to the probable "in use" context of the floor materials at the time of destruction. However, as rich as

this assemblage is, it is only a sample of what may have been associated with the structure. Construction of Pitstructure 11 subsequent to the burning of Pitstructure 10 destroyed at least half of the floor area of the earlier pitstructure and an unknown amount of associated material culture. Based on the assumption that the Pitstructure 10 assemblage is representative of a "normal" complement of perishable material culture, the role of basketry in household toolkits is seriously underestimated from the other de facto refuse assemblages.

Assemblages of Perishable Materials in Dry Deposits

The perishable material assemblages associated with the 2 rockshelter deposits are markedly different from the burned structure assemblages. Evidence of coiled basketry is lacking from the rockshelter deposits (table 2.4), and although twining is present in 1 case (feather blanket fragments), examples of this technique are scarce compared to their occurrences in the structure assemblages. Examples of plaiting are abundant in the rockshelters, primarily in the form of sandals and a single example of netting (hair rather than yucca fiber) was recovered. Bindings are abundant from the rockshelter, with knotted yucca leaves or leaf strips accounting for 27 to 32 percent of the total of basketry and cordage items recovered.

Whereas the condition of the burned worked vegetal materials is a consequence of a combination of state at discard, degree of burning, and physical damage at the times of deposition and excavation, the condition of the rockshelter materials is determined primarily by the state of the material at time of discard. All of the whole and partial plaited sandals exhibit some attrition of the basal surface due to use, and although not necessarily worn out, even the whole examples are well worn. The possible feather blankets are represented by short warp segments only, and the netting is fragmentary (part of the netting condition may be due to the greater degradation of animal fiber than vegetal fiber, even in relatively dry deposits). Twine pieces are short fragments, but the yucca leaf bindings are generally complete (i.e., whole leaves or leaf strips are present).

The contexts are characteristics of most of the rockshelter materials suggest they include considerable refuse. Most of the materials are not associated with structure floors; instead they are derived from fill or refuse deposits. With the possible exception of the whole sandals, most of the rockshelter materials appear to have been discarded in a worn or fragmentary state. Further, the most common whole materials are the expedient yucca leaf bindings, and their frequency relative to plied cordage fragments is opposite that of the structure assemblages.

Interpretations

Assuming that the rockshelter materials can be characterized as secondary refuse (Schiffer 1972:161), they provide a complementary perspective to the de facto refuse or use-association materials of the burned structure assemblages. Use lives of coiled baskets appear to have been long, resulting in their under-representation in refuse as opposed to structure assemblages. Similarly, yucca leaf bindings are under-represented in the structure assemblages as opposed to the refuse, supporting the interpretation of expediency and rapid discard. Twined and plaited materials also appear to have had long uselives, with resultant underrepresentation in trash accumulations, although plaited sandals are a notable exception.

This interpretation assumes that temporal and functional differences are not contributing to the observed differences between the burned and unburned assemblages. Considerable post-A.D. 920 (Pueblo II) affiliated materials contribute to the unburned assemblages, whereas the burned assemblages represent only A.D. 660-920 materials (late Basketmaker III through Pueblo I). In addition, all of the burned assemblage materials are associated with habitations (pitstructure floors), whereas the unburned materials are derived from seasonal and limited activity refuse as well as habitation refuse. If the assumptions of no influence from these temporal and functional factors are not warranted, then the inferred magnitude and character of the complementarity between burned and unburned assemblages is questionable. However, it is likely that either assemblage type alone provides a biased view of the role of worked vegetal materials in the Dolores area cultural system.

CERAMIC MATERIALS

Ceramic collections constitute the largest single analytic class of artifactual material recovered by the DAP, exceeding 550 000 items. Three major types of analyses have been carried out on these items or on subsets of these items. These analyses have included preliminary or inventory analysis of sherds, formal descriptions of reconstructible vessels, and refiring or controlled oxidation studies of clays and selected sherds. Data from these analyses in turn have supported a variety of descriptive and interpretive efforts. This section of this report summarizes the content and structure of the ceramic data bases and the justification and practice of DAP ceramic dating.

Ceramic Data

Nearly all DAP ceramic data are generated by 3 basic ceramic analysis systems. "Preliminary analysis" is the

Table 2.4 – Occurrences of basketry and cordage types from dry rockshelter deposits

Site No.	Basketry type					Cordage type		
	Plaiting	Coiling	Twining	Netting	Felting	Twine	Braid	Binding
LeMoc Shelter Site 5MT2151 (N = 25)	+		+	+		+		+
Singing Shelter Site 5MT4683 (N = 15)	+					+		+

Sample sizes reflect basketry and cordage items only.

most intensive and extensive data gathering procedure. All DAP ceramic materials undergo preliminary analysis, and it is designed to provide resource, technological, typological, and functional information, as well as a complete inventory. Vessel form analysis is carried out on all reconstructible vessels identified within the larger sherd collection; this analysis provides a record of form, size, and wear attributes. Finally, refiring studies compile gross compositional data for clay and selected sherd samples.

Preliminary Analysis

The DAP preliminary analysis system for ceramics was intended to record selected ceramic attributes as well as subjective evaluations of geographic and typological affiliations (Blinman 1983a; Blinman et al. 1984). The system is explicitly sherd based, splitting individual provenience collections into groups of sherds that share values for all descriptive attributes. Depending upon the size of the provenience collection and the attributes of the included sherds, groups can consist of from 1 to several hundred sherds. With few exceptions, each group (or catalog item number) within each provenience designation is the unit of inventory for storage and retrieval through the Bureau of Land Management, Anasazi Heritage Center.

Selected technological attributes (firing atmosphere, surface manipulation, polish, fugitive pigment application, slip, paint type, paint color) were recorded for each group of sherds. These were recorded in an effort to provide explicit documentation of some of the observations used in subsequent subjective typological classification. In addition, these data provide the basis for calculation of production-step-based value measures (Feinman et al. 1981), defining subsets of typological categories, and defining subsets of the total data base for intensive analyses.

The single resource attribute recorded during preliminary analysis was temper. Temper types were classified during binocular microscope examination (20×) of freshly broken sherd cross sections. An explicit effort was made to split rather than lump temper types during analysis (within the limits of consistency and perception imposed by binocular microscope examination); as a result, 32 temper classes have been used in describing DAP ceramics. Most (24) of these temper types are interpreted as representing variability within Mesa Verde region ceramic materials. Definitions of the temper types, evaluations of the consistency of their use, and comparisons with petrographic analysis data are presented by Blinman et al. (1984:18-49).

Regional and temporal/stylistic affiliations of sherds are recorded as slightly modified traditional pottery type designations. Temper type, technological attributes, and decorative style are used to identify non-Mesa Verde ceramics and to assign sherds to broad regional/culture affiliations ("culture categories") (Wilson and Blinman 1985a). Within each culture category, sherds are assigned to specific types where sufficient stylistic characteristics (e.g., design or surface manipulation) were observable and could be compared with published or accepted type descriptions. Where specific type assignment was not possible, sherds were placed into "grouped types," descriptive categories that imply considerably less temporal resolution than is implied by the specific types.

Mesa Verde region ceramics make up the vast majority of DAP collections (99.2 percent). They have been assigned to areas of origin (manufacturing tracts [Lucius 1981]) within the Mesa Verde region based on geographic patterns of temper or clay use (Blinman 1983b; Blinman et al. 1984:68-71). The geographic correlates of specific temper use are poorly known due to the limitation of DAP activities to Dolores Project-related construction features and to the relative scarcity of comparable temper analyses from other portions of the Mesa Verde region. Tentative geographic correlates of the tracts are presented in figure 2.9. The boundaries are tentative due to the

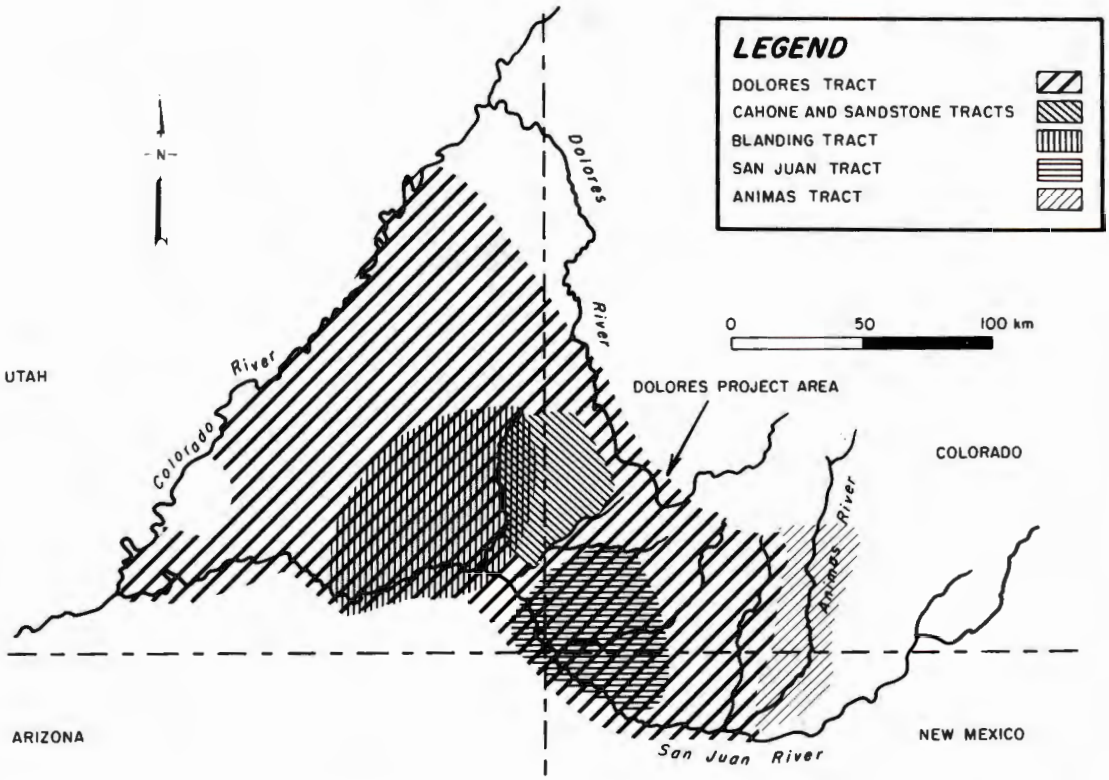

Figure 2.9 – Approximate geographic locations of ceramic manufacturing tracts within the Mesa Verde region. Boundaries are tentative and are most appropriate for the A.D. 720-920 period.

scarcity of information, and the locations and extents of the various tracts are known to change through time (boundaries presented here are expected to be most appropriate for the A.D. 720-920 time period).

Definitions of the Mesa Verde pottery types used in DAP classifications conform largely to the descriptions presented by Breternitz et al. (1974). In addition, 4 new types have been formally proposed based on DAP analyses. Dolores Brown (Lucius and Wilson 1981a), provides a label for items (usually crude figurines or pinch pots) manufactured of silt-rich alluvial clays and fired in a poorly controlled reducing atmosphere. Dolores Red (Lucius and Wilson 1981b) is a Mesa Verde analog for Tallahogan Red (Daifuku 1961:49-50). It describes sherds in which a crushed-igneous-rock-tempered gray body clay has been heavily slipped with an untempered blood-red clay. Dolores Red is the earliest occurring red ware in DAP collections (ca. A.D. 730) and may be a precursor for the San Juan Red Ware tradition. Dolores Corrugated has been proposed as a corrugated type with rim eversion intermediate between the eversion characteristics of Mancos Corrugated and Mesa Verde Corrugated (Lucius and Wilson 1981b). The type was defined to more precisely exploit the observed temporal variation in rim eversion of corrugated jars (Wilson and Waterworth 1982), and its use implies a restriction of the original definitions of Mancos Corrugated and Mesa Verde Corrugated. Finally, McPhee Black-on-red has been defined as a variety of Bluff Black-on-red (Wilson and Errickson 1985). It is distinguished from other Bluff Black-on-red sherds on the basis of sherd temper, and the justification for its designation is its consistent late appearance (post-A.D. 875) and widespread distribution across the Mesa Verde region.

As with the non-Mesa Verde ceramics, many sherds cannot be assigned to specific pottery types due to ambiguous characteristics. These are assigned to a variety of grouped types, the definitions of which are usually based on technological characteristics (Blinman et al. 1984:78-89). The choices of characteristics for grouped type distinctions are based on perceived potential for temporal resolution in dating arguments, and the grouped types are reported and manipulated as if they were types. Grouped types can be distinguished from formal types by the lack of geographic roots for grouped type names.

Vessel form classes are recorded to represent the prefiring or intended form of the vessel. Since the vessel form classification must be based on sherd attributes, considerable variation in precision occurs, depending upon the portion

of the vessel represented by the sherd. As examples, only appropriately incurving rim sherds can be identified as seed jars, and body sherds from gray ware ollas, pitchers, seed jars, cooking jars, and even bowls (unpolished and unpainted gray ware body sherds) are indistinguishable and are classified as jar sherds. Handle and lug types are also identified as vessel form classes, as are prefiring modifications such as perforations.

Whereas vessel form and technological attributes are focused on pottery production, a modification class variable records postfiring wear or alteration of form (Blinman et al. 1984:126-135). Features recorded include wear associated with vessel use prior to breakage, alteration of vessel form, and alteration of sherd form after vessel breakage. Modification classes are diverse and include functional inferences where possible (e.g., ceramic scraper, scoop, repair hole) and morphological descriptions where functional inferences are not warranted. The functional inferences are supported by models that link presumed motion of use or modification with observable abrasion features (Waterworth and Blinman 1984).

The sherd-based nature of the preliminary analysis system results in some superficial awkwardness when reconstructible vessels are encountered. Vessels are assigned unique identifying numbers within each site collection, and the identifying number is treated simply as another attribute of those sherds that are derived from the vessel. Thus, within a given provenience, sherds from a vessel will be divided into groups based on the same criteria used for sherds not identified as deriving from a vessel. For example, sherds from a Moccasin Gray jar will be divided into 1 group of manipulated (neckbanded) sherds and 1 group of plain sherds, each group having a distinct catalog item number. Each group will also be given a separate pottery type designation based on sherd attributes (Moccasin Gray and Early Pueblo Gray), but each group will be kept distinct from any other neckbanded or plain sherds from the same provenience by the attached vessel number. This procedure results in multiple listings for vessels in data tables, but it maintains data comparability between proveniences with vessels and proveniences that either lack reconstructible vessels or for which reconstructible vessels were not detected. Reconstructible vessels do not imply whole vessels, and vessel designations are given whenever the identification of multiple sherds from a single vessel would serve an analytic purpose. Appropriate purposes range from stratigraphic correlation to the documentation of the presence of whole vessels in a provenience.

Sherds within a catalog number are quantified by count, rim count, and weight. Where multiple sherds are included within a single group, the weight is the total weight for all sherds of the group. For descriptive site reports, ceramic data are usually summarized by count and by weight percent, with totals expressed for both count and weight so that individual type or grouped type abundances (absolute and proportions) can be calculated for either measure if necessary for comparisons with non-DAP data presentations. Count and weight are equivalent measures when sample sizes are large, and synthetic studies of ceramic materials rely primarily on counts and count percentages for data presentations and comparisons.

Reconstructible Vessel Descriptions

Descriptive data have been gathered on DAP reconstructible vessels to supplement the occasionally ambiguous sherd-based descriptions of vessel form and to provide additional data for formal/functional studies of vessels as containers (Blinman 1985). Descriptions vary with the degree of completeness of the individual vessels and the degree to which physical reconstruction was possible within the constraints of both vessel condition and analyst time. Under ideal conditions, scale profiles were drawn, vessel shape measurements were taken, and a variety of wear attributes were observed in both coded and discursive comments. Vessel descriptions and metric data exist as paper records and are on file with the Anasazi Heritage Center.

Controlled Oxidation of Clays and Sherds

Compositional analyses of DAP sherds have been relatively limited in scope. Neutron activation studies of some materials are being carried out independently of the DAP (Howes 1983), but the only formal DAP compositional analyses have been through controlled oxidation (refiring) of clay and sherd samples. Controlled oxidation standardizes the oxidation states of compounds (particularly iron oxides) in samples and allows gross compositional comparisons to be made on the basis of sample color (Shepard 1965:217-222; Bishop et al. 1982:277). The oxidation has been accomplished by raising the temperature of samples to 950° C in an electric resistance furnace with unlimited access to oxygen. As long as the sample has not been vitrified in previous firings, the color of the sherd after oxidation can be used as a proxy for composition (vitrification limits access to oxygen within the sample and prevents standardization of oxidation states). Color is recorded in Munsell (1976) color notation, and colors are grouped into color classes using 1 of 2 conventions: Travis (1984:table 25) or Wilson et al. (1985:tables 1 and 2).

Controlled oxidation data have been gathered systematically for all examples of ceramic clay from archaeological contexts, for samples of clay from resource surveys of the Dolores Project area, and for selected subsets of DAP sherd collections. The former data sets have been reported in a synthesis of clay resource availability and resource

use (Wilson et al. 1985), and the latter have been integrated into a variety of specific research reports. The compositional data have been collected on a research project basis rather than being integrated into a single file, and the observations are recorded as paper records on file with the Anasazi Heritage Center.

Ceramic Dating

Relatively rapid and consistent change in stylistic and technological aspects of Southwestern ceramics has led to the widespread use of ceramic materials for ordering or dating archaeological collections. Given the abundance of ceramics in DAP collections, and given the limited instances in which other dating techniques can be employed, relatively great emphasis has been placed on ceramic date estimates as a basis for DAP chronological inferences. In support of this emphasis, studies have been carried out in an effort to calibrate aspects of ceramic change and to develop ceramic dating procedures.

Neckband Dating

Attribute change within wares has been used as the basis for ceramic dating in several regions of the Southwest, as data for both seriational techniques (LeBlanc 1975) and for regression-based techniques. Characteristics of painted designs (primarily line width) have been useful in dating inferences used with Black Mesa collections (Plog and Hantman 1985), but painted sherds are relatively rare in DAP collections for which the major temporal focus is within the A.D. 600-920 period. Gray ware sherds are abundant during this time period, and the attribute basis for the typological distinctions between Moccasin Gray and Mancos Gray ceramic types suggested that variation in neckband attributes could serve as a basis for attribute dating.

Calibration of neckband variation was carried out (Blinman 1984a), and height of individual neckbands was determined to be the most temporally sensitive of the measured attributes. Mean neckband height decreased slightly through time, but the small extremes of the distributions decreased considerably (i.e., the variances of the calibration assemblages increased through time) (Blinman 1984a: fig. 80). Since increasing variance did not correlate with decreasing neckband height within sherds from individual vessels (Blinman 1984a:fig. 81), the increasing variance through time in the calibration assemblages was assumed to be the result of mixtures of stylistically "old" with stylistically "progressive" vessels within the calibration assemblages. Such mixtures could result from the effects of long vessel uselives or from the persistence of old styles among some potters at each time period. Regardless of the source of the old style vessels, the greatest potential for temporal resolution was inherent in the most stylistically progressive vessels (i.e., the vessels with the narrowest neckbands) within a given ceramic collection.

Based on this assumption, the progressive sherds of the calibration assemblages were identified using breaks in the slope of normal probability plots of neckband height distributions (Blinman 1984a: fig. 82). Variation in neckband height of these stylistically progressive sherds was continuous, but the variation was not linear through time. Two periods of slow stylistic change were separated by a period of rapid change, and jackknifed regression equations were used to describe the variation within each segment, where each equation was appropriate for a discrete portion of the A.D. 780-950 period (Blinman 1984a: table 30).

The neckband dating equations were used to generate "style dates" for neckbanded sherds in provenience collections, and the style dates are then used to infer date estimates for the associated proveniences. Due to the use of only stylistically progressive sherds in the calibration, the best neckband date inference for a provenience is represented by the latest cluster of style dates in the provenience collection. Small samples of neckbanded sherds in most proveniences further restrict the dating inferences, and the use of neckband dating is often limited to the establishment of lower limiting dates for provenience.

Neckband dates for Tres Chapulines Hamlet, site 5MT4725 (Chenault 1983), provide an example of dating inferences based on this technique. Neckband dates associated with floor collections from 5 of the 6 excavated pitstructures at the site are presented as histograms in figure 2.10. In all cases, floor collections appear to be de facto refuse or secondary refuse that accumulated at the time or within a few years of structure abandonment. Neckband dates associated with Pitstructure 1 indicate abandonment at approximately A.D. 860; the small number of dates from Pitstructures 2 and 6 are interpreted as representing abandonment at or after A.D. 870 and 880, respectively; Pitstructure 4 abandonment is also dated to A.D. 880, but the date estimate is more confident; and neckband dates for Pitstructure 3 indicate abandonment at about A.D. 890.

The only absolute dating available for these structures is a cluster of tree-ring dates that places construction of Pitstructure 1 at A.D. 845 (Chenault 1983). Features within the structure evidence considerable remodeling, and suggest a uselife equivalent to or greater than the estimated 15-year average uselife of pitstructures in the Dolores Project area (Schlanger 1985). Pitstructure 1 is part of the earliest construction at the site and is the first of the structures at the site to be abandoned (based

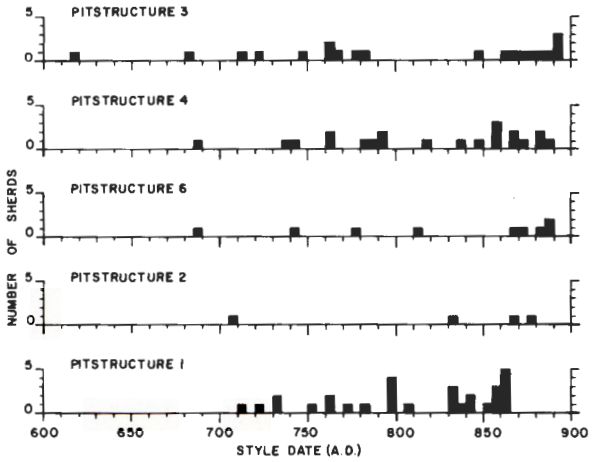

Figure 2.10 – Neckband dates associated with pitstructure floors from Tres Chapulines Hamlet (Site 5MT4725).

on stratigraphy). The sequence of abandonment continued as follows: Pitstructures 2 and 6, Pitstructure 4, and finally Pitstructure 3. The neckband styles associated with Pitstructures 2 and 6 should be relatively contemporary and should be younger than Pitstructure 4, which in turn should be younger than Pitstructure 3 (the last pitstructure occupied at the site). Ceramic assemblage dating (refer to the following section) of the last occupation of the site places the abandonment of Pitstructure 3 sometime after A.D. 880 and before A.D. 910.

This example of neckband dating is moderately successful at establishing realistic relative and absolute date estimates. Although not precise enough to duplicate the temporal resolution of the stratigraphic relationships at the site, the date estimates are acceptable given error factors of ± 10 years. What is not evident in this example is that the sample sizes available from these proveniences are unusually large, and most neckband dates associated with DAP structure proveniences are more similar to the case of Pitstructure 2 than to the case of Pitstructure 1. Also, this example exploits the rapid rate of neckband change between approximately A.D. 860-895, and confidence in dating inferences declines outside of this time range. In the absence of large numbers of neckbanded sherds and without verification of temporal relationships through stratigraphic or other means, neckband dating is best used as a supportive or confirmatory technique rather than as the sole basis for date estimates. Also, because of the reliance of neckband dating inferences on subjectively defined late clusters, the technique should not be applied to collections that represent mixtures of time periods (the technique would only identify the last contribution to the mixture).

Assemblage Dating

The second and most widely used DAP ceramic dating approach is based on calibrated temporal change in the typological composition of ceramic assemblages. Although tree-ring-dated structures are relatively rare in DAP excavation contexts, the vast amount of excavation has resulted in the recovery of enough well-dated ceramic assemblages to construct a detailed calibration of ceramic change (Blinman 1984b). Typological classifications (as opposed to other ceramic attributes) were used as the substance of the calibration because they were available for all collections as part of the preliminary analysis data set and because they could be applied readily to data sets from outside of the DAP. Several attributes were also considered, the most useful being paint color in red wares. Adoption of an assemblage approach (i.e., changing relative frequencies of types) was possible due to the presence of consistent collection and analysis biases in most DAP collections. This dating technique results in an ordering of collections based on their ceramic content, but it differs from seriational approaches in that: (1) the model of rates and directions of change in type frequencies is explicitly derived during the calibration process rather than being assumed; (2) differential collection size can be dealt with by variable precision in date estimates; and (3) mixtures of materials from different time periods can be detected and date estimates can be assigned to each component of the mixture.

Calibration. – Within the DAP collections, 21 proveniences were identified that could be used for calibration purposes (Blinman 1984b:22-38). All of these proveniences are stratigraphically discrete and can be placed in time by either direct associations with tree-ring dates (structure floor collections) or by stratigraphic relationships with dated structures. Uselife of structures and time lag between structures is explicitly argued as part of the calibration assumptions. The proveniences are not evenly distributed through time, and DAP calibration proveniences are confined to the A.D. 635-930 period. Comparable ceramic data are also available for an A.D. 1150 occupation of Escalante Ruin, Site 5MT2149 (Hallasi 1979),[1] just outside of the Dolores Project area to the south. Significant gaps exist in the sequence between A.D. 805 and 855 and between A.D. 930 and 1150, but the observed changes in ceramic assemblages between A.D. 635 and 930 appear to be robust.

[1]A limited description of the ceramic assemblage from Escalante Ruin appears in Hallasi (1979). During 1982 and 1983 Peter Kakos, then of Washington State University, re-analyzed the ceramics from the site, and the data are currently on file with the analyst. The author obtained the information presented here through personal communication with Kakos.

Collections associated with the DAP calibration proveniences are consistent in that all sherds greater than 2 cm in diameter were recovered and analyzed (no bias was introduced for or against sherds of particular types or wares). Although archaeologically introduced bias is controlled in this way, biases in the form of large variances remain due to cluster effects on small collection sizes and to collections that contain vessels as opposed to sherds. The strict use of sherd-based typological assignments minimizes the potential confounding effects of vessel presence, but considerable variability still remains. Non-Mesa Verde ceramics are excluded from the calibration and from subsequent dating arguments due to their scarcity in DAP collections and to the greater possibility of error in typological assignments of relatively unfamiliar wares.

The results of the calibration include refined definitions of occurrence ranges for individual pottery types and grouped types (fig. 2.11) as well as definitions of temporally distinctive assemblages of types (Blinman 1984b:65-77). Occurrences are interpolated between calibration points, and, for periods when data are not available from DAP sources, occurrence ranges are based on other findings within the Mesa Verde region (e.g., the data from Escalante Ruin and ranges assembled by Breternitz et al. [1974]). both occurrence ranges and assemblage characteristics are expected to be altered and refined as more work is conducted in the region.

Change observed within the calibration proveniences was used to define 7 temporally distinctive ceramic assemblages for the A.D. 600-980 period (Blinman 1984b:65-77). The upper bound (A.D. 980) of the last of these assemblages is based on assumption, as are the content and boundaries of 4 distinctive assemblages proposed for the A.D. 980-1250 period in the Dolores Project area. These assemblages span the ceramic-bearing Anasazi occupations of the Dolores Project area but do not include the ceramic materials associated with post-Anasazi occupations (Errickson and Wilson 1985).

The calibration assemblages are sufficient in quality to allow the definition of the distinctive assemblages, but are often too small and variable to allow characterizations applicable to other contexts. For that reason, the calibration assemblages within the A.D. 600-980 period have been augmented (table 2.5) by the inclusion of collections from proveniences not absolutely dated but unambiguously dated by stratigraphy, architectural style, and ceramic type occurrence ranges. The vast majority of materials contributing to the distinctive assemblages are habitation refuse, and the characterizations are most applicable to that site and deposit. Due to the common reuse of sites in the Dolores Project area, contamination of collections by later ceramic materials is common. Contamination has been minimized in the table 2.5 summaries by including only those proveniences inferred to have high integrity by the excavator, however, some obvious contaminants remained in the collections. These contaminants have been removed from the summaries only when there was an archaeologically defined source for the contamination and when the presumed contaminant was clearly separated in time from the provenience date on the basis of the calibrated occurrence ranges of the types.

Within the A.D. 600-725 period, DAP ceramic assemblages are dominated by plain gray body sherds (Early Pueblo Gray) from Chapin Gray vessels. Sherd tempered gray ware (Late Pueblo Gray) sherds have been noted in some collections, but their appearance is sporadic and indicative only of localized temper preference. Decorated wares consist only of white wares and are dominated by sherds derived from Chapin Black-on-white vessels. Unpolished white ware sherds are often present but are less abundant than polished white ware sherds.

Assemblages dating within the A.D. 725-775 period differ from the preceding period primarily in the decorated wares. Chapin Gray remains the dominant gray ware, although rare Moccasin Gray sherds may occur. Piedra Black-on-white sherds are as likely to be present as are Chapin Black-on-white sherds, and unpolished white ware sherds are still present. The greatest difference is the introduction of red ware sherds in the form of Dolores Red, Abajo Red-on-orange, and Bluff Black-on-red. Although the latter type is more common than Abajo Red-on-orange in table 2.5, orange or red paint (probably from Abajo Red-on-orange vessels) is nearly twice as common on the untypeable sherds (Early Pueblo Red and Slipped Red) of this period than is brown or black paint (probably from Bluff Black-on-red sherds). Although present, red ware sherds are not abundant, comprising only about 3 percent of the period assemblage.

After A.D. 775, the frequency of Moccasin Gray increases as this type becomes a consistent, although minority, component of the gray ware assemblage. Moccasin Gray vessels produce fewer untypeable sherds when they break than are produced by Chapin Gray vessels, and the proportion of Early Pueblo Gray sherds decreases. Mancos Gray also appears in the A.D. 775-825 assemblage, but its presence is due to the relatively minor morphological attributes that distinguish the 2 neckbanded types. Slight variations in the execution of a Moccasin Gray vessel, combined with a fortuitous breakage, can result in occasional sherds that must be classified as Mancos Gray on morphological grounds. Thus, any collection with large numbers of Moccasin Gray sherds is likely to include 1 or more Mancos Gray sherds as well.

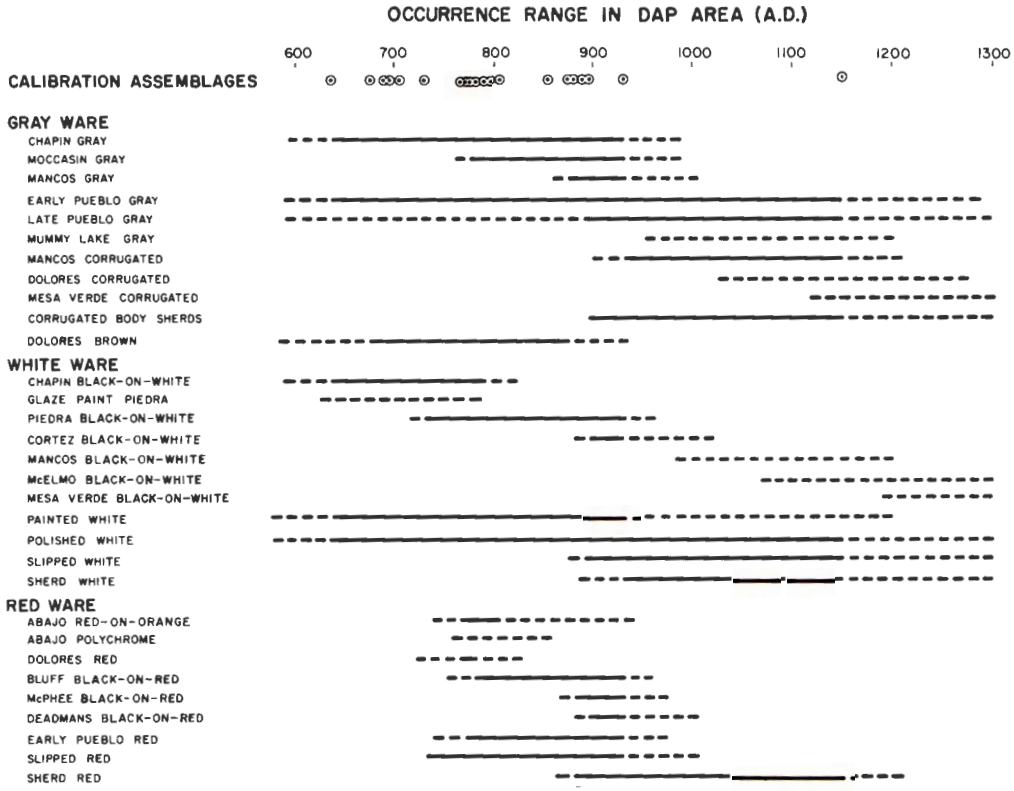

Figure 2.11 – Occurrence ranges for Mesa Verde region pottery types and Dolores Archaeological Program grouped types. Solid lines represent known occurrence ranges, and broken lines represent assumed ranges.

No new decorated types are added during the A.D. 775-825 period, but emphases do shift slightly. Piedra Black-on-white is more abundant than Chapin Black-on-white, and polished white ware sherds are much more common than unpolished ones. Red ware sherds are much more abundant than during the previous period, accounting for about 9 percent of the total assemblage. Although Abajo Red-on-orange and Bluff Black-on-red are comparable in proportions of typeable sherds, brown or black paint colors are slightly more common within the total red ware sherd assemblage. Smudged Mesa Verde sherds occur in this assemblage, but their abundance reflects a cluster attributable to several vessels at a single site.

The strongest marker for the A.D. 775-825 time period is the consistent presence of Moccasin Gray sherds as a minority in association with Chapin Gray. At some point between A.D. 805 and 855, this relationship reverses itself. This reversal takes place within the period for which DAP calibration assemblages are lacking, and the setting of the end of this period and the beginning of the next period at A.D. 825 is arbitrary.

Between A.D. 825 and A.D. 860, Moccasin Gray is 2 to 3 times as abundant as Chapin Gray, Mancos Gray is present only as trace sherds (probably derived from occasional Moccasin Gray vessels), and the frequency of Early Pueblo Gray falls below 80 percent. Both Chapin Black-on-white and Piedra Black-on-white are present, and polished white ware sherds continue to be considerably more abundant than unpolished white ware sherds. Bluff Black-on-red is now the dominant red ware type, and brown- or black-painted red ware sherds eclipse orange or red painted sherds in frequency. Red ware sherds as a whole decline somewhat from their high frequency in the previous period to about 5 percent of the total assemblage. Sherd temper may occur rarely in gray, white, or red ware sherds, but its frequency is at trace levels only.

After A.D. 860, the frequencies of the neckbanded gray ware types increase at the expense of Chapin Gray. Moccasin Gray increases in proportion to more than 10 percent of the total assemblage, and Mancos Gray is consistently present in its own right as opposed to being present as odd fragments of Moccasin Gray vessels. With the increase in neckbanded vessels, the Early Pueblo Gray frequency continues to fall to slightly over 70 percent. Piedra Black-on-white is the dominant white ware type,

Table 2.5 – Composition of temporally distinctive ceramic assemblages

Pottery type	Time period (A.D.)													
	600-725		725-775		775-825		825-860		860-880		880-910		910-980	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Chapin Gray	577	5.4	97	4.7	1 423	5.5	294	3.4	155	2.4	640	2.9	189	1.5
Moccasin Gray			1	0.0	289	1.1	802	9.2	925	14.3	2 425	10.8	831	6.5
Mancos Gray					5	0.0	16	0.2	200	3.1	738	3.3	1 071	8.4
Early Pueblo Gray	9 238	89.0	1792	87.2	21 207	81.5	6721	77.3	4671	72.4	15 629	69.9	7 019	54.9
Late Pueblo Gray	2	0.0	1	0.0			1	0.0			7	0.0	68	0.5
Mancos Corrugated													202	1.6
Dolores Corrugated														
Mesa Verde Corrugated														
Corrugated Body Sherds													657	5.1
Dolores Brown	9	0.1	3	0.1	103	0.4	2	0.0	1	0.0	7	0.0	3	0.0
Chapin Black-on-white	136	1.3	12	0.6	16	0.1	29	0.3	1	0.0	16	0.1	2	0.0
Glaze Paint Piedra	2	0.0												
Piedra Black-on-white	1	0.0	18	0.9	28	0.1	29	0.3	59	0.9	468	2.1	42	0.3
Cortez Black-on-white													642	5.0
Mancos Black-on-white													11	0.1
McElmo Black-on-white														
Painted White	75	0.7	15	0.7	18	0.1	38	0.4	6	0.1	42	0.2	17	0.1
Polished White	365	3.5	54	2.6	595	2.3	329	3.8	192	3.0	1 300	5.8	966	7.6
Slipped White					3	0.0			3	0.0	25	0.1	132	1.0
Sherd White							1	0.0	2	0.0	15	0.1	349	2.7
Dolores Red			2	0.1										
Abajo Red-on-orange			3	0.1	443	1.7	2	0.0	21	0.3	18	0.1	2	0.0
Abajo Polychrome					5	0.0					1	0.0		
Bluff Black-on-red			13	0.6	311	1.2	52	0.6	67	1.0	142	0.6	42	0.3
McPhee Black-on-red									1	0.0	59	0.3	13	0.1
Deadmans Black-on-red									2	0.0	20	0.1	50	0.4
Early Pueblo Red			44	2.1	1 525	5.9	278	3.2	121	1.9	595	2.7	345	2.7
Slipped Red					16	0.1	102	1.2	21	0.3	101	0.5	125	1.0
Sherd Red					4	0.0			4	0.1	52	0.2	10	0.1
Plain Smudged					30	0.1			1	0.0	2	0.0		
Total	10 385	100.0	2055	100.0	26 021	100.0	8696	100.0	6456	100.0	22 364	100.0	12 788	100.0

but both Chapin Black-on-white and rare Cortez Black-on-white may be present. The Cortez Black-on-white represents scroll or rick-rack design elements but lacks the classic slip and surface color associated with later examples of the type. Unpolished white ware sherds become increasingly rare. Red ware sherds continue to be dominated by brown- or black-painted sherds and Bluff Black-on-red. McPhee Black-on-red, Deadmans Black-on-red, and Sherd Red (untypeable sherds probably derived from McPhee Black-on-red vessels) may be present but are extremely rare and probably are confined to the latter part of this period.

The A.D. 880 threshold is marked by the consistent but minority presence of Cortez Black-on-white, Deadmans Black-on-red, and sherd temper in gray, white, and red wares. The Cortez Black-on-white is still present based on design elements rather than classic slip characteristics. McPhee Black-on-red and Sherd Red account for about 10 percent of the red ware sherds, and their appearance in quantity coincides with a slight increase in total red ware frequency from a low of 3.6 percent in the previous period to about 4.5 percent.

The occupation history of the Dolores area includes a widespread and perhaps total abandonment of excavated sites within the Dolores valley at about A.D. 900. Occupation was reinitiated at a minority of sites after a short hiatus, but other than its brevity, the dating of the reoccupation is unknown. For the purposes of the original calibration of ceramic change, the reoccupation collection from a site within the McPhee Community Cluster was assumed to date to A.D. 930. This may be too short a hiatus, but the reoccupation is unlikely to date as late as A.D. 950. The reoccupation assemblage is augmented by architecturally associated collections (stratigraphy and architectural style) from the McPhee Community Cluster, and the whole of the summation is assumed to reflect the A.D. 910-980 period. The end date could be in error by as much as 20 years, but the extent of the occupation does not suggest occupation lasting much beyond A.D. 1000.

This A.D. 910 (930)-980 ceramic assemblage differs from the pre-A.D. 910 assemblage by the presence of corrugated gray wares and the predominance of Cortez Black-on-white. Neckbanded gray ware jars are still the most abundant form, but sherds from Mancos Corrugated vessels account for about 7 percent of the total assemblage. Mancos Gray sherds are more abundant than Moccasin Gray sherds for the first time, augmented in part by clapboarded but noncorrugated sherds from otherwise corrugated vessels. Chapin Gray remains present, but the small numbers of sherds appear to be from miniature vessels and ollas rather than the cooking jar form associated with Chapin Gray in pre-A.D. 820 assemblages. Cortez Black-on-white is abundant in its classic well-slipped form, Piedra Black-on-white is present, and there are rare Mancos Black-on-white sherds, presumably attributable to the latter part of the period. Sherd tempered white wares are common but are not yet more abundant than crushed rock tempered sherds. White ware sherds account for about 17 percent of the total assemblage, compared with about 9 percent in the previous period. Deadmans Black-on-red is nearly as common as Bluff Black-on-red (including the McPhee Black-on-red variety), and the proportion of red wares in the total assemblage is comparable to the previous period.

Assumption plays an increasingly strong role in the definition of distinctive assemblages after A.D. 980, and the content of the assemblages is impressionistic, rather than being quantifiable from DAP collections. This is due to the scarcity of post-A.D. 910 sites within the primary Dolores Project impact areas and to the lack of independent dates in association with those sites that have been excavated by the DAP. Also, relatively few published descriptions of dated ceramic collections in the northern Mesa Verde region are comparable in typological distinctions and collection biases to DAP data. The result is that the distinctive assemblages defined for the post-A.D. 980 period are broad classification units subject to refinement in content, precision, and boundaries as more calibration data are available from the region.

The A.D. 980-1025 assemblage is assumed to be characterized by Cortez Black-on-white in association with Mancos Black-on-white. Sherd temper is expected to be as common or slightly more abundant than crushed rock temper in the white ware sherds. Corrugated gray ware sherds (Mancos Corrugated vessels) are assumed to be more abundant than noncorrugated gray ware sherds, and the latter are assumed to include Mancos Gray and Chapin Gray with only rare Moccasin Gray. Deadmans Black-on-white is assumed to be the dominant red ware type.

Between A.D. 1024 and 1100, the distinctive assemblage is assumed to consist of Mancos Black-on-white as the sole white ware type, and more than half of the white ware sherds will be tempered with crushed sherd. Gray wares will be dominated by Mancos Corrugated, with some Dolores Corrugated sherds and a minority of noncorrugated sherds (Mancos Gray, Chapin Gray, and Early Pueblo Gray). Deadmans Black-on-red remains the predominant red ware type.

The next period (A.D. 1100-1175) includes the ceramic materials associated with the first occupation at Escalante Ruin (Hallasi 1979) and its content is somewhat less speculative. Mancos Black-on-white is the most abundant white ware type but is associated with some

McElmo Black-on-white sherds. Almost all white ware sherds are tempered with crushed sherd. Dolores Corrugated sherds are more common than Mancos Corrugated sherds, and noncorrugated gray ware sherds comprise less than 10 percent of the gray ware assemblage. Mesa Verde red wares are absent, but red wares are present as exchanged materials from Kayenta sources.

The A.D. 1175-1250 period characteristics are again speculative. Corrugated types are expected to be derived from Dolores Corrugated and Mesa Verde Corrugated vessels. McElmo Black-on-white is assumed to be the dominant white ware vessel type, with some Mancos Black-on-white and possibly some Mesa Verde Black-on-white present as well. Most white wares will be sherd tempered, and no Mesa Verde red wares will be present. Instead, red wares are assumed to be derived from both Kayenta and White Mountain Redware sources.

This calibration of ceramic change is appropriate for the Dolores Project area specifically and for the north-central Mesa Verde region in general. Differences in both timing and magnitude of changes in ceramic assemblages are expected across the region, and some differences have been identified by comparison of the DAP calibration with published descriptions of dated ceramic collections (Blinman 1984b:94-99). The greatest discrepancies consist of a cline in red ware frequency (and presumably timing) from west to east across the Mesa Verde region, and a possible later adoption of Mancos Gray in the southern portion of the region. The earlier appearance and higher frequency (about 27 percent of an unbiased surface collection from Site 13 on Alkali Ridge [Blinman 1983b; Brew 1946]) of red ware sherds on sites in the western portion of the region is presumably related to that area serving as a production source for red ware vessels and their subsequent exchange eastward across the region (Lucius and Wilson 1980: Lucius and Breternitz 1981). The initial dates for Mancos Gray in Mesa Verde National Park collections are uncertain but are inferred to be closer to A.D. 900 than to the A.D. 860 date for the Dolores Project area. Other slight differences in the temporally distinctive assemblages are likely to exist, but cannot be identified with the currently available data.

Assemblage Dating Procedures. – The process of estimating ceramic dates using the distinctive assemblage characterizations requires a series of assumptions about the calibration assemblages and about the sample or collection being dated (Blinman 1984b:77-85). The distinctive assemblages are assumed to be representative of the associated time periods (there is no significant variation within the time period as compared to variation between time periods), and all possible temporal assemblages are assumed to be represented in the distinctive assemblages. The ceramic collections to be dated are assumed to be unbiased samples of a population that consists of 1 or more of the described temporal assemblages (nearly all DAP collections, both from site survey and excavation, qualify as unbiased samples, and those that do not are readily identifiable within the DAP provenience data file). Since the calibration assemblages are a byproduct of habitation activity, the accuracy of date estimates is dependent upon the assumption that no bias is present due to differences in function between habitation activities (cooking, eating, and storage) and the activities associated with the collection. Thus, date estimates will be most appropriate for habitation collections, slightly less appropriate for seasonal sites, and subject to possible error when applied to limited activity sites (Schlanger and Orcutt 1985).

Once these assumptions are made, the collections to be dated are evaluated as to the likelihood they could have been derived as samples from 1 or more of the calibration assemblages. This evaluation is subjective in the vast majority of ceramic date estimates used in the reporting interpretation of DAP activities; however, it has also been automated using regression techniques (Kohler and Blinman 1984). Tests conducted as part of the development of the regression approach validated the discriminating ability of the technique and replicated subjective date estimates derived for the same collections. Although the regression approach is better suited to mixture problems than is the subjective approach and can provide quantitative estimates of the amount of a collection that is derived from each source (Kohler 1985), the subjective approach has the advantage of being able to compensate for the high variability associated with small collections and collections with large contributions from reconstructible vessels. Subjective evaluation can also compensate for some violations of assumptions when the collections are biased or when functional factors are believed to influence collection content.

Resolution of assemblage date estimates is limited primarily by the level of detail allowed by the calibration and the quality of the sample. No collection size or purity from a pre-A.D. 725 context can improve on the 125-year resolution allowed by the apparent lack of ceramic change during that time period. This contrasts with the 20-year resolution possible for large collections from the latter half of the ninth century. Achievement of ideal resolution is unusual, however, because of ambiguities in the parentage of small collections. Most of the assemblage date estimates require the absence as well as the presence of specific types, and some of these types are rare, even when present. Thus, most date estimates are limited by the strength of negative arguments, which in turn is determined primarily by collection size.

Date estimates are also dependent on acceptable levels of confidence and precision. If a particular research

problem requires high-confidence date estimates (a low probability of being wrong), then dating precision must be broadened or the number of collections must be restricted to those that can support both high-precision and high-confidence estimates. If the research problem is robust enough that being correct half the time or better is acceptable, then relatively high-precision date estimates can be made for relatively mediocre samples. Most archaeological requirements for descriptive and interpretive inferences fall somewhere between these extremes, hoping for precision approaching that possible within the limits of the calibration and accepting the risk of error in a minority of cases. A detailed discussion of sample size requirements for types of date estimates is provided by Blinman (1984b:80-84).

An advantage of the assemblage technique is that sample (collection) requirements for a desired level of precision can be anticipated prior to field work. This can result in the tailoring of field procedures to resolve specific dating problems. This includes the judgmental placement of collection units in site survey contexts and the efficient appropriation of excavation resources when ceramic dating may be important to development of chronology. In the former contexts, suspicions of multiple componency can be explicitly evaluated if discrete collections are taken from areas of a site that may represent different occupations. In the latter contexts, sample adequacy can contribute to the decision as to how much of a fill or midden stratum should be collected before moving labor to another task. Assemblage dating is also easily adapted to site survey procedures where material is observed but not collected.

Examples. – The procedures and arguments used in assemblage dating are most easily conveyed by examples. A list of the Mesa Verde region ceramics in a survey collection from Site 5MT6672 is presented in table 2.6. Gray ware types are limited to Chapin Gray and Early Pueblo Gray (the grouped type that designates all plain gray ware body sherds that do not have sherd temper), white ware sherds are present and include Chapin Black-on-white, and red ware sherds are present and include Bluff Black-on-red. The presence of the red ware sherds places the deposition of this material clearly after A.D. 725 and probably after A.D. 775 due to the presence of Bluff Black-on-red. Neckbanded gray ware sherds are absent, but their absence may be due to collection size (229 sherds). Between A.D. 775 and 825, frequencies of Moccasin Gray are about 1 percent within the temporally defined assemblage, and a random sample as large as 365 sherds could be expected to fail to recover a neckbanded sherd as much as 5 percent of the time. After A.D. 825, the frequency of Moccasin Gray rises to about 9 percent, and random samples of 40 sherds would be expected to include Moccasin Gray 95 percent of the time. Since

Table 2.6 – Mesa Verde region ceramics from Site 5MT6672

Pottery type	N	%
Chapin Gray	8	3.5
Early Pueblo Gray	204	89.1
Chapin Black-on-white	2	0.9
Painted White	2	0.9
Polished White	4	1.7
Bluff Black-on-red	1	0.4
Early Pueblo Red	8	3.5
Total	229	100.0

ceramic collections are not random samples and more closely approximate cluster samples, these percentage rates are underestimations of true failure and overestimations of true success rates, but they provide indications of what would be reasonable inferences. Based on the presence of Bluff Black-on-red and the absence of Moccasin Gray, the most likely date estimate for the site 5MT6672 collection is A.D. 775-825 with minimal risk of error. It is possible, but improbable, that the collection could date to the A.D. 825-860 period, and a low-precision date estimate of A.D. 775-860 would entail essentially no risk of error.

A more complicated example can be drawn from the survey collection from May Canyon Ruin (Site 5MT6794) (fig. 2.12). The site consists of a core arcuate rubble mound, 2 rubble mounds extending to the east and west of the core, and a discontinuous linear rubble mound to the north of the core. Depressions lie to the south of the rubble mounds, a dense midden lies to the south of the core rubble mound, and a large (about 30 m diameter) depression lies to the southeast of the midden. The rubble mounds and depressions are interpreted as single story roomblocks with associated pitstructures, and the large depression may be the remains of a large pitstructure or great kiva.

The contents of the collection units are unbiased, and the summation for the site as a whole is presented in table 2.7. The total collection size is large, and the proportions of individual types can be assumed to be relatively stable. Co-occurrence of Moccasin Gray, Mancos Gray, and Chapin Gray in the absence of corrugated sherds supports a date estimate of A.D. 860-910. No Cortez Black-on-white, McPhee Black-on-red, Deadmans Black-on-red, or Sherd Red was recovered, although a single sherd tempered gray ware (Late Pueblo Gray) sherd is present. The latter sherd is a weak indicator of post-A.D. 880 occupation, and the lack of corroborating evidence from the other types indicates

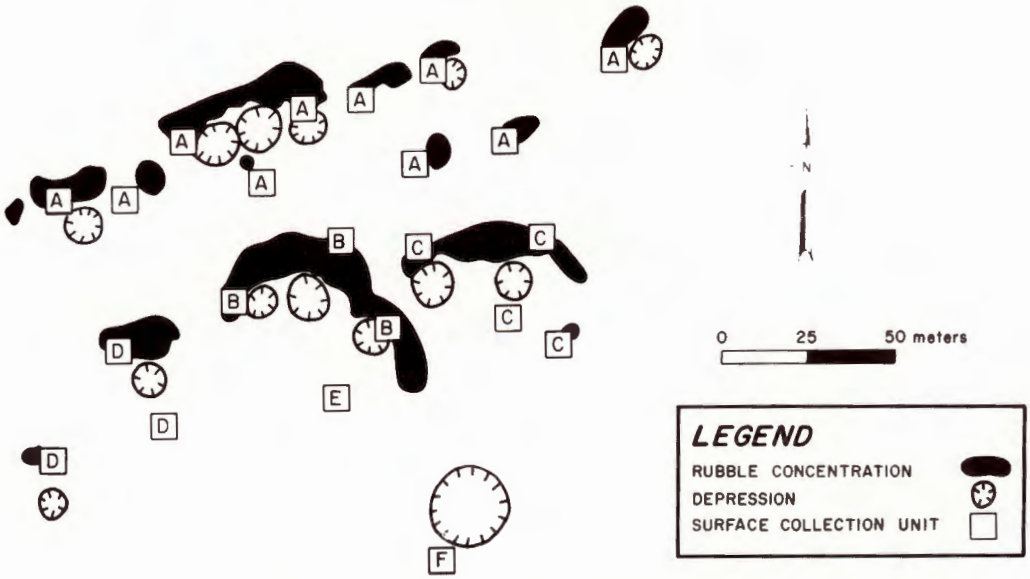

Figure 2.12 – Survey map of May Canyon Ruin (Site 5MT6794) showing the relationship between cultural features and surface collection units. Contents of the collection units (table 2.5) have been grouped into the northern roomblock (A), the core roomblock (B), the east wing (C), the west wing (D), the coremidden (E), and the large pitstructure depression (F).

that post-A.D. 880 occupation at the site, if present, is relatively minimal. This places the majority of site occupation within the A.D. 860-880 period, but there is one discrepancy. Although the Chapin Gray frequency is not unusually high, the frequency of Early Pueblo Gray sherds is higher than would be expected for a sample of this size drawn from a pure A.D. 860-880 assemblage.

The ceramic contents of the individual collection units were examined individually for ceramic date estimates. In most cases, collection size was too small for high-precision and high-confidence estimates, and the collections were enlarged by grouping them based on architectural associations (fig. 2.12; table 2.7). The northern roomblock collection conforms best to the model of A.D. 860-880 ceramic deposition with the lowest frequency of Early Pueblo Gray sherds, although by itself the sample size cannot rule out persistence into the A.D. 880-910 period. The west wing is represented by a small sample, and although it contains the single Late Pueblo Gray sherd, it is best dated to somewhere within the low-precision A.D. 860-910 period. The east wing and the core roomblock collections account for the majority of the excess Early Pueblo Gray sherds at the site, and their sample sizes are large enough to support an inference that occupation in this area of the site began prior to A.D. 860. How much earlier is problematic since occupation within the A.D. 825-860 period would not contribute significantly to the high Early Pueblo Gray frequency, and occupation within the A.D. 775-825 period should contribute increased numbers of red ware sherds as well as Early Pueblo Gray. The midden sample from the core area lends support for the earlier occupation inference because of a higher frequency of Chapin Gray sherds and the presence of the only Chapin Black-on-white sherds in the site collection, but it does not provide strong confirmation based on higher frequencies of Early Pueblo Gray sherds. The collection from the large depression can support a post-A.D. 825 inference due to the predominance of Moccasin Gray, but the sample is too small to trust the high proportion of Early Pueblo Gray as being indicative of a pre-A.D. 860 date, and the best date estimate is somewhere within the A.D. 825-910 range.

A high-confidence ceramic chronology for the site would be that occupation began in the area of the core roomblock and the east wing sometime prior to A.D. 860. This early occupation need not have been continuous with the later occupation. Population at the site increased with the establishment of the west wing and the northern discontinuous roomblock, and all of the definable roomblock units of the site were in use sometime within the A.D. 860-880 period. Some use of the site may have continued past A.D. 880, but such use would have involved either a short period of time or only a minority of the A.D. 860-880 architectural units. The use of the large depression may be contemporary with the A.D. 860-880 occupation, but its use and abandonment prior to A.D. 860 cannot be ruled out.

Table 2.7 – Mesa Verde region ceramics from May Canyon Ruin (Site 5MT6794)

Pottery type	Northern roomblock		West wing		East wing		Core roomblock		Core midden		Large depression		Whole site	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Chapin Gray	6	2.8			1	0.3	4	2.9	17	5.5			28	2.7
Moccasin Gray	31	14.6	2	6.1	39	12.7	6	4.3	17	5.5	2	6.7	97	9.4
Mancos Gray	1	0.5	2	6.1	5	1.6	3	2.2	1	0.3			12	1.2
Early Pueblo Gray	161	75.9	26	78.8	254	82.5	122	87.8	242	78.6	28	93.3	833	80.9
Late Pueblo Gray			1	3.0									1	0.1
Chapin Black-on-white									2	0.6			2	0.2
Piedra Black-on-white	1	0.5			2	0.6			1	0.3			4	0.4
Painted White	2	0.9	1	3.0									3	0.3
Polished White	7	3.3	1	3.0	5	1.6	2	1.4	14	4.5			29	2.8
Early Pueblo Red	3	1.4			2	0.6	2	1.4	13	4.2			20	1.9
Slipped Red									1	0.3			1	0.1
Total	212	100.0	33	100.0	308	100.0	139	100.0	308	100.0	30	100.0	1030	100.0

A lower confidence ceramic chronology would augment the above with a more precise date estimate for the initial use of the site. The low red ware frequency in the core roomblock and east wing area combined with the high Early Pueblo Gray frequency and the presence of the 2 Chapin Black-on-white sherds would support a pre-A.D. 775 occupation underlying the later core of the organized roomblocks. This implies that the site occupation was discontinuous and that the later architectural pattern has little to do with the initial occupation. Unfortunately, even at a lower confidence level, the relationship between the large depression and the other inferred occupations at the site remains uncertain, as does the nature of the persistence of occupation past A.D. 880.

Caveats.. – As with neckband dating, the most confident date estimates based on the assemblage dating technique are those that can be corroborated by independent evidence. Single occupations such as those in the first survey collection example or those represented by stratigraphically discrete excavated proveniences pose relatively little hazard since the relationship between the collection and the archaeological target are direct. Multiple occupations or mixture problems are more difficult and are by nature subject to greater risk or error. This is especially true for inferences based on survey collections where earlier occupations are likely to be under-represented in surface materials and where collection sizes are likely to be small.

A test of the ability of assemblage dating to discriminate subsurface occupations based on surface materials was carried out by Schlanger (1985:table 12). In 20 of the 21 cases, the surface collection date estimate encompassed an occupation of the site; the 1 error was in dating an A.D. 660-720 occupation to the A.D. 725-775 period (red ware sherds were present in the surface collection, presumably as drift from a later adjoining site). In 3 cases, earlier occupations were not detected in the surface ceramic date estimate, and in 2 cases, later occupations were not detected in the surface ceramics. These failures compare to 5 successfully identified multiple occupations. Four of these cases included occupations widely separated in time, and one case consisted of closely spaced occupations.

SYNTHESIS OF ADDITIVE TECHNOLOGIES GROUP CONTRIBUTIONS

All ATG studies have been conducted within the framework of the general DAP research design (Kane et al. 1983). The research design is phrased in terms of broad problem domains and more specific questions about the observed characteristics of the prehistoric occupation of the Dolores Project area. The first 4 problem domains (economy and adaptation, paleodemography, social organization, and extraregional relationships) are descriptive of static aspects of cultural systems, while the fifth (cultural process) provides a framework for the investigation of the causes of systemic change. Although guided by the general research design, ATG studies have been oriented to specific research questions and do not address the problem domains directly. For this reason, this section will provide a general review and quide to ATG contributions to the general research design.

Economy and Adaptation

This problem domain is structured to describe resource availability and use and related aspects of exploitive technology and organization (Kane et al. 1983:42-46). For the areas of ATG responsibility, this translates into recontructions of ceramic and plant resource distributions, the patterns of selection evident in those resources used, manufacturing techniques, functions of artifact forms within the broader subsistence system, and the organization of production and use. Data for most of these questions require excavated materials, effectively limiting evaluations to the A.D. 600-980 period or portions thereof.

Ceramic Resources and Resource Use

Ceramic resources include clay, temper, pigment, water, and fuel. High-quality ceramic clays are available from many sources within the boundaries of the Dolores Project area (Wilson et al. 1985). Most of these are geologic sources, but some pottery clays are available as localized deposits within the Dolores River floodplain alluvium or within soil horizons developed in loess. Geologic clays are associated with the Morrison, Burro Canyon, Dakota, and Mancos Shale formations, and the ranges of quality and color after firing are considerable, both between formations and members and within formations and members. Although the best alluvial or pedogenic clays are suitable for pottery manufacture, they are less plastic and are available in smaller quantities than the geologic clays.

The exposures of geologic clays are determined by the truncation of strata by the Dolores River canyon and major side canyons, the House Creek Fault, and minor gullies. Exposures of alluvial and pedogenic clays are determined by the movement of the Dolores River through its floodplain and minor gullies that dissect the loess cover; additional exposures can be created by subsurface excavations such as those for pitstructures. The pattern of exposures insures that clay resources are locally available within any portion of the project area, although slight differences occur in the local availability of types of particular geologic formations or members.

Clay resource characterization has been limited to comparisons of the oxidized colors of clay resource samples and archaeological samples. The considerable variability of geologic clays within and between formations precludes the use of these data for sourcing, but it is clear that despite the considerable number of suitable clay sources, only a minority of the clays were being selected. Although individual samples of the archaeological clays could have been derived from any of the geologic sources (few of the archaeological samples could have been derived from the alluvium or loess), the aggregate properties of the archaeological clays are slightly better matches to clays available from the middle member of the Dakota Sandstone Formation and to clays from members of the Mancos Shale Formation. These formations are the most widely distributed of those in the project area, and the possibility of selection for these sources would not have constrained ceramic manufacture.

All of the available clays in the Dolores Project area swell with the addition of water and shrink as they dry. Temper (aplastic material) must be added to the clays to control shrinkage and to prevent stress from cracking the vessels between forming and firing. Any nonplastic material is a potential temper if it does not change in volume during firing, including organic as well as mineral materials. Functional considerations in temper selection consist of size (control of strength, porosity, and resistance to heat shock in the fired vessel [Braun 1983:123-124, Shepard 1965:25-26]) and angularity (the strength of the bond between clay and temper increases with temper roughness [Shepard 1965:131]). Despite these measurable functional considerations, the range of tolerance is relatively great, and the penalty for violation of these considerations is likely to be a slight increase in the rate of vessel loss rather than an inability to create usable vessels.

Within this latitude, cultural selection plays a considerable role, with a strong tendency for conservatism in temper selection within a group of potters (Shepard 1965:164). Tempers used by northern Anasazi groups range from sand (requiring no preparation prior to use) to potsherds (requiring some crushing) to rock (requiring considerable crushing). Sand, potsherds, sedimentary rocks, and igneous rocks are all available within the Dolores Project area, but use of crushed igneous rock temper predominates (95 out of 96 examples of tempered clay are tempered with crushed igneous rock). This is true for most of the Mesa Verde region for the pre-A.D. 1000 period, and the greatest exception (use of crushed sedimentary rock) appears to be controlled by a lack of locally available supplies of igneous rocks in portions of the region. Thus, temper selection within the Dolores area conforms to Mesa Verde region norms and is not constrained by resource availability.

Pottery production also requires access to water and fuel. Permanent water was always available within the Dolores Project area, and the amount of water consumption in ceramic manufacture would have been minor in comparison to other domestic needs and the needs of structure construction. Fuel resources were probably unconstrained during the occupation of the Dolores Project area, both as renewable supplies from the vegetation communities (cf. Samuels and Betancourt 1982) and as a byproduct of field clearance and agricultural activity. Also, the demand for fuel for pottery production was likely a minor component, compared to cooking and heating, of the total fuel demand.

Ceramic Technology

The technology of pottery production appears to have been relatively consistent throughout the A.D. 600-980 period. Stages in pottery production are inferred from the recovery of raw materials, rare unfired vessels, tools believed to be associated with ceramic manufacture, the finished appearance of vessels, and sherds or vessels that represent "errors" in the manufacturing process. These pieces of evidence are contrasted with ethnographic models of pottery manufacture (e.g., Guthe 1925) to provide a more complete picture of the manufacturing process.

Preparation of the body clay included the grinding or soaking of the clay and the grinding of temper. No evidence for either preparation technique for the clay has been recovered, but experimental evaluations of the geologic clays suggest that one or the other means of disaggregating the raw material would have been required for most sources. Igneous rock is available both as hard cobbles from the modern river bed and as weathered and friable cobbles in Pleistocene river terraces. No direct evidence for the grinding of either of these source materials has been recovered, but caches of temper indicate that one or the other source was reduced by either grinding or pounding. Mixing and kneading of body clays could have been carried out on any flat clean surface. Traces of clay have been observed on sandstone slabs and on both room floors, and metate surfaces may have been used as well.

Vessel forming techniques appear to conform well to the general model of pottery manufacture described by Guthe (1925). All but very small vessels were constructed by coiling with subsequent scraping to obliterate coil junctures and to thin and shape vessel walls. Basketry impressions are preserved on the bases of some vessels, and some traces of more rigid supports (i.e., large sherds or bowls) indicate at least occasional use of pukis in the forming process. Most vessels lack such traces, and it is unknown whether pukis were not commonly used or whether traces were consciously obliterated in most cases. Both concentric coiling and spiral coiling have been noted, and the difference between the 2 techniques does

not appear to have value in typological distinctions (contrary to Breternitz et al. 1974:6).

Scraping or wiping was used to obliterate coil junctures except where junctures were intended to serve a decorative purpose (neckbanded and corrugated exterior surfaces). Two distinctive processes are subsumed by the term scraping, one implying the removal of material with a sharp-edged implement, and the other implying the redistribution of material without significant removal. The former action is accomplished in ethnographic contexts with knives or can lids used against exterior surfaces, whereas the latter is accomplished by using shaped pieces or gourd rind called "kajepes" on interior surfaces and to a lesser extent on the exterior surfaces (Guthe 1925:27). Flakes of stone appear to be the prehistoric analog of the knives, and the studies of flakes in DAP collections have identified a distinctive pattern of use-wear that has been replicated only by the scraping of tempered clay (Neusius 1983). Interior scraping was accomplished with shaped potsherds ("ceramic scrapers") or, in one case, a shaped piece of sandstone, but the use of perishable gourd "kajepes" cannot be ruled out. Ceramic scrapers have been identified as such by their shape, distinctive wear on their margins (Waterworth and Blinman 1984), and adhering clay (2 examples).

The scraping or wiping technology appears to have changed through time, such that the above model of coil obliteration may not be applicable prior to A.D. 800 (Blinman and Wilson 1985a). No ceramic scrapers have been identified in DAP collections dating prior to A.D. 800, and only 5 sherds from this period could be fragments of ceramic scrapers. This contrasts with 58 ceramic scrapers and 85 possible fragments that are confidently assigned to the A.D. 800-920 period. Although collection size associated with the A.D. 800-920 period is 3.5 times larger than the pre-A.D. 800 collection, sampling error alone cannot account for the discrepancy in ceramic scraper frequency if the ceramic production technologies were the same. It appears that other tools were employed for at least the interior scraping function until about A.D. 800.

Gray ware vessels are completely formed at this point, but additional manufacturing steps are necessary for the production of white, red, and smudged wares. Most white wares and all red and smudged ware vessels are polished. Polishing is accomplished by rubbing a hard stone over the surface, alining clay particles on the surface, and creating an extreme smoothness or luster (Shepard 1965:123-124; Guthe 1925:27-28). Ceramic polishing stones are subsumed within the larger category of polished and polishing stones, as defined within the nonflaked lithic tool analysis system, and those stones appropriate for ceramic manufacture cannot be specifically identified. Examination of a subset of this class of nonflaked lithic tools indicates that only a small minority can be interpreted as ceramic manufacturing implements based on size, shape, and luster. This scarcity of ceramic polishing stones could be attributable to their curation (Guthe 1925:28), but their scarcity also could be explained by a low frequency of white, red, or smudged ware manufacture within the Dolores Project area.

Painting with mineral pigment characterizes most A.D. 600-980 white and red wares in DAP collections (white wares include polished but unpainted sherds and vessels in DAP analyses). Although possible pigment stones have been recovered from DAP sites (Keane and Clay 1985), all have the potential for multiple uses, and their presence need not imply the manufacture of decorated ceramics. Brushes are likely to have been strips of yucca leaf (based on analogy [Guthe 1925:28] and on the abundance of yucca as a component of the DAP perishable material culture), but no items interpretable as paint brushes have been recovered. Also, although unfired gray ware vessels have been recovered from excavations, no unfired decorated vessels have been recovered. The scarcity of direct evidence of the production of decorated ceramics corresponds to inferences of limited local production based on the abundance of nonlocal (exchanged) sherds in the decorated component of the collections. Red ware vessels are assumed to be nonlocal to the Dolores Project area based on other evidence (Lucius and Wilson 1980; Lucius and Breternitz 1981), and the limited evidence of decorated ware production is assumed to be that of white ware and smudged ware production.

Independent data on firing procedures are lacking from DAP excavations. Shallow, slab-lined, pit kilns have been encountered elsewhere within the Mesa Verde region (Helm 1973; Hibbets and Harden 1982; Fuller 1984; Hibbets 1984), and, although most postdate A.D. 980, one falls within the temporal span of the Dolores occupations. No similar kilns or firing features have been identified in the immediate vicinity of DAP sites (near architectural features), and none have been identified in the course of several blading programs that have been carried out at site peripheries in an effort to identify extramural features. The isolated settings of those Mesa Verde kilns that have been found, coupled with the abundant evidence of ceramic manufacture in DAP sites, indicates that the lack of identified kilns in the Dolores Project area is probably due to the architectural emphasis of the DAP excavation strategy.

In the absence of firing features, firing regimes must be inferred from sherd characteristics alone. Most DAP ceramics are gray wares and their surface color relative to both unfired clay colors and the oxidized colors of sherd samples indicates a neutral to slightly oxidizing firing atmosphere. Enough oxygen was present to remove most of the organic content of the clays, but not

enough oxygen was present to oxidize iron compounds in the clays. Subjective evaluation of the frequencies and types of fire clouds indicates that errors toward reducing conditions were more common than were errors toward oxidizing conditions. White ware sherds evidence a firing regime similar to that of gray wares, but there appears to be better control, with a slightly greater tendency to err toward oxidizing conditions.

The color of red ware vessels requires a conscious effort to achieve strong oxidizing conditions during firing. Fire clouds on red ware bowls are common on vessel exteriors (bases), indicating that oxidation took place with the bowls upright in the setting, maximizing the intensity of color for the decorated bowl interiors. Red ware sherds often have gray ("carbon") cores, reflecting either the use of carbonaceous clays in vessel production or the application of an initial strong reduction firing followed by a final oxidation firing to achieve the surface color. The differences between red ware and gray and white ware firing regimes are marked, and the specialized nature of the red ware oxidation firing may have contributed to the apparent lack of red ware production in the Dolores Project area.

Ceramics as Containers

Vessels are integrated into the Anasazi toolkit as containers that serve a variety of functions. Functions are inferred for DAP vessel shape classes using models that relate access, security, leverage, stability, and size requirements of functions to specific vessel shapes (Blinman 1985). Shape classes within A.D. 600-920 DAP vessel collections are discrete (fig. 2.13), with relatively little overlap between the characteristics of the classes and only rare instances of ambiguity in class affiliation for individual vessels. Wear and context observations for members of the shape classes generally support the inferred functions, but occasional exceptions support the observation that not all vessel use is appropriate to the intentions of the original design (cf. Shepard 1965:228).

Cooking, serving, dry storage, and liquid storage functions are consistently represented in vessel assemblages from all time periods. Cooking jars are the most abundant vessel form, but although most cooking was carried out in these vessels, they were used for other functions as well (e.g., short-term storage). The high frequency of the cooking jar form in the sherd data set appears to be due to a relatively high breakage rate, but the form appears to have been the most common vessel type in static assemblages as well (with the possible exception of the A.D. 600-720 period). Increases in the abundance of cooking jar sherds relative to the sherds of other forms after A.D. 840 may be the consequence of increasing reliance on soaking and boiling of corn as

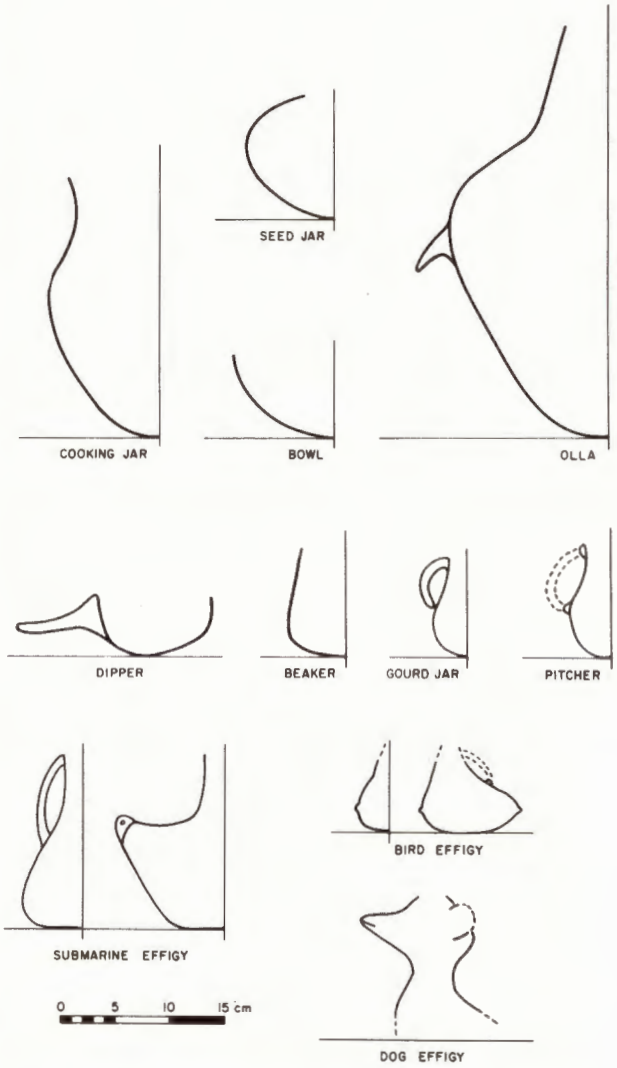

Figure 2.13 – Representative profiles of vessel form classes in A.D. 600-920 collections.

a concomitant of agricultural intensification during the population maximum in the Dolores Project area (Blinman and Wilson 1985b, 1985c).

Three size classes can be defined within the cooking jar form, and although proportions of the three size classes vary through time, the median size remains relatively constant. Both small and large jars increase in frequency relative to medium-sized jars after A.D. 840. This date marks the extreme population increase in the Dolores Project area as well as the concentration of population in aggregated villages. If vessel size is interpreted as reflecting the size of the intended consuming group, the increase in small vessels would indicate an increase in the number of instances in which food

was prepared for subsets of the household group. Conversely, the increase in large vessels would indicate an increase in the number of instances of food preparation for suprahousehold groups. Both interpretations are compatible with the observed demographic changes in that aggregation is assumed to result in an increase in field house strategies and greater potential for occasional fragmentation of the household unit. Also, aggregation would bring greater numbers of households into direct contact, which would provide more opportunities for reciprocal hosting. These possibilities are discussed in greater detail by Phagan and Blinman (chap. 11).

Bowls and saucers satisfied most of the need for serving and temporary storage functions. Frequencies of bowls vary through time, partly as a result of constraint in relation to fluctuations in jar frequency, but perhaps as a result of changing exchange relationships as well (chap. 14). Most bowls are either white or red ware vessels, with red ware bowls predominate within the A.D. 720-840 period. Many white ware vessels appear to be nonlocal to the Dolores Project area and all red ware vessels are assumed to be nonlocal. If the same types of population dislocations evident in the Dolores area occurred in the southeastern Utah area (the apparent source area for red ware vessels), the disruption in both the supply and distribution of red ware vessels is likely to have occurred. White ware vessel production does not appear to have had such a strong geographic restriction, and white ware bowls increase in frequency to compensate for the decline in red ware availability. Although red ware frequencies increase again after A.D. 880, the increase does not reverse the pattern of greater white ware production and exchange, and white ware vessels dominate the bowl form from A.D. 840.

Storage functions are associated with all wares, but forms and emphases change through time. Long-term storage of liquids was carried out in gray ware ollas for most of the A.D. 600-920 period, with increasing use of white ware ollas after A.D. 920. Early (pre-A.D. 840) gray ware ollas were often distinguished from other gray ware forms by applications of fugitive red pigment as well as by shape and function (Errickson 1985). Long-term storage of dry materials was first accomplished in gray ware seed jars, with increasing use of decorated (usually red ware) seed jars and an elaboration of forms through time. The early dry storage containers tend to be larger in volume than those in post-A.D. 840 contexts and may have more general storage functions. Short-term liquid storage functions (small volume, small orifice, high stability) encompass the greatest variety of vessel forms, including gourd jars, some effigies, some pitchers, and ring vessels. Many of these forms have been interpreted as ritual in overtone due to their biomorphic shapes, but they do not occur in great enough frequency to verify ritual interpretations through analyses of regularities of associations with ritual features or structures.

The Organization of Production and Use

Organization aspects of the production and use of ceramics are somewhat more difficult to evaluate than the technology of production and use. There is a weak indication that prior to A.D. 800 not all household groups were engaged in pottery manufacture (Blinman and Wilson 1985a). This inference is based on the absence of unfired clay or temper in collections, and the weakness of the inference is due to the difficulty in accepting negative evidence in the contexts of moderate or small samples. Later in time (after A.D. 840), evidence of pottery production is more abundant and appears to be evenly distributed within the aggregated villages (Blinman and Wilson 1985d). No large collections from either household or interhousehold cluster lack evidence of pottery production, and there is no indication of craft specialization.

Possible organizational differences in ceramic use have only been perceived in A.D. 840-920 contexts. Comparisons between front room, back room, and pitstructure vessel assemblages have revealed few differences that could be attributable to functional differentiation of the structures. These observations are weak due to small samples, but there appears to be a slightly greater diversity of vessel forms in pitstructure collections, and small cooking jars are slightly more likely to be recovered from rooms than from pitstructures (Blinman 1985). Within pitstructure floor collections, slightly higher frequencies of red ware sherds and vessels have been noted in structures that have ritual features (Wilshusen 1985). Similarly, red ware sherds are unusually abundant at those roomblocks within the A.D. 840-920 McPhee Community associated with oversize or ritually associated pitstructures (Blinman and Wilson 1985d). The nature of these 2 red ware associations is not clear, but they may be more related to an imbalance of food consumption to preparation within and in the vicinity of large or ritually oriented pitstructures. This inference is based in part on the observation that most red ware vessels are bowls and that any relative increase in food consumption during this time period will increase the local frequency of bowl breakage and red ware sherd deposition.

Basketry Resource Use and Technology

Basketry is the only class of worked vegetal materials well enough represented to evaluate contexts of economy and adaptation. Resource availability is determined by the interaction of spatial distributions of vegetation and the

potential of particular plant materials for use in basketry. Like ceramic temper raw materials, potential basketry uses for particular plant products are relatively unlimited, and this discussion is limited to plants specifically identified in Anasazi archaeological collections as being used in basketry or cordage (Adovasio 1977; Osborne 1980; Rohn 1971; Kent 1983; Morris 1980).

Of the plants identified in Anasazi basketry, those available within the Dolores Project area or in the immediate vicinity of the project area include yucca (*Yucca*), willow (*Salix*), squawbush (*Rhus aromatica*), rabbitbrush (*Chrysothamnus*), reed (*Phragmites*), dogbane (*Apocynum*), milkweed (*Asclepias*), cliff rose (*Cowania*), cattail (*Typha*), sedge (*Scirpus*), and juniper (*Juniperus*). Of these, all except the reeds would have been present if not common under all environmental conditions during the Anasazi occupation of the Dolores Project area (Petersen 1985a, 1985b). *Phragmites* is currently found at slightly lower elevations to the south and southwest of the project area and may never have been a component of the local flora (Matthews 1985).

From these available resources, the Dolores area weavers were extremely selective. Yucca was used for the majority of all cordage, plaited items, and twined items. Squawbush (in combination with small amounts of yucca) was used for nearly all coiled basketry. Reeds were used for at least 1 twined mat, and rabbitbrush was used in 1 coiled basket. Dogbane, milkweed, or cliff rose could have been substituted for yucca in cordage but was not, and willow could have been substituted for squawbush in coiled basketry but was not. The use of reeds rather than cattail or sedge in matting, even though it may not have been locally available, is presumably due to the longer and more pliable characteristics of the reed culms.

As noted previously in the description of worked vegetal materials, basketry technology as represented in DAP collections was remarkably conservative. Temporal variation in techniques is either not present or is too slight to be identifiable within the limits of sample quality. Spatial variation is greater, and although basic basketry construction types are uniform (e.g., 2 rod and welt coiled basketry), some variation can be attributed to the individual weaver.

Use of basketry as part of the adaptive toolkit is difficult to assess due to the vagaries of preservation. If the few cases of abundant finds of basketry in burned structures are assumed to be approximations of actual basketry use, then individual basketry items may have been nearly as common as pottery vessels within household assemblages. Basketry provided tray, bag, and bowl forms, as well as mats and articles of clothing. No carrying or burden baskets were found in DAP collections, but their presence is likely due to their wide spatial and temporal distribution across the Southwest (Guernsey and Kidder 1974; Adovasio 1977).

Basketry production is more difficult to assess than basketry use. The tendency for coiled basketry characteristics to be similar within structures argues for individual production with only limited distribution outside of the producing household. However, the low frequency of coiled basketry in refuse contexts (none in dry refuse deposits and some in hearth fills) suggests relatively long uselives and low rates of production, despite high inventories. Raw materials are present in some DAP contexts, but some of these may be dissociated from once whole items rather than indicating local production. The less equivocal finds of raw material are from the dry rockshelter deposits and cannot be reliably placed in time. Although some types of bone awls can be associated with coiled basketry production, characterizations of awls within the DAP bone tool analysis system (Phagan and Hruby 1984:113-115) do not allow the differentiation of these from general purpose awls, and awls cannot be used to evaluate basketry production.

Paleodemography

Paleodemography (Problem Domain 2) is concerned with the estimation of population levels within the Dolores Project area, the distribution of population across space, the estimation of household size, and the evaluation of the physical condition of the prehistoric population. Ceramic material studies have contributed to questions of paleodemography through dating of sites, studies of the accumulation of ceramic materials as estimators of occupation intensity, evaluation of possible migration instances, and variation in vessel size as a possible indicator of variation in the size of the domestic unit.

Sherd Deposition and the Duration of Site Use

Site dating has already been reviewed, and similar principles have been used in the evaluation of changing intensity of occupation within site histories (Kohler 1985; Kohler and Blinman 1984). Given sherd population estimates from probabilistic site samples, the concept of distinctive assemblages can be used to estimate the proportions of the sherd population attributed to occupation during different time periods. Stepwise regression identifies the best quantitative combination of the distinctive assemblages that can account for the estimated population. This provides an estimate of the number of sherds deposited during each of the time periods for the distinctive assemblages, and that estimate can be compared with theoretical models of sherd deposition and architectural-based population estimates.

In the application of this technique at Grass Mesa Village, Site 5MT23 (Kohler 1985; Kohler and Blinman 1984;

Blinman and Wilson 1985c), comparisons between the sherd-based estimates of occupation intensity and those based on other criteria were able to elaborate the population history of the village. A possible hiatus in site occupation in the early decades of the ninth century was weakly indicated by discontinuities in both site stratigraphy and tree-ring dating. This weak indication was supported by relatively small numbers of sherds assigned to the same time period by the regression technique.

After A.D. 880, a major change in site organization (referred to as the Grass Mesa Subphase) was evident in the distribution and architectural characteristics of pitstructures (Lipe et al. 1985). This period was also characterized by a deterioration of local agricultural conditions (Orcutt 1985a), and increasingly seasonal use of the site was 1 possible adaptive consequence. The estimated number of sherds deposited during this period is well below the number that would have been predicted based on the estimated number of households and the same pitstructure life expectancy used previously. Decreasing the assumed length of pitstructure uselife for this period improved the agreement between the sherd deposition rate and time, but the estimated number of sherds remains too small for the apparent extent of the occupation. Resolution of the conflicts appears to lie in the acceptance of the model of increasingly seasonal occupation at the site after A.D. 880, with a resultant decrease in sherd deposition per household per year at the site.

Evaluation of Long-Distance Immigration

The reconstruction of population history within the Dolores Project area calls for periods of immigration as necessary explanations for some of the observed population increases (Schlanger 1985). This, coupled with the possible importance of long-distance population dislocations in Southwestern prehistory (Berry 1982:103-126), prompted examination of DAP ceramic distributions for evidence of immigration. Distinctions between ceramic distributions resulting from exchange and those resulting from the movement of households with their associated possessions are difficult to perceive, and a conservative model of migration evidence was adopted (Wilson 1985).

Migration of a potter into the area is assumed to be detectable only when the potter persisted in employing aspects of production technology or decorative style that contrasted with local technologies. This persistence would result in the manufacture of nonlocal appearing vessels using locally available resources. These nonlocal appearing products would be restricted in their spatial and temporal distributions and should co-occur with the similar nonlocal items. Since communication between the migrant and the homeland could conceivably continue, subsequent exchange could also occur along the established linkage.

Adoption of this model of ceramic migration evidence precludes the identification of short-distance migration due to the similarity of ceramic technology within the northern Mesa Verde region. However, 2 potential cases of long-distance migration were identified within the DAP collections. These were based on the use of glaze paint in Mesa Verde White wares in the eastern portion of the Mesa Verde region (Waterworth 1985) and the use of a smudging technology in Mogollon ceramics (Wilson 1985).

Although not common, glaze painted sherds occur in DAP collections, and the temper associated with most of these sherds is identical to that found in unfired clay from DAP collections (Waterworth 1985). Glaze paint is commonly associated with white wares from the Durango area of the Animas River valley in the eastern Mesa Verde region (Carlson 1963; Ellwood 1980), and both gray and white ware sherds originating from the Durango area are associated with a distinctly different temper (Lucius 1982). Based on the temper difference, the majority of the DAP sherds were possibly locally produced, rather than imported. Verification of local production was sought through comparison of refired clay characteristics, and gray ware sherds from La Plata River valley sites were included for an additional comparison. The DAP glaze painted sherds do not match the clay characteristics of DAP clays or gray ware sherds, nor do they match the temper of Animas River valley gray wares or glaze painted white wares, but they do match the clay and temper characteristics of La Plata River valley gray wares. The clay color data contradicted the initial impression that local production of glaze painted white wares occurred, and there is no basis for asserting that immigration took place from the eastern Mesa Verde region.

The case for immigration from the Mogollon region is much stronger; but it is not conclusive, and if it occurred it could not have involved many individuals (Wilson 1985). Mogollon smudged ware sherds occur in some DAP collections based on the occurrence of a non-Mesa Verde temper (Wilson and Blinman 1985a) in association with highly polished and smudged bowl sherds. In addition, local crushed igneous rock temper has been identified in smudged sherds, although smudging is not acknowledged as a technique within the repertoire of Mesa Verde region potters. The smudged Mesa Verde sherds could simply be errors in the execution of white ware firing, but the appearance was judged to be too consistent for all examples to be explained in this way. Refiring analyses of samples of the 2 smudged wares verified the distinctiveness of the clays associated with the 2 tempers, and the locally tempered smudged clays are similar to Dolores Project area archaeological clays and gray ware sherds.

The characteristics of the smudged sherds satisfy the initial conditions of the model of potter immigration, but the temporal and spatial distributions are not strongly supportive. Both the Mogollon and Mesa Verde smudged sherds are widely distributed in time, and for some of the Mogollon sherds, exchange is the most probable explanation. However, some spatial concentrations of the Mesa Verde smudged sherds suggest localized production at specific sites, and these sites also include Mogollon sherds. If these collections do reflect the consequences of Mogollon immigration, very few potters are involved, and this source of immigration is insignificant in the face of Dolores area population growth and larger models of regional immigration.

Variation in Household Size

Broad population trends within the Dolores Project area are expressed in units of numbers of households that can be inferred from architectural remains (Schlanger 1985; Orcutt 1985b), but population changes can occur as changes in the size of households as well as their number. Cooking jar volume has been used as a proxy measure for the size of prehistoric household groups (Turner and Lofgren 1966). The basic premise is that cooking jar volume will change if the size of the food consuming unit changes, and that measured change in archaeological collections of cooking jars can be used as a measure of change in the size of prehistoric households. When calibrated with ladle and bowl volumes as indicators of serving size, jar volumes from western Pueblo archaeological contexts were interpreted as reflecting a slight increase in household size, from 4.5 to 4.8 to 5.1 persons for the periods A.D. 500-750, 750-900, and 900-1250 (Turner and Lofgren 1966:table 3).

Although the Turner and Lofgren study produced plausible results, an ethnoarchaeological evaluation of the basic premise suggests the relationship between cooking jar volume and household size is not necessarily direct (Nelson 1981). Correlations were poor between mean vessel volume and household size for Highland Maya village data, and the relationship appears to be complicated by factors such as social rank, area of associated fields, and age grade composition of households. In the context of a long temporal span, further confounding effects could include changes in dietary composition, food preparation techniques, or the social definition of the food-consuming unit.

Within the context of A.D. 600-920 culture change in the Dolores area, no conclusive indications of differential access to status items or to land are found. As a result, the confounding effects of social rank and economic status factors are likely to be less important considerations than in the Maya ethnographic case. However, the relationship between vessel size and household size in the Dolores area could be confused by dietary change (increasing reliance on agricultural products as part of population increase and resource intensification) and by changes in the definition of the food-consuming unit (larger gatherings and greater social interaction between households as a consequence of aggregation [Orcutt 1985b]).

With these caveats in mind, vessel volume data (calculated as part of the study of DAP vessels and vessel assemblages [Blinman 1985]) for bowls and cooking jars were assembled. Histograms (based on both 0.5- and 1.0-L intervals) of these volumes are presented by time period in figures 2.14 and 2.15 Extremely small or extremely large bowls were not likely used for routine meal consumption. Based on the summary histogram of bowl volumes (fig. 2.14), those bowls smaller than 0.25 L and those larger than 3 L are assumed not to have significant roles in food consumption. This range includes most bowls for all time periods. Extremely small cooking jars are likely to have served either subsets of the household or to have been used to prepare condiments rather than staples. The extremely large cooking jars are also unlikely to reflect household food preparation (the largest jars are associated with post-A.D. 840 villages (cf. Turner and Lofgren 1966:125-127). For these reasons, and based on examination of the summation of cooking jar volumes (fig. 2.15), only those jars between 2 and 6 L in volume are considered to be representative of normal food preparation activities. Limiting the cooking jar volume range based on the breakpoints in the summation histogram appears to be appropriate for the A.D. 800-920 periods, but a smaller initial break point would have been chosen if the decision had been based on the A.D. 720-800 collection.

Mean volumes of DAP bowls and cooking jars for the A.D. 720-920 period are presented in table 2.8. Bowl volumes fluctuate and no unidirectional trend continues through time, possibly due to sampling error associated with the relatively small samples sizes for each period (between 6 and 13 bowls). Mean jar volumes are based on larger samples (ranging from 13 to 25), and show a consistent increase through time. The increase is relatively sharp (more than 0.6 L) across the A.D. 800 threshold but is relatively minor (less and 0.2 L) thereafter. Assuming a constant serving size based on the grand mean for DAP A.D. 720-920 bowls (1.32 L), mean jar capacity increases by nearly half of a serving across the A.D. 800 threshold, but increases by only 0.02 and 0.12 serving across the next 2 thresholds.

If dietary, organization, and other aspects of the Dolores area cultural systems were constant, these changes

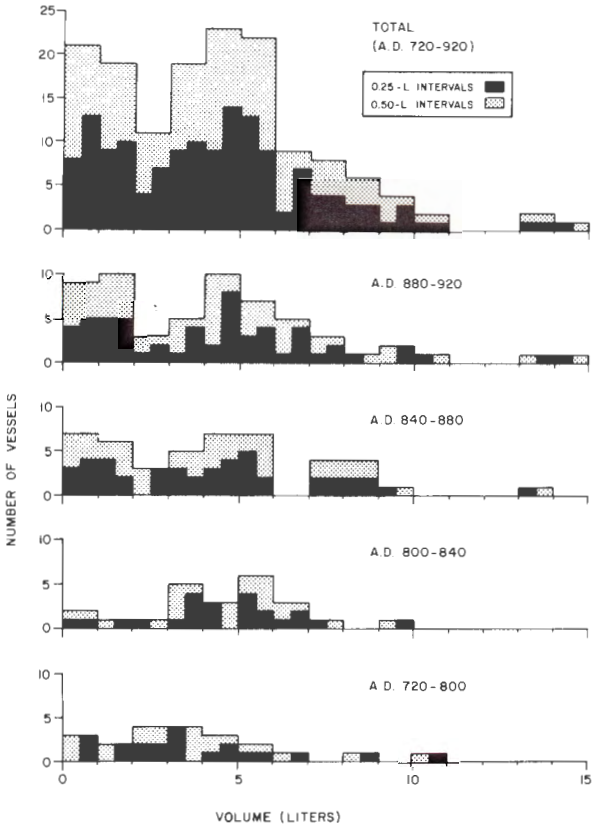

Figure 2.14 – Volumes of bowls by time period for Dolores Archaeological Program vessel assemblages. Histograms are constructed for both 0.25 L (dark shading) and 0.5 L (light shading) intervals. The A.D. 600-720 bowls are not included in the summation because no precisely measurable cooking jars were available from this time period for comparison.

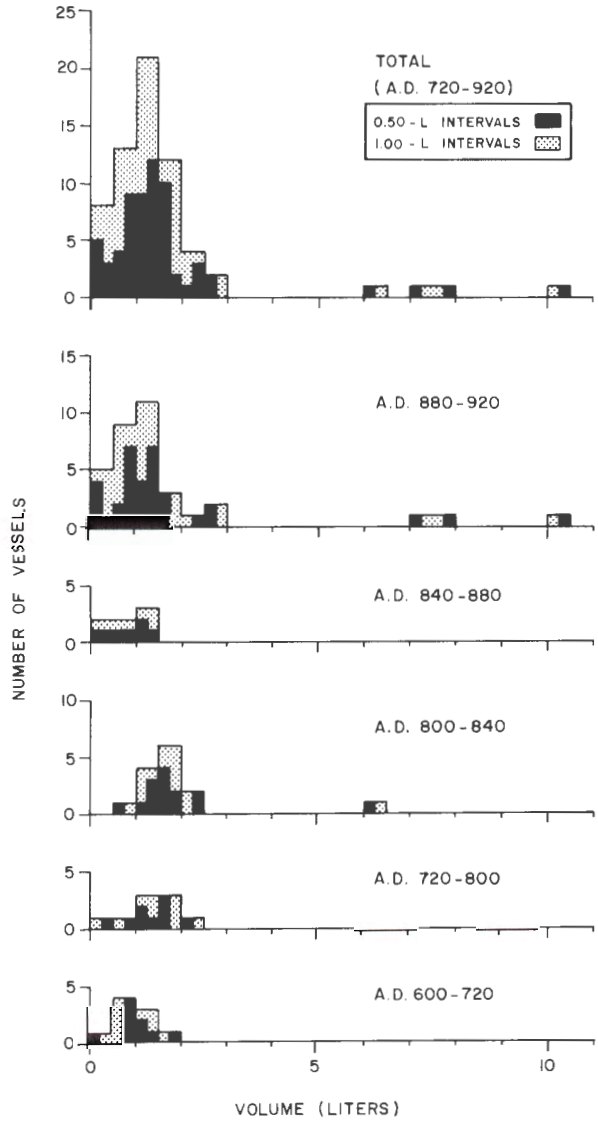

Figure 2.15 – Volumes of cooking jars by time period for Dolores Archaeological Program vessel assemblages. Histograms are constructed for both 0.5 L (dark shading) and 1 L (light shading) intervals. Only precisely estimated volumes were included; thus, A.D. 600-720 vessels were excluded.

could be interpreted as an increase in household size across the A.D. 800 period with stability or only very slight increases thereafter. However, mitigating factors are present that limit the confidence in these interpretations. The greatest of these affects the A.D. 800 threshold and consists of a change in the style of cooking jar shape. Chapin Gray jars with a relatively constricted neck dominate pre-A.D. 800 vessel assemblages, but give way to Moccasin Gray and Mancos Gray jars with flaring necks after A.D. 825. Since jar volumes were measured to the rim, this change in neck shape would tend to increase the measured volume of post-A.D. 800 cooking jars without necessarily increasing the functional volume. Conceivably the change of shape was an adaptation to accommodate a demand for a larger cooking volume, but the implications for household size are suspect.

The post-A.D. 800 period is also the period in which population aggregation increases dramatically and in which a potential change toward an increased reliance on corn in the diet occurs. In the face of these possible contributing factors, the small increases in cooking jar volume after A.D. 800 need not be reflecting household size change. However, if we assume that the factors independent of household size are selecting for larger cooking jars, then the stability and relatively minor increase through the A.D. 800-920 period is reflecting stability of household size rather than growth. If this conclusion can be supported through independent lines

Table 2.8 – Mean bowl and jar volumes and volume ratios

Vessel form	Period (A.D.)				Grand mean
	720-800	800-840	840-880	880-920	(A.D. 720-920)
Bowl	1.325 L	1.605 L	0.933 L	1.259 L	1.316 L
Jar	3.658 L	4.287 L	4.319 L	4.471 L	4.249 L
Jar/bowl	2.76	2.67	4.63	3.55	3.23
Jar/bowl*	2.78	3.26	3.28	3.40	3.23

* Ratio of period means of jar volumes to grand mean of bowl volumes.

of evidence (e.g., living floor area, burial population data), then it would support the immigration model, as opposed to the internal growth model, of the A.D. 860-880 population maximum in the Dolores Project area (chap. 8).

Social Organization

Social organization (Problem Domain 3) includes studies of group definition, status, integration, economic organization, political organization, and ideology, Ceramic contributions include discussions of the social interaction aspects of ceramic exchange, the organization of ceramic production, and the evaluation of status- and ritual-related concentrations of ceramic materials. These contributions are necessarily indirect, are often assumption laden, and some aspects have received more detailed treatment under the discussions of other problem domains.

Ceramic Production and Social and Economic Interaction

Two patterns of ceramic production may have been operable within the A.D. 600-980 period in the Dolores Project area (Blinman and Wilson 1985a, 1985d). Between A.D. 600 and 800, evidence of ceramic manufacture is scarce and appears to be unevenly distributed, leading to the weak inference of small-scale specialization in gray ware manufacture. Clay characteristics of gray and white ware sherds are also disparate, suggesting even greater specialization in white ware manufacture. Red ware manufacture does not appear to have been part of the production repertoire of Dolores area potters and it was the object of strong regional specialization. This probable scenario implies levels of interdependence, with mandatory economic and social ties between gray ware producing and consuming households, and a more extensive exchange and social network through which decorated ceramics were obtained.

By A.D. 860 and through at least A.D. 980, ceramic manufacturing evidence is much more abundant and is so evenly distributed that most household groups were likely engaged in the manufacture of gray ware vessels (Blinman and Wilson 1985d). White ware manufacture continued to be more specialized, but the overlap between gray and white ware clay characteristics suggest some white ware sources were present locally near the large populations in the Dolores Project area. Red ware vessel sources continued to be regionally restricted. The removal of most gray ware vessel procurement needs as motivation for exchange suggests that subsequent gray ware vessel movement would reflect social more than economic interactions. This scenario implies more geographically restricted economic networks, and the greater density of population implies less geographically extensive social networks as well.

Political and Ritual Determinants of Ceramic Distributions

Recent Southwestern studies have placed considerable emphasis on the roles of valued ceramic materials as symbols in the operation of political and ceremonial systems (Feinman et al. 1981; Upham et al. 1981; Upham 1982; Lightfoot 1984). Valued ceramics are defined as those requiring considerable effort in their production, and corollaries include visual distinctiveness, nonlocal production, and scarcity. The premise of the cited studies is that these ceramics are symbols exchanged between the leadership elite within social or political systems, and that the items could be banked within the broader economic relations between systems. From this assumption, the spatial distributions and occurrences of these ceramics provide evidence for both the existence and the spatial organization of such systems.

Although no suggestions of systematic social ranks appear in DAP burial accommodations or in living room sizes or associations, changes through time in geographic foci of ritual and perhaps political activity do occur within the Dolores Project area. An oversize A.D. 720-800 pit-structure at Grass Mesa Village is unique within the known contemporary structures in the Dolores Project area and was followed closely in time (ca. A.D. 800) by the construction of a great kiva at the same site (Lipe et

al. 1985). This structure fell into disuse within the next 20 years, and an unroofed great kiva was established in a rockshelter (Singing Shelter, Site 5MT4683) about 4.5 km to the south sometime in the first half of the ninth century (Nelson and Kane 1985). This great kiva, in turn, fell into disuse sometime before A.D. 920 and possibly prior to A.D. 860 (the exact timing is unknown), and a series of very large pitstructures was incorporated into some of the roomblock units in the McPhee Community Cluster (about 1.5 km to the southwest) in the middle ninth century A.D. These structures appear to have continued in use through the A.D. 800's, with what appears to have been an abortive construction of another great kiva within the McPhee Community Cluster sometime after A.D. 880 and probably before A.D. 900 (Pueblo de las Golondrinas, Site 5MT5107 [Brisbin 1984]).

Sherd collections associated with these architecturally defined foci or ritual and perhaps political activity are presented in table 2.9. Collections are reported by source category and by the dichotomy between gray and decorated wares. The Dolores Tract sherds include those local to the Dolores Project area as well as some that may have been manufactured elsewhere within the Mesa Verde region. The other Mesa Verde category includes all those sherds manufactured within the Mesa Verde region but that are unlikely to have been produced within the Dolores Project area. Extraregional sherds are those believed to have been manufactured outside of the Mesa Verde region, and those of indeterminate affiliation could not be classified, usually because of ambiguous temper characteristics. The decorated ware category includes all white, red, and smudged or brown ware sherds. Individual types were not distinguished on the basis of production steps measures (Feinman et al. 1981) because of the scarcity of the high-value types (their absence from collections could in all cases be attributable to sampling error).

Collection content is defined by spatial association with a particular ritual focus and by contemporary collections not associated with the ritual focus. Since no contemporary habitations were associated with the great kiva at Singing Shelter, the collections reported here are derived from contemporary villages (Rio Vista Village, Site 5MT2182 [Wilshusen, comp. 1985], and House Creek Village, Site 5MT2320 [Robinson and Brisbin 1984]) that, on the basis of proximity, are assumed to be part of the great kiva "community." The McPhee Community Cluster (Kane 1985) is a village composed of a tight cluster of sites (individual roomblocks), several of which have the oversize pitstructures. The McPhee Community Cluster collections include some contaminating sherds from later occupations within the immediate vicinity. The collections from these occupations contain higher proportions of nonlocal sherds than those from the occupations being considered here, similar sources of contamination are rare at the comtemporary sites away from the McPhee Community Cluster, and the contamination will artificially raise the nonlocal proportions associated with the oversize pitstructures. The pottery types contributing to the McPhee Community Cluster collections have been reviewed (2 sherds are clearly extraregional contaminants and an additional 15 sherds could be extraregional contaminants), and the number of contaminants does not significantly affect the proportion of nonlocal sherds.

The effort measure of vessel value implies that the decorated wares should be more abundant at the ritual foci, and since the concepts of alliance and exchange of goods are linked with possible political interpretations of these foci (Upham 1982), nonlocal ceramics may also be more abundant. Both expectations are met for the time period during which the oversize pitstructure at Grass Mesa Villge was occupied. Decorated ceramics comprise 15.2 percent of the Grass Mesa Village collections as opposed to only 9.5 percent in contemporary occupations elsewhere in the Dolores Project area. The most dramatic difference, however, is in an extremely high proportion of nonlocal gray wares at the village. This does not carry over to the proportion of nonlocal decorated wares for which the differences in source proportions between Grass Mesa Village and the other collections are not significant due to the small number of decorated sherds from Grass Mesa Village.

During the subsequent use of the great kiva at Grass Mesa Village, the differences in proportions are the opposite of these expected based on the potential ritual and political implications of the presence of the structure. Decorated sherds comprise only 9.9 percent of the Grass Mesa Village collection, whereas they comprise 12.5 percent of other contemporary collections. (This difference would be marginally significant if the collections could be interpreted as random samples.) In addition, a smaller proportion of the decorated sherds are nonlocal (although nonlocal gray ware sherds remain more common at the village than elsewhere). The perceived differences in decorated sherd frequencies may reflect the higher variability associated with archaeological sampling and clustering of vessels, in which case no claim could be made for significance of the different proportions.

Proportions of decorated sherds are different in the direction expected for ritual foci during the slightly later use of the great kiva at Singing Shelter. Decorated sherds comprise 13.0 percent of collections from Rio Vista and House Creek Villages, whereas they only comprise 10.6 percent in the remainder of the project area. Nonlocal sherds are also considerably more abundant in association with the 2 villages, and nonlocal decorated sherds account for nearly all of the perceived difference. The large sample sizes for the 2 collections

Table 2.9 – Sherd source frequencies at ritual foci within the Dolores Project area

Location	Sherd origin	Gray		Ritual focus Decorated		Total		Contemporary collections					
								Gray		Decorated		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Oversize pitstructure at Grass Mesa Village	Dolores Tract	881	87.1	52	28.6	933	78.1	17 300	97.1	622	33.3	17 922	91.0
	Other Mesa Verde	127	12.5	25	68.7	252	21.1	452	2.5	1228	65.8	1 680	8.5
	Extraregional	4	0.4	2	1.1	6	0.5	38	0.2	9	0.5	47	0.2
	Indeterminate			3	1.6	3	0.3	29	0.2	7	0.4	36	0.2
Total		1 012	100.0	182	100.0	1 194	100.0	17 819	100.0	1866	100.0	19 685	100.0
Great kiva at Grass Mesa Village	Dolores Tract	2 381	93.9	65	23.3	2 446	86.9	15 515	96.3	388	14.7	15 853	86.1
	Other Mesa Verde	137	5.4	206	73.8	343	12.2	498	3.1	1932	84.2	2 430	13.2
	Extraregional	7	0.3	8	2.9	15	0.5	80	0.5	16	0.7	96	0.5
	Indeterminate	11	0.4			11	0.4	20	0.1	8	0.3	28	0.2
Total		2 536	100.0	279	100.0	2 815	100.0	16 113	100.0	2294	100.0	18 407	100.0
Great kiva at Singing Shelter	Dolores Tract	6 242	98.1	201	21.2	6 443	88.2	9 876	98.0	570	47.9	10 446	92.7
	Other Mesa Verde	115	1.8	748	78.8	863	11.8	152	1.5	613	51.5	765	6.8
	Extraregional	2	0.0			2	0.0	40	0.4	7	0.6	47	0.4
	Indeterminate	1	0.0			1	0.0	7	0.1	1	0.1	8	0.1
Total		6 360	100.0	949	100.0	7 309	100.0	10 075	100.0	1191	100.0	11 266	100.0
Oversize pitstructures at McPhee Community Cluster	Dolores Tract	35 009	97.6	2009	45.6	37 018	91.9	22 296	98.0	1077	45.5	23 373	93.1
	Other Mesa Verde	768	2.1	2260	51.3	3 028	7.5	395	1.7	1270	53.7	1 665	6.6
	Extraregional	77	0.2	99	2.2	176	0.4	24	0.1	17	0.7	41	0.2
	Indeterminate	20	0.1	40	0.9	60	0.1	25	0.1	1	0.0	26	0.1
Total		35 874	100.0	4408	100.0	40 282	100.0	22 740	100.0	2 365	100.0	25 105	100.0

decrease the probability that the perceived differences could be interpreted as sampling error.

Differences persist in the expected direction of ceramic distributions during the use of the oversize pitstructures at the McPhee Community Cluster, but the differences decrease in magnitude. Decorated sherds comprise 10.9 percent of the McPhee Community Cluster collections during this period and 9.4 percent of other collections. At smaller collection sizes, this difference could not be interpreted as significant, but the proportions should be relatively stable in these cases. One explanation for the small differences could be the scale of comparison, in that the specific roomblocks associated with the oversize pitstructures have higher proportions of decorated sherds than do the remaining roomblocks (Blinman and Wilson 1985d). Nonlocal sherds are also slightly more abundant at the McPhee Community Cluster, but the difference is due to gray wares and extraregional decorated wares rather than to other Mesa Verde decorated wares.

The characteristics of these dichotomies support the association of valued ceramics with architecturally defined ritual foci in most cases. The significant exception is the great kiva at Grass Mesa Village, whose associated ceramic collection is in opposition to the expected trends. In general, differences are more consistently manifested in higher frequencies of decorated ceramics (primarily bowl forms) at the ritual foci than in concentrations of nonlocal decorated ceramics. This observation increases the probability that the association has stronger ritual implications than political implications. If the architectural foci were associated with the operation of regional, exchange-cemented alliances (Upham 1982), the representation of nonlocal decorated ceramics would be expected to be as strong as the representation of decorated ceramics as a whole.

Although the association between decorated ceramics and the ritual association is defensible at a general level, the small magnitude of the differences contrasts with the obvious differences attributed to "centers" reported by Upham et al. (1981). Although collection sizes and sherd frequencies are not reported, these authors assert a strong relationship between the presence of high-value pottery types and large sites, and the near absence of the types at small sites. In the Dolores Project area, a similar relationship holds for sites with and without great kivas or oversize pitstructures, but the differences are not obvious, and the differences could not be defended as other than sampling error without collection sizes of thousands of sherds.

Extraregional Relationships

Studies of extraregional relationships (Problem Domain 4) overlap with studies of production (i.e., the definition of what is local), economic aspects of provisioning, and social aspects of exchange. Such studies have been a traditional use of ceramic data in archaeological interpretation (along with dating inferences), and specific descriptive discussions of ceramic exchange have been included in a variety of ATG reports (Blinman and Wilson 1985a, 1985b, 1985c, 1985c, 1985d; Wilson and Blinman 1985b; Errickson and Wilson 1985; Waterworth 1985; Wilson 1985). In addition, models of ceramic exchange are included in the synthesis of exchange as part of the larger study of culture change in the Dolores Project area (chap. 14).

Exchange inferences assume that locally produced vessels (those assigned to the Dolores Manufacturing Tract) will be tempered with crushed igneous rock, but that at least some of the Dolores Tract sherds are derived from outside of the Dolores Project area. Gray ware vessels are assumed to be produced locally, with some level of specialization prior to A.D. 800 and no significant specialization after A.D. 840. White ware vessels are assumed to be produced in only limited quantities within the Dolores Project area, and a larger proportion of the Dolores Tract white ware sherds than gray ware sherds is assumed to be derived from vessels manufactured outside of the Dolores Project area. Red ware vessels are all assumed to be manufactured outside of the Dolores Project area, specifically in the southeastern Utah area.

Archaeological ware distinctions correspond relatively closely to production and function categories in the prehistoric cultural system. Gray ware vessels are the most locally accessible for all time periods, and their predominant use as cooking jars insures a relatively high rate of breakage and replacement. White ware vessels are less accessible for all time periods, and their predominant uses as serving containers (bowls) and storage containers results in their less frequent breakage and replacement. Red ware vessels are the least accessible of the ware categories, they are almost exclusively used for serving (bowls) and long-term storage of small quantities of dry materials, and their rate of breakage and replacement should be similar to that of white ware vessels.

Based on the differences in accessibility and use, exchange networks for vessels of each ware should have somewhat different configurations (cf. Fry 1980; Blinman and Wilson 1985d). Gray ware vessels should be locally available, and although some household provisioning of gray ware vessels would have to occur prior to A.D. 800, their exchange after A.D. 840 is likely to have occurred as an adjunct to the movement of their contents. However, long-distance movement of large quantities of goods is more easily accomplished in bags or baskets (cf. Lightfoot 1979), and transport in gray

ware jars is more likely to be associated with the movement of partially processed foods over short distances. Most white ware vessels would have to be obtained through exchange, but sources were probably widely distributed across the Mesa Verde region. White ware vessels (and decorated vessels in general) also have enhanced visual characteristics, and their exchange could be conditioned by symbolic content, but the vessel form charateristics of white wares limit the potential for their exchange as an adjunct to the exchange of their contents. The geographically restricted source of red ware vessels requires their exchange as a commodity, their visual characteristics support the potential for symbolic influences on exchange, and their vessel form characterstics imply limited exchange as an adjunct to the exchange of vessel contents.

Vessels are assumed to have been the unit of exchange, but the archaeological measurement of exchange must be based on sherd counts. Project area summations include tens of thousands of sherds, and with samples this large, even small differences in frequencies (as little as 0.1 percent) would be significant if the collections could be interpreted as random samples of populations of sherds. Although unbiased, the collections are not random samples, and instead they have some of the properties of cluster samples. The consequence of this is that extreme variance in frequencies should be expected due to the occasional recovery of clusters of sherds from a single vessel. Since it is impossible to determine the presence of vessel clusters based on summarization of ceramics across all DAP sites, the following conventions will be used in interpretation. Differences in proportions of sources within wares will only be considered for interpretation if the differences are sufficient to be considered significant at a 0.05 level using a test for equality of percentages (Sokal and Rohlf 1969:607-610). Numbers of sherds will be used as a further screening criteria, as will pottery type and vessel form classifications, and site affiliation data when they are available.

Frequencies of sources for ceramic materials are presented by ware and time period in table 2.10. These data reflect confidently dated excavated collections only, and post-A.D. 980 materials are not represented. (For a review of the later ceramic exchange patterns based on survey collections and less precise dating resolution, refer to Wilson and Blinman [1985b]). Due to the multiple occupations of many DAP sites, some contaminants are present in the collections. These contaminants have not been removed, but they have been noted in discussions when their presence affects interpretation. Sources are expressed as manufacturing tracts within the Mesa Verde region (refer to fig. 2.8) and as culture categories for extraregional sherds. Some ambiguity exists as to the affiliations of sand and crushed sandstone tempered gray and white ware sherds (assigned to the Cibola and the Kayenta or Cibola Culture Categories), and some of these sherds may be of Mesa Verde origin (Wilson and Blinman 1985a).

Gray ware sherds comprise the majority of the collections, with a minimum collection size of slightly over 10 000 sherds. Within these large samples, differences in proportions of as little as 0.1 percent from period to period would be significant if the collections represented random samples. However, the potential variability of cluster effects and the differences from site to site within periods suggest caution when percentages of a source are based on less than 100 sherds.

The vast majority of gray ware sherds are derived from Dolores Tract sources for all time periods. The proportion of Dolores Tract sherds increases steadily from A.D. 600 through 920, and then decreases to a low of about 93 percent in the A.D. 920-980 period. San Juan Tract gray ware sherd frequencies fluctuate at 1 percent or less through A.D. 920, but increase to almost 6 percent in the A.D. 920-980 collection. The majority of the non-Dolores Tract sherds are derived from the Cahone and Sandstone Tracts through A.D. 880, but the frequencies of sherds from these sources decline consistently from period to period until they stabilize at about 0.5 percent after A.D. 880. Frequencies of extraregional gray ware sherds fluctuate between 0.1 and 0.5 percent, but prior to A.D. 880 most are sand and crushed sandstone tempered sherds, the origins of which are equivocal. Chuska Gray Ware sherds are the only unequivocal extraregional category and are present in more than trace quantities only in the post-A.D. 880 collections. Although present in the A.D. 600-720 collection, this sherd is probably a contaminant from a later adjacent site, since the use of trachybasalt temper in the Chuskan region is rare in Basketmaker III times (Toll and McKenna 1980).

White ware sherds are present in all time periods but are present in much smaller quantities than are gray ware sherds. The smallest collection size is only 671 sherds, and all but 2 of the collections contain fewer than 2000 sherds. These smaller collection sizes imply a relatively greater instability of proportions due to cluster effects and other sampling errors. As a whole, the white ware category fluctuates as a proportion of the total collection size, decreasing through A.D. 840 (probably due to constraint caused by the introduction and increasing popularity of red wares in the A.D. 720-840 periods) and then increasing slightly through A.D 920 and dramatically thereafter.

Dolores Tract white ware sherds always constitute a plurality of the white wares, but Dolores Tract white wares are always relatively less abundant than Dolores Tract

Table 2.10 – Frequencies of ceramics by ware and presumed source in dated collections

Time period (A.D.)	Ware	Mesa Verde manufacturing tracts												Cibola		Kayenta		Kayenta or Cibola		Chuska		Mogollon		Indet		Total	
		Dolores		San Juan		Cahone		Sandstone		Animas		Blanding															
		(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)
600-720	Gray	9 594	94.6	52	0.5	297	2.9	151	1.5	1	0.0							14	0.1	1	0.0			27	0.3	10 137	93.8
	White	588	87.6	34	5.1	8	1.2	26	3.9							2	0.3	5	0.7					8	1.2	671	6.2
	Red											2	66.7			1	33.3									3	0.0
	Total N	10 182		86		305		177		1		2				3		19		1				35		10 811	
	Total %		94.2		0.8		2.8		1.6		0.0		0.0				0.0		0.2		0.0				0.3		100.0
720-800	Gray	22 054	95.5	76	0.3	524	2.3	271	1.2	2	0.0			89	0.4			33	0.1	1	0.0			50	0.2	23 100	90.4
	White	872	82.0	74	7.0	76	7.1	24	2.3					3	0.3	1	0.1	4	0.4					9	0.8	1 063	4.2
	Red											1359	99.7			1	0.1							3	0.2	1 363	5.3
	Smudged	30	85.7																			5	14.3			35	0.1
	Total N	22 956		150		600		295		2		1359		92		2		37		1		5		62		25 561	
	Total %		89.8		0.6		2.3		1.2		0.0		5.3		0.4		0.0		0.1		0.0		0.0		0.2		100.0
800-840	Gray	26 124	97.0	259	1.0	311	1.2	130	0.5	1	0.0			26	0.1			63	0.2	3	0.0			25	0.1	26 942	86.9
	White	741	68.4	315	29.1	4	0.4	4	0.4					2	0.2	3	0.3	9	0.8	1	0.1			5	0.5	1 084	3.5
	Red											2988	100.0											1	0.0	2 989	9.6
	Smudged	1	33.3																			2	66.7			3	0.0
	Total N	26 866		574		315		134		1		2988		28		3		72		4		2		31		31 018	
	Total %		86.6		1.9		1.0		0.4		0.0		9.6		0.1		0.0		0.2		0.0		0.0		0.1		100.0
840-880	Gray	25 135	97.7	208	0.8	239	0.9	48	0.2	7	0.0			22	0.1			41	0.2	4	0.0			22	0.1	25 726	90.4
	White	1 051	83.5	124	9.8	18	1.4	33	2.6					2	0.2	13	1.0	6	0.5	5	0.4			7	0.6	1 259	4.4
	Red											1453	99.5							2	0.1			6	0.4	1 461	5.1
	Smudged	15	88.2																			2	11.8			17	0.1
	Total N	26 201		332		257		81		7		1453		24		13		47		11		2		35		28 463	
	Total %		92.1		1.2		0.9		0.3		0.0		5.1		0.1		0.0		0.2		0.0		0.0		0.1		100.0
880-920	Gray	45 863	98.0	430	0.9	160	0.3	101	0.2	6	0.0			11	0.0	18	0.0	71	0.2	67	0.1			83	0.2	46 810	88.5
	White	2 807	76.8	669	18.3	5	0.1	15	0.4					52	1.4			27	0.7	40	1.1			39	1.1	3 654	6.9
	Red											2411	99.5							2	0.1			10	0.4	2 423	4.6
	Smudged	2	66.7																			1	33.3			3	0.0
	Total N	48 672		1099		165		116		6		2411		63		18		98		109		1		132		52 890	
	Total %		92.0		2.1		0.3		0.2		0.0		4.6		0.1		0.0		0.2		0.2		0.0		0.2		100.0
920-980	Gray	19 695	92.9	1248	5.9	62	0.3	35	0.2	1	0.0							22	0.1	75	0.4			52	0.2	21 190	80.4
	White	1 925	49.4	1713	44.0	8	0.2	4	0.1					65	1.7	12	0.3	70	1.8	68	1.7			28	0.7	3 893	14.8
	Red											1274	99.7							1	0.1			3	0.2	1 278	4.8
	Smudged	1	50.0																			1	50.0			2	0.0
	Total N	21 621		2961		70		39		1		1274		65		12		92		144		1		83		26 363	
	Total %		82.0		11.2		0.3		0.1		0.0		4.8		0.2		0.0		0.3		0.5		0.0		0.3		100.0

NOTE: Indet – Indeterminate.

gray wares. The A.D. 800-840 collection has an unusually small amount of Dolores Tract white wares relative to the adjacent periods, but this is due in part to the presence of several reconstructible San Juan Tract vessels at a single site. If this site is excluded from the period summation, the Dolores Tract white ware sherd frequency rises to 77.7 percent. Using this revised figure and acknowledging the instability of proportions due to sample size, the A.D. 600-920 period is characterized by about 80 percent "local" white wares. After A.D. 920, this frequency drops to just under 50 percent.

Most nonlocal white wares are derived from Mesa Verde region sources. San Juan Tract sherds comprise between 5 and 10 percent of the white ware sherds between A.D. 600-880 (ignoring the inflated value for A.D. 800-840) but increase dramatically to 44 percent from A.D. 880 through A.D. 980. Cahone and Sandstone Tract sherds fluctuate in abundance around 4 percent through A.D. 880 (again ignoring the A.D. 800-840 frequency), but account for 0.5 percent or less thereafter.

Extraregional white ware sherds suffer from ambiguities of affiliation similar to those of gray ware sherds, with the exception of organic painted sherds from the Kayenta region and the trachybasalt tempered Chuskan sherds. Frequencies of the extraregional sherds remain at about 1 percent through A.D. 840, but the definite extraregional sherds remain below 0.5 percent. After A.D. 840 the proportion of extraregional sherds increases steadily, with increasing contributions from both the Chuska and Cibola Culture categories. Kayenta sherds remain scarce as the other culture categories increase, and this perceived trend is probably robust since the collection sizes exceed 3000 white ware sherds after A.D. 880.

Red ware sherds represent a variety of ceramic traditions. The 2 Kayenta red ware sherds in the collections are sherds from Tallahogan Red vessels, and some of the A.D. 600-800 Blanding Tract red ware sherds are slipped sherds from Dolores Red vessels (the Mesa Verde technological equivalent of Tallahogan Red). The single remaining Mesa Verde (San Juan) Red Ware sherd in the A.D. 600-720 collection is a contaminant, and the earliest "classic" Mesa Verde Red Ware sherds (from Abajo Red-on-orange or Bluff Black-on-red vessels) occur in the A.D 720-800 collection. The frequency of the classic red ware sherds jumps to just over 5 percent immediately upon their introduction, and they reach a high of just under 10 percent in the A.D. 800-840 period. Tallahogan Red is not present in collections after A.D. 800, and although sherds from Sanostee Black-on-red vessels (Chuska Culture Category) are present after A.D. 840, Blanding Tract sherds account for over 99 percent of the red wares.

Smudged sherds are attributable to both the Dolores Tract and the Mogollon region, and sherds from both sources are present continuously from A.D. 720 through A.D. 980. The high frequency of Dolores Tract sherds in the A.D. 720-800 collection is due to a cluster of sherds from at least 2 vessels from a single site. Other than this cluster, smudged sherds are always scarce and their fluctuations in frequency are probably more appropriately attributed to sampling error than to variation in regional interactions.

The patterns of sources within the different wares conform partially to the general assumptions about the interaction between production and exchange. Nonlocal gray ware vessels are more common in the A.D. 600-800 period, when production appears to have been somewhat specialized, than in the A.D. 800-920 period, when gray ware production was ubiquitous. Interactions throughout most of this period extended to the west and southwest, with the intensity of interaction decreasing abruptly after A.D. 880.

However, the production explanation breaks down due to an unexpectedly high frequecy of nonlocal gray ware sherds associated with the A.D. 920-980 collection, when gray ware production is still expected to be ubiquitous. Population history may be playing a role in the apparent discrepancy, since nearly all of the excavated sites in the Dolores Project area were abandoned for the A.D. 920-980 period, and the collections for this period are derived only from several sites within the McPhee Community. Contemporary occupations are to the south, at the edge of the project area and beyond, and the temper variability associated with these sites is poorly known. Most of the nonlocal gray ware sherds for this period are assigned to the San Juan Tract based on the presence of a variety of crushed igneous rock. The boundaries of this tract are not well documented (Blinman et al. 1984), and its geographic boundaries could lie relatively close to the project area to the south. The possibility of this proximity is further supported by the unusually high frequency of San Juan Tract white ware sherds in the same collections.

Long-distance transport of gray ware jars was not expected due to their inefficiency as transport containers, but some such transport did occur. Although some of the extraregional sourcing inferences are equivocal, the occurrences of Chuskan gray ware sherds are not, and a small number of these jars were transported to and were broken in the Dolores Project area. The assumptions about the contexts of gray ware jar movement would require that these vessels arrive in the project area at the end of a "random walk" rather than through a limited number of long-distance moves, but this assumption cannot be independently evaluated. Regardless of the mechanism of movement, a tendency for increasing interaction between the Dolores area and regions to the south (Chuska and Cibola) is evident in both gray and white ware vessels.

White ware vessels were obtained from generally greater distances than gray ware vessels (fewer locally made white wares) throughout the A.D. 600-980 period. This conforms to the expected frequency distribution based on the assumption of a restricted number of white ware producing households scattered across the Mesa Verde region. The sources of white wares do not appear to vary with the sources of gray wares through the A.D. 600-920 period, and San Juan Tract sources are disproportionately abundant. This pattern suggests that the exchange networks for the 2 wares were partially distinct, and that relatively more white ware production took place in the San Juan tract as opposed to the Cahone and Sandstone Tracts. After A.D. 920, gray and white ware sources covary to a greater degree, with fewer Cahone and Sandstone Tract vessels of both wares.

Unequivocal extraregional white ware sherds are derived from the Kayenta region prior to A.D. 800, and from the Chuska region after A.D. 800. Cibola white ware sherds are present from A.D. 720 and are present in large numbers after A.D. 880, but their identification is less secure than those of the other regions. However, the Cibola sherd frequency pattern matches the relative shift in regional exchange network orientation (from the west and southwest to the south and southwest) that is evidenced in vessels from the other regions. The discrepancy between the relatively stable extraregional gray ware frequency and the steadily increasing extraregional white ware frequency points to the expansion of regional ties at the same time that increasing local population should satisfy kinship-based obligation networks within a more restricted area. Since white ware vessels were available within the region, an increasing importance of symbolic motivations for some of the extraregional white ware exchange is possible.

Red ware vessel exchange fluctuated in intensity through time with little or no source variation. Tallahogan Red was present from the Kayenta region in extremely low frequencies and for only a short period of time. Sanostee Black-on-red was available from the Chuska region for a slightly longer period of time, but also in low frequencies. Since interplay between different sources does not appear to have been a factor, the variation in red ware frequency must be either a consequence of variation in production volume or in the efficiency of the distribution network. The increase in red ware frequency in A.D. 800-840 collections is assumed to be the result of increased production in response to the developing demand for vessels of the ware. The decline in red ware frequency corresponds to the period of greatest population in the Dolores Project area (Schlanger 1985) and could conceivably be the result of stable production spread over increasing population. However, immigration appears to contribute significantly to the population growth (Schlanger 1985). Under these condition, immigrants should bring some of their exchange network linkages with them, and the imbalance between a stable supply and the A.D. 840-880 population increase is unlikely to account for a halving of the red ware frequency. Instead, the same factors influencing population dislocation in the Dolores Project area may have affected production in the southeastern Utah source area for red ware vessels (chap. 14).

Mogollon smudge ware vessels represent an unusual case, and the mechanism for their movement may include the immigration of several individuals into the Dolores Project area (Wilson 1985). Mogollon vessels have been described in Basketmaker III Anasazi contexts to the south of the Mesa Verde region (Roberts 1929:108), and what appear to be Anasazi replicas of the smudging technique have also been reported (Roberts 1929:108; Morris 1980:56-57).

Cultural Process

The study of culture process (Problem Domain 5) has been formalized within DAP activities as an integrated effort to investigate culture change within the Dolores Project area. This effort has sought to relate patterns of change identified within the confines of individual DAP analysis groups to the adaptive aspects of cultural systems. Contributions of the ATG toward this effort are dispersed throughout the latter half of this volume, and the substantive studies will not be reiterated here.

CONCLUSION

Additive Technologies Group activites have spanned the 1978-1985 period and have involved more than 25 individual analysts, 2 administrators (William A. Lucius and the author), and over half a million items of material culture. The long duration of the effort and its intensity have provided ample opportunity for errors in judgment, corrections of errors, subsequent additional errors, and occasional success. Personnel turnover was an inevitable consequence of the duration of the project, and this, coupled with the evolution of the perception of differences, have created monumental problems in maintaining data consistency, problems addressed with variable success (Blinman et al. 1984). The masses of material have been a liability in that preliminary analysis of sherd collections have consumed nearly all of the ATG effort allocation, leaving relatively little time for intermediate data analysis and the evaluation and revision of analysis procedures. However, these same masses of material have supported studies of material culture variability that could only be conducted at this scale and that are necessary foundations to the investigation of the operation of past cultural systems. Although many of the substantive contributions of

the ATG have been summarized or listed in this volume, considerably more potential lies untapped with the voluminous data files of the DAP.

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Chapter 3

REDUCTIVE TECHNOLOGIES

Carl J. Phagan

LITHIC PROFILES

The DAP (Dolores Archaeological Program) Reductive Technologies Group has frequently used a "profile" of lithic assemblage characteristics to compare and interpret large data sets (Phagan 1984, 1985a; Hruby 1985; Hruby 1984). The effectiveness of this analytic approach depends on the availability of data units similarly defined and comparable, and on the selection of appropriate and consistently evaluated variables. Profiles are presented here for DAP phases, subphases, and site types. Variables for comparison and interpretation are selected from the flaked lithic tool, flaked lithic debitage, and nonflaked lithic tool preliminary analysis data files. A complete description of these preliminary analysis systems and their included variables/values is provided elsewhere (Phagan and Hruby 1984).

The organization of lithic data by phase is expected to demonstrate variation in lithic profiles related to major changes in Dolores Anasazi subsistence/settlement behavior. The DAP phase system is outlined by Kane (1983a:42-52) and is based primarily on settlement pattern characteristics. Within the period of Anasazi occupation, phases primarily reflect degrees of architectural aggregation, which presumably correspond with degrees of social organization. In addition, DAP phases are defined as temporally nonoverlapping and may therefore be used to examine areal cultural development in gross temporal units.

The Cougar Springs Phase (A.D. 1-600) has been identified as representing a preceramic, early Anasazi (Basketmaker II) occupation of the Dolores River valley (Kane 1983a:43-44). Use of the valley by such groups is presumed to have been restricted to brief seasonal exploitation of various resources. Cougar Springs Cave (Site 5MT4797) provides the only evidence of this phase in the DAP area (Gross 1984), and its identification as a Basketmaker II site is made on the basis of much less than a complete suite of traditionally diagnostic characteristics. The 500-year temporal overlap in the DAP phase sequence between the late Archaic Great Cut Phase (2000 B.C.-A.D. 500) and the early Anasazi Cougar Springs Phase (A.D. 1-600) (Kane 1983a:42-44) is best interpreted as a statement of uncertainty in the face of very little information, rather than as a theoretical statement of even temporary cultural coexistence in the area. This issue will be further addressed later in this chapter.

The Sagehen Phase represents settlement of the valley by Anasazi horticultural groups from A.D. 600 to 850. Early in the phase, the settlement pattern is one of individual households occupying small hamlets; as population expanded, households began to aggregate into larger interhousehold units occupying larger hamlets (Kane 1983b:23). The McPhee Phase represents the cultural climax of Anasazi populations in the valley between A.D. 850 and 975. During this phase large villages were developed and subsequently abandoned. A brief occupational hiatus apparently occurred at most village sites in the valley around A.D. 900; this hiatus was followed by small, brief, archaeologically distinct episodes of reoccupation, which were followed by complete abandonment of the valley by the middle-to late-10th century. At approximately A.D. 1050, the Dolores River valley was reoccupied by small Anasazi groups, at least on a seasonal basis and perhaps for several-year periods, though population in the valley remained quite small. This final Anasazi occupation is designed the Sundial Phase.

Stone artifacts from DAP assemblages are separated into the following categories for preliminary analysis: FLT (flaked lithic tools), FLD (flaked lithic debitage), and NFLT (nonflaked lithic tools, or ground stone tools). The analysis sytem for each artifact class is described elsewhere in detail (Phagan and Hruby 1984). Assignment of archaeological contexts and their associated artifacts to cultural units such as households or organizational units such as phases and site types is made with varying degrees of "confidence" (Farley 1983; Kane and Phagan 1981), and these contexts are also evaluated with reference to their "integrity," or degree of contamination (Farley 1983). Selected DAP lithic artifacts assigned to phases on the basis of multiple, independent lines of evidence (confidence = 3, 4)

and that contain no more than 30-percent contaminating materials (integrity = 2, 3, 4) are presented in tables 3.1, 3.2, and 3.3.

From the tables, several important variables have been selected for discussion, and data for these variables are presented as a series of graphs. Figure 3.1 presents DAP phase data for the FLT variable "morpho-use," which is a grouping of flaked lithic tools into major types, and 2 diversity measures calculated from tool types. In addition, a site category called group "A" is presented for comparison with the phase profiles. This group "A" category is the collection of all excavated DAP aceramic or minimally ceramic sites. Data samples from the Cougar Springs Phase and the Sundial Phase are rather small, particularly the former, because few relatively uncontaminated contexts can be confidently assigned to these early and late phases.

From figure 3.1, the 4 phases display generally similar FLT assemblages, suggesting a rather basic flaked lithic toolkit throughout the entire DAP sequence, without the addition or deletion of major tool types, at least insofar as they are recognized in this analytic system. In addition, major proportions of these types in the phase assemblages differ minimally, particularly among the Sagehen, McPhee, and Sundial Phases, indicating a fundamentally stable pattern of environmental adaptation with respect to flaked lithic tools. The Sagehen and McPhee Phases, which comprise considerably the greatest proportion of the DAP archaeological remains, are especially similar to FLT profile. The earlier Cougar Springs Phase is noticeably distinct in having a greater proportion of used flakes; fewer bulky items such as cores, cobble tools, and thick unifaces or bifaces; and relatively more high-production-input items such as thin bifaces and projectile points. These differences are anticipated, given the presumed association of these remains with activities that are seasonal in nature and require considerable mobility. The late (post-A.D. 1050) reoccupation of the Dolores valley expressed in the Sundial Phase FLT materials seems consistently to indicate a slight shift in assemblage composition back towards the Cougar Springs pattern, though this indication is not strong.

The group A category presented in figure 3.1 consists of DAP excavated sites that have fewer than 5 sherds; these are contexts with the greatest chance of being preceramic, since they are virtually nonceramic (these sites are discussed later in detail). This group may, however, include nonceramic Anasazi contexts. Not surprisingly, therefore, the group A FLT profile resembles the Cougar Springs Phase profile in several ways, particularly since most of the Cougar Springs materials are included in the group A category.

Throughout this examination of DAP lithic assemblage characteristics, the measurement and interpretation of assemblage diversity is presented. The Shannon-Wiener index is a synthetic measure of diversity that combines the number of classes (or richness) with the distribution of individual cases among those classes (or evenness). It is an "information content" measure of group heterogeneity especially sensitive to variation in rarely occurring classes (Peet 1974:292-304) but is also sensitive to sample size. The equitability index measures the evenness of the distribution of items among the classes present in the sample (Peet 1974:288, 298-301) and is less dependent on sample size. (Refer to Hruby [1985] for a discussion of the definition and use of these diversity measures.) More classes of tools and more even distribution of individual tools among those classes result in higher diversity scores. Increased tool diversity should be associated with increased task diversity, at least to the extent that the tool types defined in the analysis can be related to functional task categories. Formulas for both the Shannon-Wiener and equitability indexes are from Odum (1971:144). FLT morpho-use diversity is calculated from a recode of 18 functionally defined tool classes (Phagan and Hruby 1984:55).

The interpretation of assemblage diversity among such composite data groups as phases should be considered tentative. Values for the Shannon-Wiener index, which includes both the number of classes and the distribution of cases among them, and which is also rather sensitive to sample size, are expected to be higher than equitability scores, which involve only the distribution of cases among a known number of classes and which are much less sensitive to sample size. The Cougar Springs Phase, which is presumed to represent brief summer occupations of the valley for rather specialized procurement purposes, quite expectedly demonstrates a considerably reduced FLT diversity. The Sagehen and McPhee Phases, which represent a complete range of year-round subsistence and maintenance activities, demonstrate an increased FLT assemblage diversity. The intermediate diversity of the Sundial Phase assemblage tends to support the assumption that this later Anasazi occupation of the Dolores River valley may have been seasonal in nature, or of restricted duration. The unusual pattern of diversity demonstrated by group A, particularly its high equitability value, is not easily explained but does suggest that the differential manner in which the site groups were selected may be responsible (i.e., other data groups have a definitive underlying similarity in that they are organized by phase, subphase, or site type).

Figure 3.2 presents several FLT and FLD variables interpretable largely with reference to production technology, with data again arranged by phases and the

Table 3.1 – Flaked lithic tool variables, by phase and group A

Variable Value	Phase				
	Cougar Springs (N=149) %	Sagehen (N=8298) %	McPhee (N=12 680) %	Sundial (N=502) %	Group A (N=1164) %
Specific material identification*					
Nonlocal	13	3	3	5	10
Morrison quartzite	25	28	29	21	13
Morrison chert	0	5	5	4	3
Burro Canyon quartzite	49	10	8	13	40
Burro Canyon chert	6	19	13	14	24
Local cobbles (hornfels)	0	14	23	25	4
Local, nfs	5	15	13	14	6
Grain size					
Fine	48	19	27	19	38
Very fine	32	50	50	55	23
Microscopic	19	29	22	25	37
Morpho-use†					
Utilized flake	66	43	43	53	50
Core	3	8	6	5	2
Used core, cobble tool	3	13	13	11	2
Thick uniface	4	11	11	9	6
Thin uniface	1	5	3	2	5
Specialized form	2	2	2	3	3
Thick biface	1	7	9	5	6
Thin biface	7	4	3	3	5
Projectile point	9	4	6	4	12
Dorsal face evaluation					
Items with cortex	16	40	47	38	23
Unworked items	69	64	65	69	62
Edged items	9	9	9	8	10
Primarily thinned	1	2	2	2	5
Secondarily thinned	9	2	3	2	6
Well shaped	5	2	3	2	8
Stylized	0	<1	1	<1	1
Ventral face evaluation					
Items with cortex	4	5	5	4	§
Unworked items	73	65	66	69	§
Edged items	5	9	9	9	§
Primarily thinned	3	2	2	1	§
Secondarily thinned	7	2	3	2	§
Well shaped	6	2	3	2	§
Stylized	0	<1	1	<1	§
Edge direction					
Unidirectional	8	18	18	16	15
Both	4	8	10	6	7
Bidirectional	17	11	12	11	22
Edge placement					
None	67	54	54	61	51
Some	13	29	30	24	22
All	15	7	9	8	19
Core form					
Unspecialized	3	18	15	13	3
Specialized	1	1	1	1	1
Stylized	0	<1	<1	0	0
Complete items	77	86	83	78	58
Mean weight (g)	62	99	95	75	32
Standard deviation (g)	157	197	176	149	107
FLT acquisition cost index	16.2	11.4	9.5	11.2	14.6
FLT production cost index	10.4	8.8	9.2	8.8	11.2
Total cost index	26.6	20.2	18.7	20.0	25.8
Morpho-use diversity					
Shannon-Wiener index	0.60	0.84	0.84	0.75	0.75
Equitability index	0.52	0.67	0.67	0.61	0.75
Raw material diversity					
Shannon-Wiener index	0.59	0.82	0.81	0.82	0.72
Equitability index	0.76	0.91	0.89	0.91	0.79
FLD/FLT ratio	35.0	7.7	7.9	6.1	13.3
FLT/NFLT ratio	6.2	2.8	2.1	2.7	2.8

* This variable is SPEFIDB, a recode of the raw material type (Phagan and Hruby 1984:45).
† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:54-56).
§ Data not available.
All data are expressed as percentages except indexes, ratios, and weights.
nfs – Not further specified.

Table 3.2 – Flaked lithic debitage variables, by phase and group A

Variable	Phase												Group A		
	Cougar Springs			Sagehen			McPhee			Sundial					
	N	%	Mean wt(g)	N	%	Mean wt(g)	N	%	Mean wt(g)	N	%	Mean wt(g)	N	%	Mean wt(g)
Flakes/flake frags:															
Grain size															
Medium	5	*	3.6	1 478	2.0	17.5	2 226	2.0	13.6	41	1.0	12.9	174	1.0	7.7
Items with cortex	3	60.0	...	577	39.0	...	1 005	45.0	...	13	32.0	...	37	21.0	...
Fine	3135	60.0	0.6	11 856	19.0	10.6	31 796	32.0	8.7	825	27.0	4.7	5 006	32.0	1.6
Items with cortex	55	2.0	...	4 301	36.0	...	11 725	37.0	...	230	28.0	...	374	7.0	...
Very fine	1952	37.0	0.7	31 460	49.0	7.8	44 426	44.0	7.0	1395	46.0	6.0	6 534	42.0	1.7
Items with cortex	96	5.0	...	8 136	26.0	...	15 839	36.0	...	453	32.0	...	685	10.0	...
Microscopic	118	2.0	0.5	19 002	30.0	3.5	22 149	22.0	2.8	785	26.0	1.6	3 820	25.0	1.1
Items with cortex	3	3.0	...	2 779	15.0	...	4 446	20.0	...	48	6.0	...	291	8.0	...
Total flakes/ flake frags	5210	100.0	0.6	63 796	100.0	7.3	100 597	100.0	6.8	3046	100.0	4.6	15 534	100.0	1.8
Total items with cortex	157	3.0	...	15 793	25.0	...	33 015	33.0	...	744	24.0	...	1 387	9.0	...
Nonlocal items	27	0.5	...	110	0.2	...	571	0.6	...	7	0.2	...	101	0.7	...
FLD/FLT ratio	35.0			7.7			7.9			6.1			13.3		

* Less than 0.1
Grain-size percentages are calculated for the proportion of the total phase assemblage; cortex percentages are calculated for the number of items within each grain-size category.
frags – Fragments.
... – Information not available.

group A category. Most raw material variability is considered in another section of this volume. The 3 later Anasazi phase groupings are most similar, and the Cougar Springs Phase and the group A sites are quite different. Greatest variability among the 3 later Anasazi phases occurs in the proportion of microscopic-grained raw material in both FLT's and FLD, the mean weight of both FLT and FLD items, and, to a lesser extent, the proportions of both FLT and FLD items retaining cortex.

The early Cougar Springs Phase demonstrates very much lower proportions of both FLT and FLD items that retain cortex; a slightly reduced proportion of microscopic-grained FLT raw materials, but virtually no microscopic-grained debitage items; increased proportions of FLT items with bidirectionally produced edges and with margins completely produced; an increased FLT production cost index;[1] lower FLT and FLD mean weight; and an extremely high FLD/FLT ratio. All of these are general indications of a high-production-input technology focused on careful production and increased curation rates, and all are expected assemblage characteristics of more mobile hunting-collecting groups compared with those produced by settled horticulturalists. The group A profile is similar in many respects to the Cougar Springs Phase profile but differs in having a much greater proportion of microscopic-grained raw materials for both FLT and FLD items and an increased proportion of small high-production-input tools. These are all the likely result of combining very specialized aceramic Anasazi contexts with the preceramic Cougar Springs Phase contexts.

Figure 3.3 presents several NFLT variables for phase and group A assemblages, including morpho-use tool types, tool type diversity, production stage evaluation, and FLT/NFLT ratio. These NFLT variables demonstrate more between-phase differential than FLT or FLD variables, but the 3 later Anasazi phases are again similar, while the Cougar Springs Phase and the group A category are quite different. The small size of the Cougar Springs assemblage is largely responsible for its

[1]Variability in production cost index values is expected to be rather minimal for phase assemblages, particularly at the scale used in figure 3.2. Refer to Phagan and Maloney (1983) for an explanation of this index value and its interpretation.

Table 3.3 – Nonflaked lithic tool variables, by phase and group A

Variable Value	Phase				
	Cougar Springs (N=24) %	Sagehen (N=3105) %	McPhee (N=5978) %	Sundial (N=184) %	Group A (N=414) %
Material class*					
Igneous	13	21	16	12	7
Coarse sandstone	4	2	3	6	7
Medium sandstone	50	30	42	58	65
Fine sandstone	29	22	21	16	15
Other sedimentary	4	2	2	1	2
Metamorphic	0	15	8	3	4
Ornamental	0	1	1	0	0
Morpho-use†					
Miscellaneous	33	28	26	28	14
Hammerstone	13	19	17	19	4
Mano fragment	13	4	3	10	5
One-hand mano	13	5	3	4	11
Two-hand mano	4	12	22	19	3
Metate fragment	4	5	2	5	13
Trough metate	4	7	13	3	1
Slab metate	0	<1	<1	1	1
Basin metate	4	<1	<1	0	1
Hafted item	0	4	5	1	<1
Ornament	0	1	2	<1	2
Blank type					
Rounded cobble	13	14	13	13	6
Flattened cobble	63	29	48	48	23
Thick slab	4	1	3	2	1
Thin slab	4	3	6	5	1
Very thin slab	4	3	4	10	1
Completely modified	0	1	2	0	2
Production stage evaluation					
Unmodified	33	55	44	45	30
Minimal modification	13	17	17	21	11
Well shaped	21	13	26	15	8
Stylized	0	1	1	1	2
Complete items	50	55	62	51	24
Morpho-use diversity					
Shannon-Wiener index	0.77	0.94	0.95	0.82	0.75
Equitability index	0.85	0.80	0.81	0.76	0.69

* This variable is MATERA, a recode of the raw material class (Phagan and Hruby 1984:78).

† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:91).

All data are expressed as percentages except indexes.

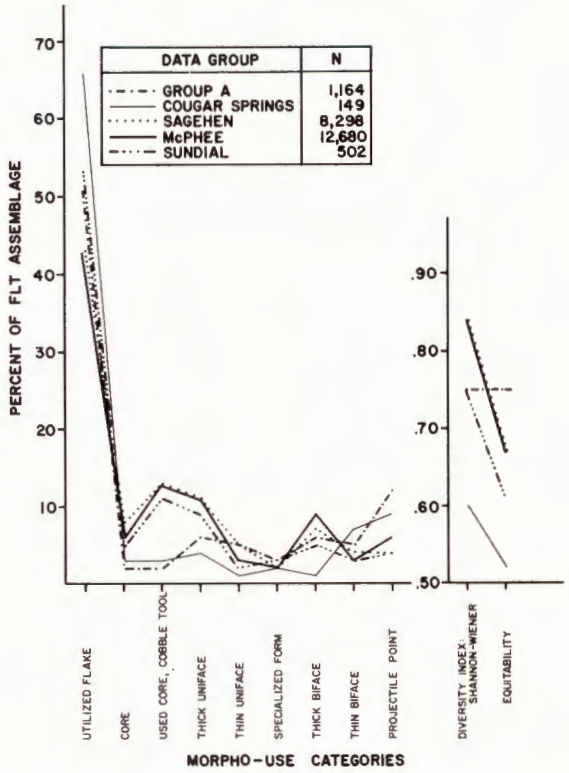

Figure 3.1 – Flaked lithic tool morpho-use and diversity, by phase and group A.

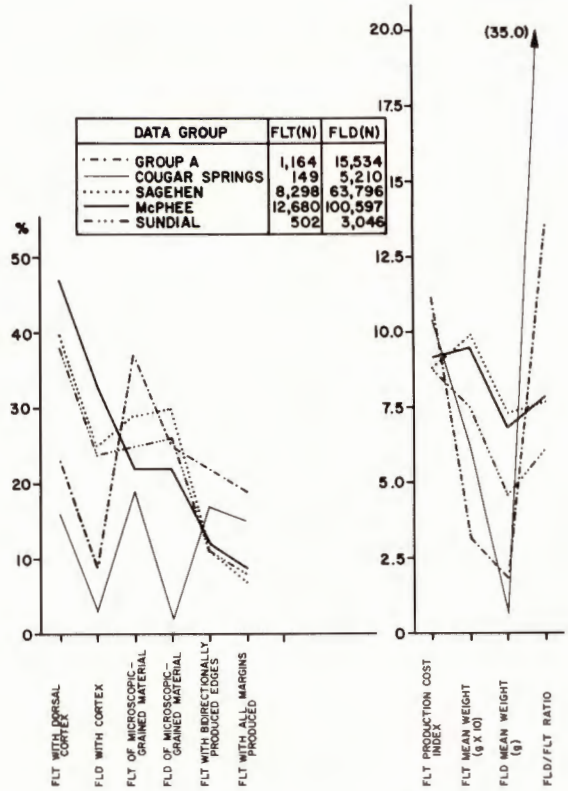

Figure 3.2 – Flaked lithic tool and debitage technological variables, by phase and group A. Flaked lithic tool and flaked lithic debitage percentages are calculated from their respective assemblages.

unusual diversity profile and its very high FLT/NFLT ratio.

Variability in one-hand manos, two-hand manos, and trough metates seems particularly important. There is, for example, almost no one-hand mano or slab/basin metate variation among the 3 later Anasazi phases, but considerable two-hand mano and trough metate variation. Increased proportions of both two-hand manos and trough metates in the McPhee Phase assemblage is directly responsible for its increased proportion of well-shaped items. This two-hand mano and trough metate variability constitutes the most unambiguous lithic distinction between the Sagehen and McPhee Phases, and is one that appears to be temporally correlated. The fundamental similarity of these 2 phases with respect to lithic artifact assemblages, along with the implications of this mano and metate variability for horticultural production and processing, are discussed in considerable detail elsewhere (Phagan 1985b).

Organization of lithic data into subphase profiles should allow an examination of the relationship between subsistence behavior associable with lithic tool assemblages and the social and environmental factors that influence/determine the settlement patterns by which subphases are recognized. Kane (1983a, 1984) has outlined DAP subphases as distinctive patterns of architectural and settlement distribution characteristics. These subphases also have corresponding spatial, material culture, and temporal characteristics, and their temporal correspondences are particularly important. While subphases are not formally defined as temporal periods, they are nevertheless frequently referred to as such (Kane 1984:26-32) because their temporal associations are considered to be particularly strong. This is not an unreasonable use of subphases as long as temporal interpretations based on them are rather broad and general, and as long as any relevant spatial restrictions or temporally overlapping characteristics are not ignored. Subphase data are presented in tables 3.4, 3.5, and 3.6. In the following lithic data presentation, subphases are arranged in general chronological order and are interpreted as both organizational/structural units and loosely defined temporal units.

Subphases with adequately large sample size for inclusion in the study are the Tres Bobos (A.D. 600-700), Sagehill (A.D. 700-780), and Dos Casas (A.D. 760-850) Subphases of the Sagehen Phase; the Periman (A.D. 850-900), Cline (A.D. 880-925), and Grass Mesa (A.D.

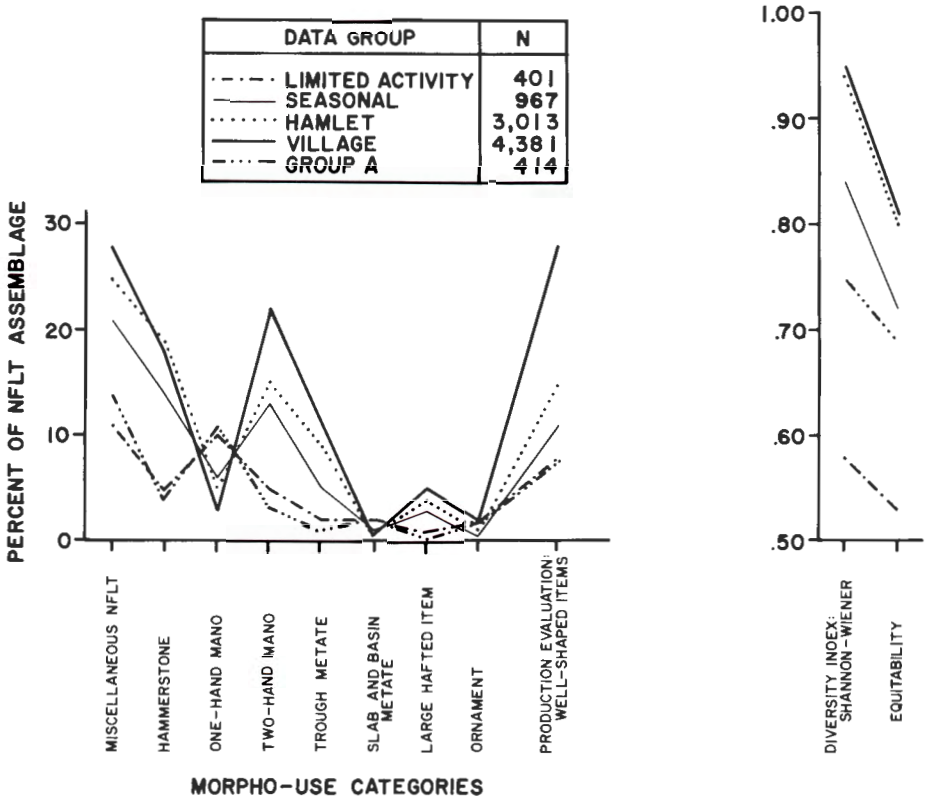

Figure 3.3 – Nonflaked lithic tool morpho-use and diversity, by phase and group A.

900-975) Subphases of the McPhee Phase; and the Marshview Subphase (A.D. 1050-1200) of the Sundial Phase. Figure 3.4 presents for these subphases the same FLT morphouse type and diversity information as presented for phases in figure 3.1. Two things are apparent from this subphase distribution: first, a single pattern of FLT distribution for all subphases is clearly shown, with only minor variation in the proportions of used flakes, used cores/cobble tools, and thick bifaces; and second, no indication of temporal trends occurs in the overall flaked lithic toolkit distribution or in any morpho-use type. The Marshview Subphase demonstrates extreme values for several of the morpho-use types, suggesting a slightly different pattern of FLT-related subsistence behavior for this later reoccupation of the Dolores valley. Both diversity measures tend to confirm these interpretations: general similarity of all subphases, lack of temporal trends, and extreme variability in the later Marshview Subphase.

The FLT and FLD production technology characteristics shown in figure 3.5 demonstrate considerably more subphase variability than did the FLT morpho-use distributions. However, no indication of temporal trends in the data is shown, insofar as their subphase organization may be interpreted temporally. Only the 3 FLT production input variables (FLT with bidirectionally produced edges, with all margins produced, and production cost index) show reduced ranges of subphase variability. In addition, the mean weight of FLD items shows a slightly reduced variability range. Variables such as these are not expected to show strong subphase differential since basic tool production technology remains rather constant throughout the DAP sequence. The later Marshview Subphase again consistently demonstrates extreme values for most of the selected technological variables. Subphase technological variability is likely to be associated with such spatial/organizational/functional differential as raw material availability, overall settlement pattern, or location of production, or subsistence behavior. The variability is perhaps most appropriately subject to subphase-by-subphase evaluation and interpretation on the basis of specifically anticipated characteristics.

Figure 3.6 presents the subphase distribution for NFLT morpho-use and diversity variables. This distribution is quite similar to that observed for phases: very little subphase variability in some of the tool types and a great deal in others. Of particular importance is the very low variability for one-hand manos and the rather extreme variability for two-hand manos.

Table 3.4 – Flaked lithic tool variables, by subphase

Variable Value	Subphase						
	Tres Bobos (N=793) %	Sagehill (N=1317) %	Dos Casas (N=4864) %	Periman (N=7049) %	Grass Mesa (N=375) %	Cline (N=1799) %	Marshview (N=322) %
Specific material identification*							
Nonlocal	3	2	3	3	5	4	5
Morrison quartzite	22	32	27	30	43	21	23
Morrison chert	3	6	4	4	7	4	6
Burro Canyon quartzite	10	7	10	9	6	8	12
Burro Canyon chert	8	11	23	14	6	8	12
Local cobbles (hornfels)	27	20	12	25	13	30	26
Local, nfs	20	17	14	14	15	11	15
Grain size							
Fine	27	21	18	29	28	24	19
Very fine	54	58	46	47	52	56	57
Microscopic	16	20	33	22	19	20	23
Morpho-use†							
Utilized flake	33	32	48	43	35	42	57
Core	7	8	9	7	7	5	7
Used core, cobble tool	20	21	11	13	21	14	11
Thick uniface	11	10	10	12	9	11	8
Thin uniface	4	7	4	3	5	3	2
Specialized form	3	2	2	2	3	2	2
Thick biface	8	10	6	9	8	9	4
Thin biface	3	4	4	2	2	4	2
Projectile point	7	4	3	5	8	7	4
Dorsal face evaluation							
Items with cortex	40	34	40	48	41	48	37
Unworked items	57	58	67	67	60	57	68
Edged items	8	10	9	8	6	13	9
Primarily thinned	2	1	2	2	1	2	1
Secondarily thinned	3	2	2	3	3	3	2
Well shaped	5	2	2	2	5	7	3
Stylized	<1	1	<1	<1	1	1	1
Ventral face evaluation							
Items with cortex	7	6	5	5	7	5	4
Unworked items	57	59	68	67	60	58	70
Edged items	7	9	8	8	7	13	7
Primarily thinned	2	1	2	2	1	2	1
Secondarily thinned	3	2	2	3	2	3	2
Well shaped	4	2	2	2	5	6	3
Stylized	<1	1	<1	<1	1	1	1
Edge direction							
Unidirectional	17	19	17	18	17	18	12
Both	7	9	8	11	7	10	8
Bidirectional	17	13	9	11	17	14	8
Edge placement							
None	51	50	56	53	53	53	65
Some	29	32	27	31	29	30	20
All	11	9	6	8	11	11	8
Core form							
Unspecialized	22	25	16	16	23	14	14
Specialized	2	1	1	1	1	2	<1
Stylized	<1	<1	<1	<1	<1	<1	0
Complete items	80	89	87	82	89	83	83
Mean weight (g)	121	140	98	97	176	91	68
Standard deviation (g)	208	209	200	181	249	164	116
FLT acquisition cost index	13.2	14.3	10.7	9.0	11.2	11.6	11.8
FLT production cost index	9.2	8.7	8.7	8.9	9.0	9.9	8.7
Total cost index	22.4	23.0	19.4	17.9	20.2	21.5	20.5
Morpho-use diversity							
Shannon-Wiener index	0.91	0.90	0.80	0.83	0.92	0.86	0.71
Equitability index	0.75	0.73	0.64	0.66	0.76	0.68	0.59
Raw material diversity							
Shannon-Weiner index	0.80	0.78	0.81	0.76	0.76	0.81	0.81
Equitability index	0.88	0.87	0.90	0.85	0.84	0.90	0.90
FLD/FLT ratio	6.4	8.2	7.1	7.4	7.4	9.3	4.0
FLT/NFLT ratio	1.9	1.7	3.4	2.3	1.0	1.6	2.8

* This variable is SPEFIDB, a recode of the raw material type (Phagan and Hruby 1984:45).
† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:54-56).
All data are expressed as percentages except indexes, ratios, and weights.
nfs – Not further specified.

Table 3.5 – Flaked lithic debitage variables, by subphase

Variable	Subphase																				
	Tres Bobos			Sagehill			Dos Casas			Periman			Grass Mesa			Cline			Marshview		
	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt (g)	N	%	mean wt(g)
Flakes/flake frags																					
Grain size																					
Medium	178	4	17.4	238	2	26.7	809	2	15.8	1 094	2	13.9	79	2	13.7	269	2	15.9	20	2	6.2
Items with cortex	85	48	...	69	29	...	330	41	...	495	45	...	29	37	...	160	59	...	5	25	...
Fine	1061	21	11.8	2 398	22	10.5	6 596	19	10.6	15 741	30	9.4	1288	37	5.0	4 999	37	9.2	399	31	6.5
Items with cortex	402	38	...	706	29	...	2 538	38	...	5 984	38	...	290	23	...	1 879	38	...	185	46	...
Very fine	2895	57	8.0	5 705	53	8.9	16 363	48	8.0	23 980	46	7.3	1579	45	7.1	3 820	29	7.4	684	53	6.7
Items with cortex	883	31	...	1 183	21	...	4 587	28	...	8 846	37	...	435	28	...	1 498	39	...	278	41	...
Microscopic	923	18	4.4	2 444	23	3.6	10 577	31	4.2	11 312	22	3.1	559	16	3.4	4 305	32	1.4	189	15	2.5
Items with cortex	142	15	...	114	5	...	2 123	20	...	2 491	22	...	87	16	...	486	11	...	26	14	...
Total flakes/ flake frags	5057	100	8.5	10 785	100	8.4	34 345	100	7.5	52 127	100	7.2	3505	100	5.9	13 393	100	6.3	1292	100	6.0
Total items with cortex	1512	30	...	2 072	19	...	9 578	28	...	17 816	34	...	841	24	...	4 023	30	...	494	38	...
Nonlocal items	24	0.5	...	11	0.1	...	68	0.2	...	315	0.6	...	16	0.5	...	167	1.2	...	3	0.2	...
FLD/FLT ratio	6.4			8.2			7.1			7.4			9.3			7.4			4.0		

Grain-size percentages are calculated for the proportion of the total phase assemblage; cortex percentages are calculated for the number of items within each grain-size category.
... – information not available.

Table 3.6 – Nonflaked lithic tool variables, by subphase

Variable Value	Subphase						
	Tres Bobos (N = 408) %	Sagehill (N = 774) %	Dos Casas (N = 1419) %	Periman (N = 3089) %	Grass Mesa (N = 359) %	Cline (N = 1011) %	Marshview (N = 115) %
Material class*							
Igneous	26	18	21	16	14	16	14
Coarse sandstone	2	5	2	3	3	6	5
Medium sandstone	36	22	35	43	34	45	60
Fine sandstone	23	24	19	19	34	15	14
Other sedimentary	2	3	2	3	3	2	0
Metamorphic	9	26	10	6	10	13	3
Ornamental	0	1	1	1	2	1	0
Morpho-use†							
Miscellaneous	29	21	32	29	18	23	24
Hammerstone	16	25	17	15	19	21	17
Mano fragment	5	2	5	3	4	3	9
One-hand mano	5	5	5	3	2	3	3
Two-hand mano	12	11	13	21	33	25	22
Metate fragment	2	8	3	1	1	2	6
Trough metate	11	9	5	12	10	10	5
Slab metate	0	0	0	<1	0	<1	0
Basin metate	<1	<1	<1	<1	0	0	0
Hafted item	2	2	5	6	6	4	2
Ornament	1	1	2	2	2	2	0
Blank type							
Rounded cobble	13	5	20	15	12	12	10
Flattened cobble	36	20	33	56	46	37	46
Thick slab	1	1	1	4	4	3	1
Thin slab	7	3	3	7	3	3	4
Very thin slab	5	3	3	5	4	1	7
Completely modified	1	<1	2	3	2	2	0
Production stage evaluation							
Unmodified	53	60	57	45	42	45	39
Minimal modification	12	23	16	16	19	14	24
Well shaped	18	6	15	26	32	31	16
Stylized	1	<1	1	1	2	2	0
Complete items	49	54	60	66	82	64	51
Morpho-use diversity							
Shannon-Wiener index	0.90	0.92	0.96	0.97	0.91	0.91	0.78
Equitability index	0.79	0.78	0.81	0.83	0.77	0.77	0.78

* This variable is MATERA, a recode of the raw material class (Phagan and Hruby 1984:78).
† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:91).
All data are expressed as percentages except indexes.

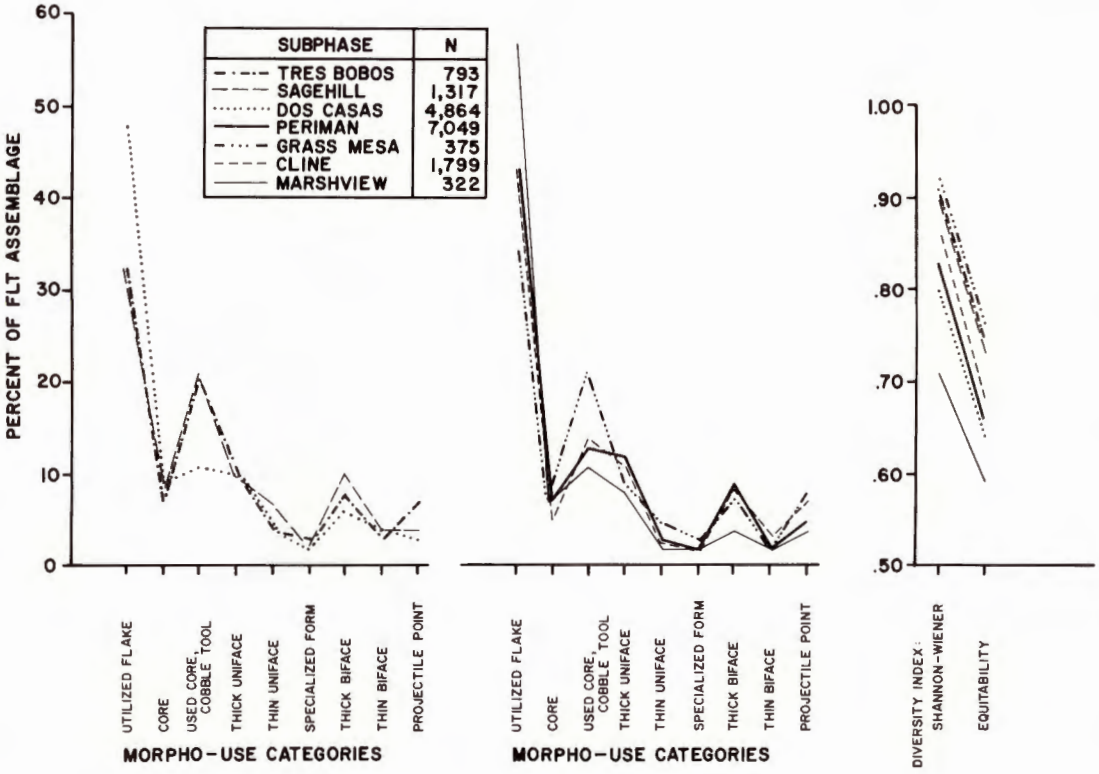

Figure 3.4 – Flaked lithic tool morpho-use and diversity, by subphase.

This two-hand mano variability, and the closely related proportion of well-shaped items, is the only lithic characteristic that clearly appears to be temporally correlated. Its distribution reflects a major jump at the Dos Casas-to-Periman Subphase transition, which is also the Sagehen-to-McPhee Phase transition, rather than a continuous progression.

Subphase variability in NFLT diversity is virtually nil, except for an unusual Marshview Subphase expression that may indicate a rather specialized NFLT assemblage. However, the low Shannon-Wiener index for this Marshview Subphase may also be the result of its small sample size.

As with subphase flaked lithic technological variability, much NFLT subphase variability may be associated with spatial, organizational, or functional differential, and this variability may be most appropriately used for response to specific predictions on a subphase-by-subphase basis. Apparently, DAP phase/subphase settlement pattern variability is largely independent of, and unrelated to, subsistence behavior variability as it is observable in lithic artifact assemblages.

A third important data-structuring mechanism is provided by the DAP functional series of site types (Kane 1983a; Lipe and Kohler 1984: 16-17). Several site type categories and subcategories are identified, and various combinations of these units are possible. For this analysis 4 site type categories have been selected: limited activity sites; seasonal sites; small habitations, or hamlets; and large habitations, or villages.

Limited activity sites are loci at which a minimal range of activities occurred over very brief periods of times. In the DAP context they normally lack architectural characteristics, and are considered collectively to have served a wide range of collecting, hunting, processing, and maintenance functions, though individual sites are anticipated to be single-function in character. Limited activity sites are expected to have occurred throughout the entire DAP temporal sequence, though perhaps with some concentration both early and late in the sequence.

Seasonal sites are those occupied on a short-term or periodic basis by small groups, usually for a restricted set of economic subsistence activities. They may incorporate minimal architectural features. Most DAP seasonal sites are agricultural field houses and are expected to occur predominantly in the later McPhee Phase when they constituted, along with aggregated villages, a major aspect of the Dolores Anasazi settlement system.

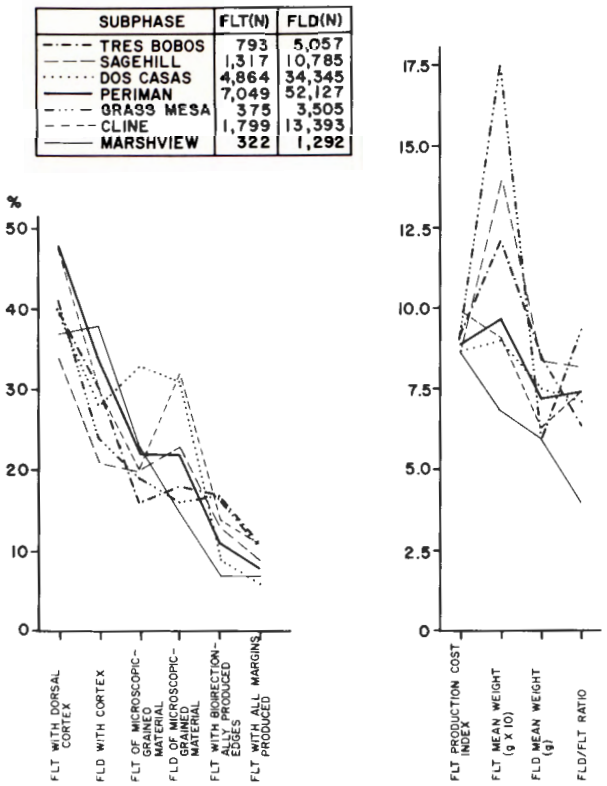

Figure 3.5 – Flaked lithic tool and debitage technological variables, by subphase. Flaked lithic tool and flaked lithic debitage percentages are calculated from their respective assemblages.

Small habitation sites, or hamlets, represent year-round occupation by 1 or a few families. They are sites at which a wide range of subsistence and maintenance activities occurred, usually over a several-year period, they always involve significant architecture, and are expected to occur most frequently during the earlier Sagehen Phase, prior to the development of large aggregated villages.

Large habitation sites, or villages, represent permanent occupation by 10 or more household units, they include a maximum range of activities over a multiyear period, and within the DAP sequence they are limited to the late Sagehen and McPhee Phases.

The arrangement of lithic data by these 4 site type groups should result in lithic artifact profiles particularly useful in examining organizational/functional variability in associated subsistence-related behavior. Some particular correspondences of site type with temporal period are anticipated. The site type lithic profiles are presented in the following figures along with the group A category defined in the preceding section, which is included for comparison. The often problematic aceramic sites included in this category may be more interpretable in the functional site type framework, rather than in the temporal or structural phase context. Lithic data are presented by site type and group A in tables 3.7, 3.8, and 3.9.

Figure 3.7 presents profiles by site type for FLT major tool types and diversity indexes. All site types display a more or less consistent FLT profile, which by this point in the analysis may be considered a standard toolkit for exploiting the area's major resources during the first millenium A.D. The greatest FLT site type assemblage variation occurs in the proportions of used flakes, used cores/cobble tools, and projectile points, or at both ends of a rather generalized production input continuum. Of more importance is the obvious division of the profiles into 2 distinct sets: the limited activity and group A sites are clearly similar to each other and distinct from the seasonal, hamlet, and village sites. Some of these distinctions are not large, but are quite consistent for a majority of the tool types.

The FLT tool type diversity measures are generally consistent with this dual profile but have unusual and unexpected characteristics as well. The hamlet and village site type FLT assemblages have identical diversity scores for both the Shannon-Wiener and equitability indexes, while the seasonal site type assemblage is slightly less diverse, indicating a slightly reduced range of FLT-associated activity at these seasonal sites. Based on the site type definitions outlined, this is precisely the expected diversity pattern. The increased diversity for limited activity sites, however, was not anticipated, since these sites are presumed to represent a reduced range of subsistence or maintenance activities. It may be that any single limited activity site or even all limited activity sites of a particular kind (such as large game kill sites or resource quarry sites) could in fact have a reduced FLT diversity, but that all limited activity sites combined represent a much larger behavioral, and therefore tool type, diversity. It seems unlikely, however, that this would totally account for the very high diversity shown in figure 3.7. The unusual group A diversity, particularly its low Shannon-Wiener index value, is at least partly the result of the analytic site-grouping criteria outlined previously for this site group.

The FLT and FLD production technology profiles presented for site types in figure 3.8 even more clearly demonstrate the distinction between seasonal, hamlet, and village sites as opposed to limited activity and group A sites. The limited activity and group A profiles are virtually identical except for slightly increased proportions of production input at limited activity sites, along with a much greater FLD/FLT ratio. This may indicate more actual production or maintenance of bifaces at limited activity sites than at group A sites.

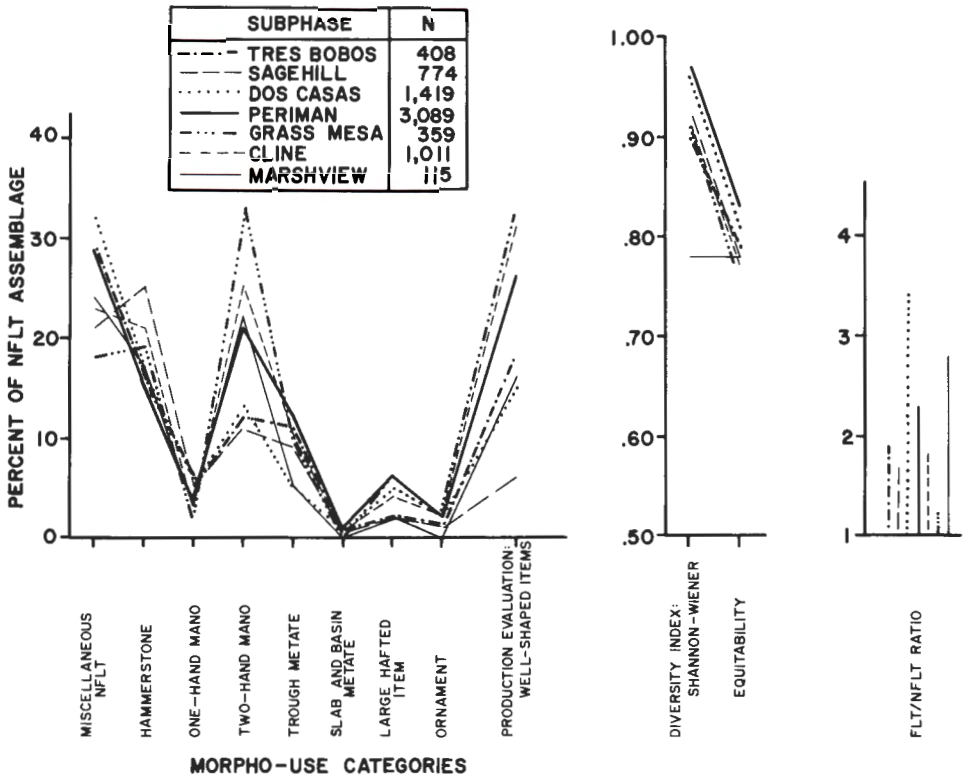

Figure 3.6 – Nonflaked lithic tool morpho-use and diversity, by subphase.

The set of seasonal, hamlet, and village sites demonstrates many more FLT and FLD items retaining cortex, fewer FLT items of microscopic-grained raw material (especially villages), consistently less production-input, much larger mean weight for both FLT and FLD, and fewer debitage items/tool. These characteristics all seem quite consistent with both the postulated behavior ranges for the site types and the rather expedient nature of most Dolores Anasazi FLT production and use.

The site type profiles of NFLT distribution and diversity in figure 3.9 continue to illustrate the consistent distinction between limited activity and group A sites as opposed to seasonal, hamlet, and village sites. The limited activity and group A sites display similarly lower proportions of most NFLT categories than do the longer occupied sites, except for onehand manos and slab/basin metates, precisely the 2 related categories that should be better represented at these briefly occupied or aceramic sites (refer to Phagan [1985b]). The relative proportions of two-hand manos and trough metates at seasonal, hamlet, and village sites indicates an increased importance of these specialized food-processing items with increased occupation duration and site complexity. The proportion of well-shaped items is directly related to that of manos, trough metates, and large hafted tools. The site type variability in large hafted items is not great but consistently indicates their proportionally greater occurrence at more complex, longer occupied, and increasingly architectural site types.

Both measures of NFLT diversity at site types show extreme variability quite consistent with tool-task associations and subsistence behavioral patterns assumed for the site types. Hamlet and village site NFLT diversity is virtually equivalent; seasonal sites show reduced diversity; group A sites demonstrate an even more reduced diversity; and limited activity sites show very much the lowest number of tool types as well as the most uneven distribution of items among those types.

The site type variability in lithic artifact assemblages presented in figures 3.7, 3.8, and 3.9 is clearly more quantitatively distinct and interpretable than is the temporal or settlement system variability presented earlier as phase or subphase profiles. Apparently, lithic assemblages contribute more to an understanding of the nature and range of subsistence and maintenance tasks performed at various site types than they do to questions about when or within what subphase units they were performed. In addition, seasonal sites are shown

Table 3.7 – Flaked lithic tool variables, by site type and group A

Variable Value	Site Type				
	Limited activity (N=792) %	Seasonal (N=2205) %	Hamlet (N=7595) %	Village (N=8415) %	Group A (N=1164) %
Specific material identification*					
Nonlocal	11	5	3	3	10
Morrison quartzite	13	22	27	25	13
Morrison chert	3	4	4	4	3
Burro Canyon quartzite	37	16	9	9	40
Burro Canyon chert	19	18	17	13	24
Local cobbles (hornfels)	5	16	15	27	4
Local, nfs	7	17	15	13	6
Grain size					
Fine	39	25	18	28	38
Very fine	24	45	51	49	23
Microscopic	36	28	28	21	37
Morpho-use†					
Utilized flake	37	50	42	42	50
Core	3	5	8	6	2
Used core, cobble tool	2	9	14	14	2
Thick uniface	8	11	11	11	6
Thin uniface	6	3	5	3	5
Specialized form	3	4	2	2	3
Thick biface	8	6	7	9	6
Thin biface	5	3	3	3	5
Projectile point	14	6	4	5	12
Dorsal face evaluation					
Items with cortex	24	43	40	48	23
Unworked items	51	70	64	64	62
Edged items	16	8	9	10	10
Primarily thinned	5	2	2	2	5
Secondarily thinned	7	2	2	3	6
Well shaped	10	4	3	4	8
Stylized	1	<1	<1	1	1
Ventral face evaluation					
Items with cortex	5	4	6	5	§
Unworked items	55	71	64	64	§
Edged items	13	8	9	10	§
Primarily thinned	5	2	2	2	§
Secondarily thinned	7	2	2	3	§
Well shaped	10	4	2	3	§
Stylized	1	<1	<1	1	§
Edge direction					
Unidirectional	17	18	18	18	15
Both	10	8	8	11	7
Bidirectional	29	11	11	12	22
Edge placement					
None	39	57	54	53	51
Some	27	28	29	31	22
All	24	9	8	9	19
Core form					
Unspecialized	4	10	18	16	3
Specialized	1	1	1	1	1
Stylized	0	0	<1	<1	0
Complete items	60	78	86	82	58
Mean weight (g)	43	69	102	100	32
Standard deviation (g)	125	150	201	181	107
FLT acquisition cost index	16.9	11.3	11.6	9.6	14.6
FLT production cost index	12.2	9.2	8.8	9.2	11.2
Total cost index	29.1	20.5	20.4	18.8	25.8
Morpho-use diversity					
Shannon-Wiener index	0.92	0.80	0.84	0.84	0.75
Equitability index	0.75	0.64	0.67	0.67	0.75
Raw material diversity					
Shannon-Wiener index	0.77	0.81	0.83	0.80	0.72
Equitability index	0.85	0.90	0.92	0.89	0.79
FLD/FLT ratio	20.2	5.7	7.6	6.7	13.3
FLT/NFLT ratio	2.0	2.3	2.5	1.9	2.8

* This variable is SPEFIDB, a recode of the raw material type (Phagan and Hruby 1984:45).
† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:54-56).
§ Data not available.
All data are expressed as percentages except indexes, ratios, and weights.
nfs – Not further specified.

Table 3.8 – Flaked lithic debitage variables, by site type and group A

Variable	Site type														
	Limited activity			Seasonal			Hamlet			Village			Group A		
	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)	N	%	mean wt(g)
Flakes/flake frags															
Grain size															
Medium	176	1	8.0	269	2	16.6	1 560	3	16.8	1 238	2	14.5	174	1	7.7
Items with cortex	34	19	...	127	47	...	599	38	...	611	49	...	37	21	...
Fine	4 776	30	2.4	5 073	40	7.9	11 607	20	11.0	18 226	32	9.6	5 006	32	1.6
Items with cortex	429	9	...	2 025	40	...	4 269	37	...	6 965	38	...	374	7	...
Very fine	7 146	45	1.8	4 352	34	7.2	27 751	48	8.6	22 873	40	7.5	6 534	42	1.7
Items with cortex	743	10	...	1 327	30	...	7 583	27	...	8 728	38	...	685	10	...
Microscopic	3 903	24	1.1	2 962	23	3.2	16 913	29	3.8	14 341	25	2.6	3 820	25	1.1
Items with cortex	281	7	...	511	17	...	2 508	15	...	2 708	19	...	291	8	...
Total flakes/ flake frags	16 001	100	1.8	12 656	100	6.7	57 831	100	7.9	56 678	100	7.1	15 534	100	1.8
Total items with cortex	1 487	9	...	3 990	32	...	14 959	26	...	19 012	34	...	1 387	9	...
Nonlocal items	68	0.4	...	46	0.4	...	107	0.2	...	436	0.8	...	101	0.7	...
FLD/FLT ratio	20.2			5.7			7.6			6.7			13.3		

Grain-size percentages are calculated for the proportion of the total phase assemblage; cortex percentages are calculated for the number of items within each grain-size category.
frags – Fragments.
... – Information not available.

to be more similar to habitations than to limited activity sites, at least with reference to the tasks that may be associated with both flaked and nonflaked stone tools. The nonceramic or minimally ceramic group A sites are also more convincingly interpreted as representing some sort of functional category, rather than some temporal or settlement unit. These interpretive suggestions based on lithic profile comparisons are thought to have rather important implications for a comprehensive understanding of Dolores Anasazi behavioral organization and of systemic stability and change during their occupation of the Dolores valley.

An additional, more specific example of the use of lithic profiles is presented here because of the practical and theoretical importance of distinguishing Archaic from aceramic Anasazi manifestations, particularly in archaeologically mixed contexts, and as a continuation and amplification of earlier reports (Phagan 1984, Greenwald 1981) on the identification and characterization of the DAP Archaic expression. The DAP sequence of prehistoric remains is very predominantly an expression of the Anasazi culture during the period A.D. 600 to 1000. No evidence shows that these Anasazi either developed from or were substantially influenced by earlier Archaic hunter-gatherer populations in the region. The earliest year-round or extensive use of the Dolores River valley was by Anasazi immigrants who came into the area after A.D. 600 and brought with them an already established practice of corn horticulture. Further, evidence of only minimal change is shown in this basic subsistence pattern during their 400 years of nearly continuous occupation in the valley. Against this broadly consistent Anasazi pattern, however, several unusual archaeological assemblages have been recognized that may be, or may contain, Archaic material. These assemblages are usually rather small, they normally lack significant ceramics or architecture, and both features and artifacts subjectively appear to "look Archaic." A few such assemblages contain traditionally diagnostic Archaic projectile points.

Two major problems preclude the facile interpretation of these contexts as Archaic. First, both theoretically and as documented situations, aceramic artifact scatters without architectural evidence occur within the range of Anasazi site types as limited activity loci. Second, no reasonably adequate projectile point typology has been developed that is geographically applicable, includes both Archaic and Anasazi time periods, is statistically supportable, and deals with the problem of Anasazi discovery and reuse of relic items. A most suitable approach to the identity of these possibly Archaic situations would be their direct comparison with an

Table 3.9 – Nonflaked lithic tool variables, by site type and group A

Variable Value	Site type				
	Limited activity (N = 401) %	Seasonal (N = 967) %	Hamlet (N = 3013) %	Village (N = 4381) %	Group A (N = 414) %
Material class*					
Igneous	7	7	13	21	16
Coarse sandstone	7	7	5	3	4
Medium sandstone	65	67	51	30	45
Fine sandstone	15	12	16	22	16
Other sedimentary	2	2	2	3	2
Metamorphic	4	6	9	15	8
Ornamental	0	0	<1	<1	1
Morpho-use†					
Miscellaneous	14	11	21	25	28
Hammerstone	4	5	14	19	18
Mano fragment	5	5	5	4	3
One-hand mano	11	10	6	5	3
Two-hand mano	3	5	13	15	22
Metate fragment	13	11	11	4	1
Trough metate	1	2	5	9	11
Slab metate	1	1	1	<1	<1
Basin metate	1	1	<1	<1	<1
Hafted item	<1	1	3	4	5
Ornament	2	2	<1	1	2
Blank type					
Rounded cobble	6	4	9	12	14
Flattened cobble	23	13	31	27	50
Thick slab	1	1	1	2	3
Thin slab	1	2	3	4	6
Very thin slab	1	1	3	3	3
Completely modified	2	2	1	1	3
Production stage evaluation					
Unmodified	30	31	41	53	45
Minimal modification	11	12	19	19	15
Well shaped	8	8	11	15	28
Stylized	2	2	<1	1	1
Complete items	23	40	57	65	24
Morpho-use diversity					
Shannon-Wiener index	0.58	0.84	0.94	0.95	0.75
Equitability index	0.53	0.72	0.80	0.81	0.69

* This variable is MATERA, a recode of the raw material class (Phagan and Hruby 1984:78).
† This variable is MORPHOA, a recode of the morpho-use category (Phagan and Hruby 1984:91).
All data are expressed as percentages except indexes.

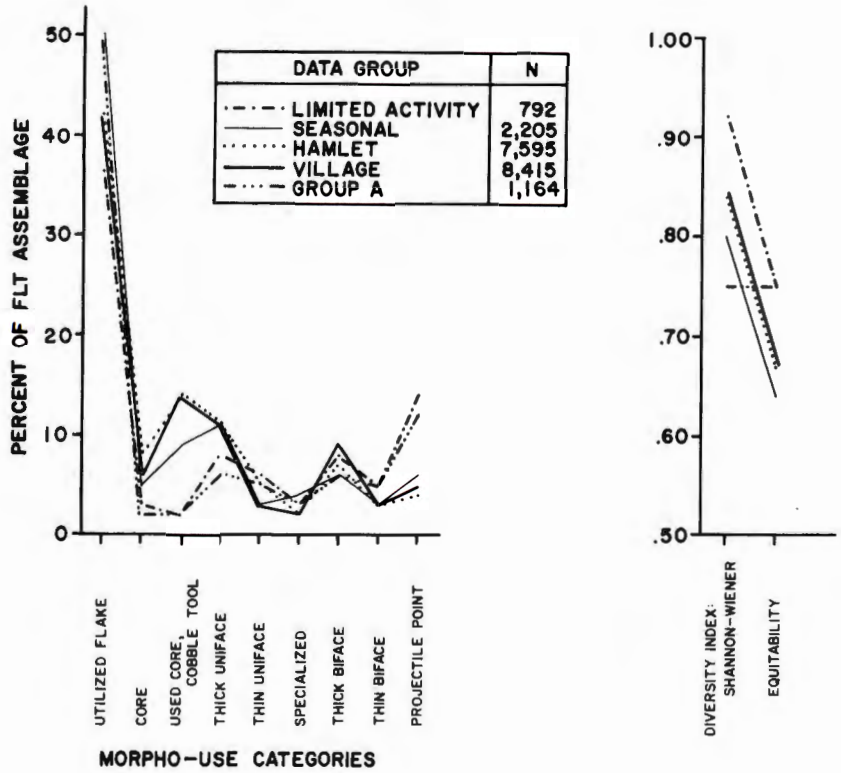

Figure 3.7 - Flaked lithic tool morpho-use and diversity, by site type and group A.

adequate sample of statigraphically defined and independently dated Archaic data. However, such data do not exist, either within the DAP itself or from directly relevant contexts. All DAP suspected Archaic contexts either are of questionable derivation in some important way, are definitely mixed with Anasazi materials, or both. Thus, the problems remain of adequately defining and interpreting these possible Archaic cultural resources in the project area and of accurately recognizing small limited activity Anasazi sites that are primarily lithic in character.

A first-level approach to these problems (Phagan 1984) was to group all suspected Archaic material, along with any accompanying Anasazi material, into a rather gross category of "all possible DAP Archaic material plus some mixed-in Anasazi stuff." This data group was then compared, as a profile of selected lithic variables, with the total group of unmixed Anasazi material. This rough comparison demonstrated rather large differences for several of the variables, which may have been caused by an Archaic component in 1 group. However, when the unmixed Anasazi group was divided into either phase or site type categories, some resulting lithic profiles differed from the Archaic-plus-Anasazi profile much more than others. In addition, some of these resulting profiles differed from each other as much as they did from the Archaic-plus-Anasazi. All this suggested that temporal, organizational, or site type factors within the Anasazi portions of the 2 large data groups could be responsible for the observed differences rather than any distinctions between Anasazi and Archaic. A more carefully planned and controlled study was therefore undertaken to resolve, if possible, some of these analytic problems, and this study is reported in some detail by Greenwald (1981). Further theoretical and data refinements are included here.

A set of explicit differences anticipated for Archaic and Anasazi lithic assemblages was postulated, so that any observed differences could be evaluated with reference to them. These differences were based on distinctions in subsistence strategies and settlement behavior hypothesized for the 2 groups (Chapman 1977; Gomolak 1981, Laumbach 1980, Phagan 1984; Simmons 1981), particularly those associated with greater Archaic mobility and with hunting-gathering versus horticultural economies. These anticipated differences are expressed in the following outline as expectations for Archaic assemblages relative to Anasazi.

I. As a direct or indirect result of greater Archaic mobility, these Archaic assemblages should be characterized by the following:

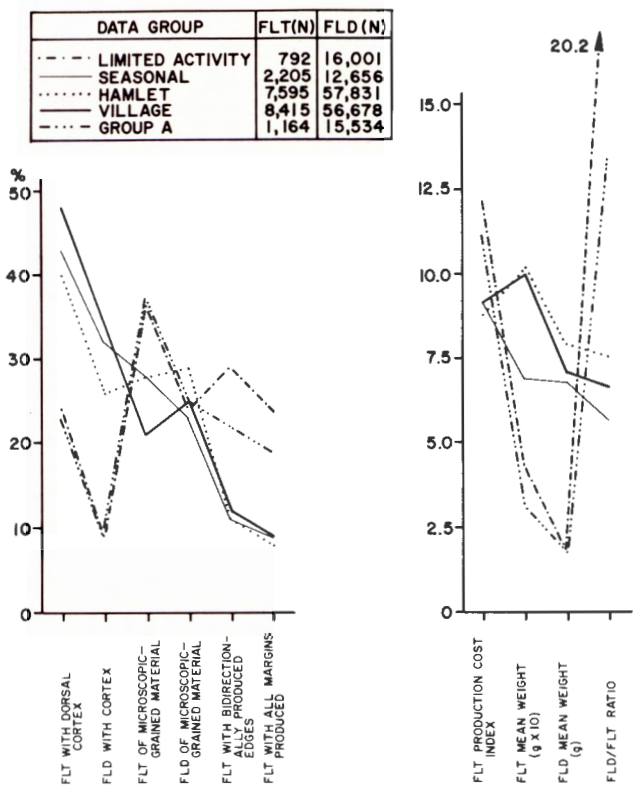

Figure 3.8 – Flaked lithic tool and debitage technological variables, by site type and group A. Flaked lithic tool and flaked lithic debitage percentages are calculated from their respective assemblages.

A. Greater raw material diversity
B. Better raw material quality, smaller grain size
C. Greater assemblage curation; more worn and broken items
D. Smaller mean tool weight
E. More technological production input/tool
F. More and smaller debitage/tool
G. Fewer and more specialized cores
H. Less cortex remaining on tools and debitage

II. As a direct or indirect result of a hunting-collecting subsistence pattern, Archaic assemblages should be characterized by the following:
A. More projectile points and thin bifaces
B. More flaked lithic tools relative to nonflaked lithic tools
C. Fewer expedient tools, such as used flakes
D. More functionally specialized flaked lithic tools
E. More functionally generalized nonflaked lithic tools

The 2 data sets to be used for comparison were then carefully examined. From the possible Archaic or Archaic-containing contexts, only the better examined and better defined were selected. Intensive and controlled surface collection, plus significant excavation were required for inclusion. In addition, only site assemblages with at least 20 flaked lithic tools or 25 total lithic artifacts were included in the analysis to improve the statistical adequacy of the sample and to increase the probability of its representing a substantial Archaic expression. Seven DAP site assemblages were retained to constitute data group I, mixed Archaic and Anasazi.

These 7 assemblages were then carefully scrutinized to identify their Anasazi components with reference to nonlithic characteristics such as independent dating evidence, site function, architecture, ceramic assemblage, locality, assemblage size, and excavation strategy. After thus identifying the Anasazi components in the mixed Archaic-plus-Anasazi data group (I), all DAP pure Anasazi sites were then examined to select a set of site assemblages that duplicated as closely as possible the Anasazi aspects of the mixed group I data set. Five site assemblages were selected as the comparative, pure Anasazi data group II.

While unusual lithic characteristics may have been involved in the initial recognition of potentially Archaic

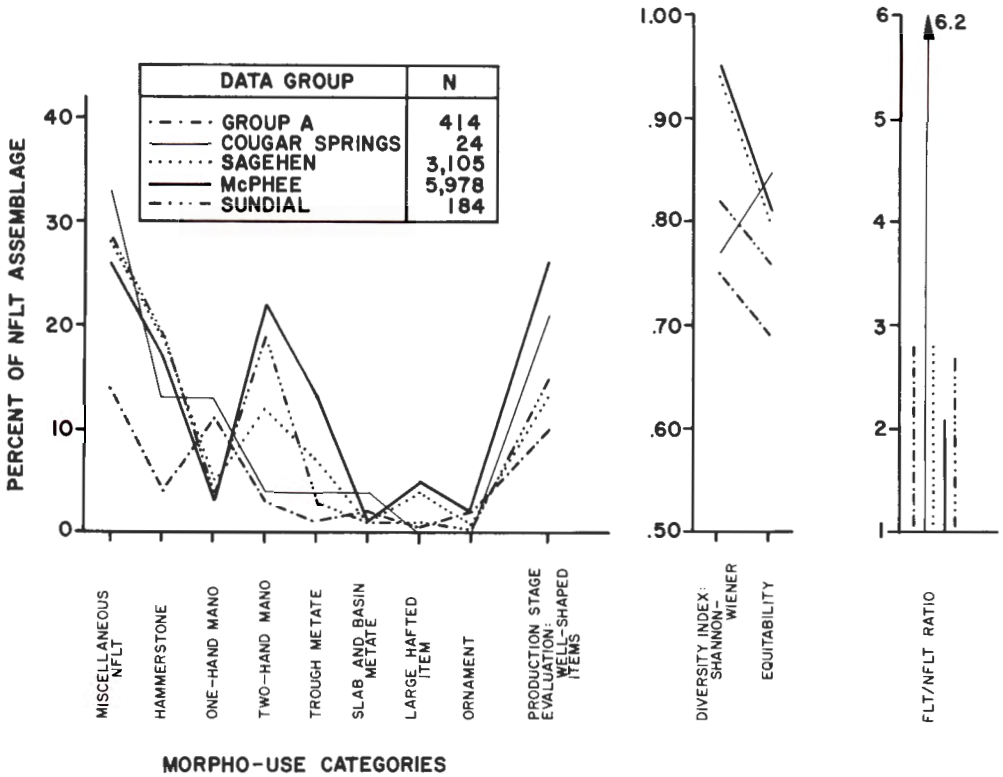

Figure 3.9 – Nonflaked lithic tool morpho-use and diversity, by site type and group A.

or Archaic-containing assemblages, such lithic characteristics, particularly as an explicitly identified and measured suite of logically associated variability, do not define group I or its constituent sites. More important, lithic characteristics have been explicitly avoided in defining the matching Anasazi components of the 2 data groups, so that any observed lithic variability is not a product of the manner in which the groups were constructed.

On the assumption that archaeological contexts with similar nonlithic characteristics should also have similar lithic assemblages, it is expected that the matched Anasazi components of the 2 data groups will contribute only minimally to any lithic differences between them. Any major lithic assemblage differences should then be due largely to the presence in group I of the suspected Archaic materials. In addition, the confidence with which any such differences are interpreted as an Archaic expression should be dependent on the extent of their agreement with the anticipated distinctions between Archaic and Anasazi assemblages.

A one-way analysis of variance (SPSS [statistical package for the social sciences] ANOVA) was run on the two data groups, using the FLT variable tool weight, as a preliminary assessment of the overall variability (Nie et al. 1975). Group I demonstrates high internal variability, and group II demonstrates very little. This can be considered at least a preliminary indication that the 2 data groups do include different sorts of lithic variability, and in broadly anticipated fashion; i.e., the mixed group I was expected to demonstrate greater within-group variability.

A set of lithic variables thought to be relevant and useful as indicators of the anticipated distinctions between Archaic and Anasazi assemblages (refer to Phagan and Hruby [1984] for the definitions and measurement of these variables and their values). These data were then compiled from the preliminary analysis computer files for the 2 groups and are summarized in table 3.10. In addition, several diversity and toolkit cost measures have been calculated for the 2 groups, and these are also presented in table 3.10 (the calculation of toolkit cost is discussed later in this chapter and in Phagan and Maloney [1983]; the calculation and use of diversity measures is discussed in Hruby [1985]).

It is clear from table 3.10 that of the more than 30 direct comparisons between the 2 data groups, the large majority demonstrate differences of considerable magnitude. In addition, an evaluation of these differences with reference to the anticipated Archaic distinctions

Table 3.10 – Selected lithic variables, by groups I and II

Variable	Group I*	Group II†
FLT variables	(N=491)	(N=299)
Morpho-use category:		
Used flakes (%)	28.7	34.4
Cores (%)	4.9	20.1
Specialized forms (%)	5.7	1.7
Thick bifaces (%)	9.0	10.4
Thin bifaces (%)	12.0	6.0
Projectile points (%)	18.7	6.0
Microscopic raw material grain size (%)	36.3	22.1
Complete or nearly complete items (%)	67.0	82.9
Dorsal face evaluation:		
Items with cortex (%)	21.4	32.4
Well-shaped and stylized faces (%)	29.8	4.6
Items with bidirectional edges (%)	40.5	22.0
Items with all margins produced (%)	19.8	12.4
Cores, unspecialized (%)	50.0	71.7
Cores, specialized (%)	29.2	23.3
Item weight:		
Mean weight (g)	39.2	102.0
0.95 confidence interval (g)	30.4-48.0	79.5-124.5
FLD variables	(N=10 836)	(N=3861)
Mean weight (g)	1.9	6.7
Items with cortex (5)	10.8	16.8
Microscopic raw material grain size (%)	28.8	24.1
FLD/FLT ratio	22.1	12.9
NFLT variables	(N=149)	(N=206)
Morpho-use category:		
One-hand manos (%)	25.5	5.3
Two-hand manos (%)	3.4	14.1
Complete or nearly complete items (%)	36.2	44.7
Item weight:		
Mean weight (g)	975	2315
0.95 confidence interval (g)	582-1332	1606-3024
NFLT (% of all tools)	23.3	40.8
FLT raw material diversity:		
Shannon-Wiener index	.75	0.83
Equitability index	0.83	0.92
FLT morpho-use diversity:		
Shannon-Wiener index	0.93	0.92
Equitability index	0.77	0.74
NFLT morpho-use diversity:		
Shannon-Wiener index	0.52	0.85
Equitability index	0.50	0.74
Flaked lithic toolkit cost:		
Acquisition cost index	16.3	15.6
Production cost index	12.5	9.7
Total cost index	28.8	25.3

* Group I – Mixed Archaic and Anasazi; includes Sites 5MT2199, 5MT2202, 5MT2236, 5MT2242, 5MT4690, 5MT4789, and 5MT4797.
† Group II – Unmixed Anasazi; includes Sites 5MT2174, 5MT2181, 5MT2191, 5MT2241, and 5MT4512.
Percentages are calculated from the group total for the appropriate data category.

indicates that virtually all of the observed variability is of the nature anticipated if the major between-group difference is the presence of an Archaic component in group I. Not all of these differences, however, are statistically significant. A series of appropriate tests was performed on 15 of the variables or combinations of them, and statistically significant differences at the 0.05 level were confirmed for 10 of the tests (refer to Greenwald [1981] for details of these significance tests). Several variables from table 3.10 that could be conveniently graphed at the same scale are presented in figure 3.10.

It may be safely concluded that data group I does represent a mixture of Anasazi and Archaic materials. Further, the lithic profiles may be used as a frame of reference to determine the likelihood that other unknown aceramic site assemblages in the project area might be either Anasazi or Archaic expressions, so long as their Anasazi components are not statistically overwhelming.

RAW MATERIALS

In response to the DAP general research design (Kane et al. 1983), and as specifically indicated in the midlevel research design of the Reductive Technologies Group (Phagan 1983:18-22), considerable analytic attention has been directed to an assessment of lithic resources: What resources were available? Which ones were used? How were they used? How was their exploitation organized? All are questions of importance in understanding Dolores Anasazi patterns of environmental adaptation, particularly with reference to Problem Domain 1: Economy and Adaptation (Kane et al. 1983:4-9).

The needs of Dolores Anasazi populations for lithic materials are focused in 2 categories: stone for building and stone for producing tools. The latter may be divided into materials for producing tools by flaking, such as scrapers and projectile points, or by a pecking-grinding-polishing technique, such as manos and axes. Lithic properties, or characteristics, required for these 2 methods of stone tool production are very distinct, and materials with these differing properties occur quite differentially in the environment. These sets of properties are identified in DAP preliminary analyses by assigning a "lithic material class" and "grain size" to each item. In addition, each flaked stone tool receives a "specific material identification" (refer to Phagan and Hruby [1984] for definitions of these lithic raw material variables and values).

The bedrock geology of the DAP area consists of late Jurassic and early Cretaceous period formations, which are well exposed in the steep canyon walls of the Dolores River, Dry Creek, Beaver Creek, and House Creek, as well as the House Creek Fault escarpment. These exposures are indicated on the map included as figure 3.11, and an abbreviated and localized stratigraphic description is provided in figure 3.12. Both the Morrison and Burro Canyon Formations contain a wide range of silicified sediments, cherts, and a few opals and chalcedonies, many of which are good to fine quality for producing flaked stone tools. In addition, the full range of these locally available materials, a wide variety of sedimentary and metamorphic materials, and a few intrusive igneous materials are available to at least some degree in both the recent and ancient Dolores River gravel deposits.

Materials for architectural use and for producing ground stone, or nonflaked lithic, tools are also widely available in the Dolores Project area, primarily from the Dakota Sandstone, which forms the upper, most resistant bedrock and controls surface topography over most of the upland portion of the project area. It outcrops frequently in small drainages as thin- to medium-bedded, coarse-grained, well-cemented material, which is ideal in shape and structure for both building stone and the manufacture of grinding implements.

While many areas of the American Southwest have adequate lithic resources to meet the stone tool and construction needs of sizable populations, rarely is the DAP area's range of desirable variability and relative ease of procurement matched. Only materials of spectacular appearance and flaking quality are not found within the project area. Many of the fine-grained silicified sediments from both the Morrison and Burro Canyon Formations are of adequate quality to produce the most technologically demanding of the Anasazi stone tools. Certainly the abundance and quality of lithic resources was one of the area's attractions for aboriginal populations. To the extent that modern availability of these resources in gravels and natural exposures is equivalent to prehistoric availability, they may be treated as virtually unlimited and unchanging throughout the Anasazi occupation.

In such a situation, lithic resource procurement strategies should be rather casual and relaxed, should involve little scheduling effort, and should normally involve only individual or small-group activity. In many cases, this procurement would frequently be embedded within other scheduled activities: individuals or small groups, in the process of traveling to or from other activity locations, would simply stop briefly to collect a few needed raw material items, reduce them minimally, and continue with scheduled activity. Such an expedient approach to raw material procurement should be accompanied by a similar approach to both production and use of most stone tools (Binford 1977,

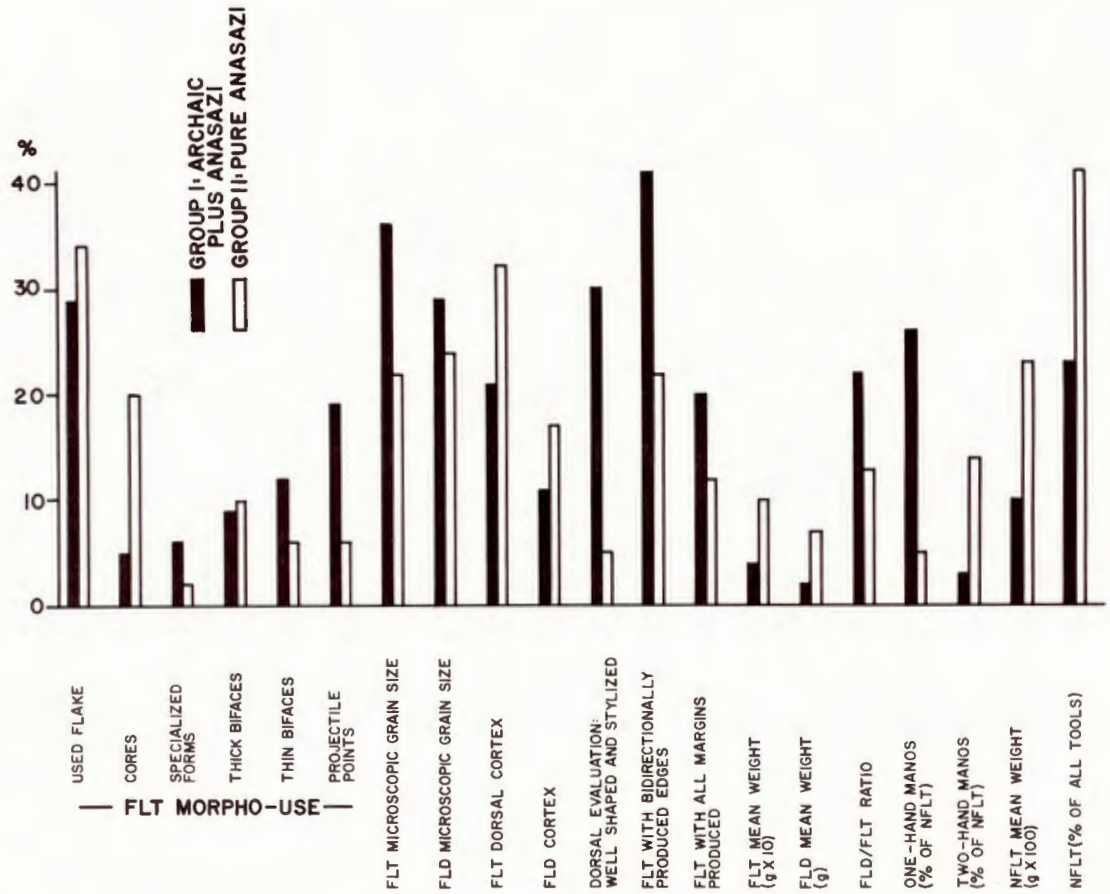

Figure 3.10 – Selected lithic variables, by groups I and II.

1979). When little effort is involved in raw material procurement, little motivation exists for intensive labor investment in production, maintenance, and curation of most tools. Exceptions to this generalization should be those technologically specialized high-production-input items necessary for specific and critical tasks, such as some manos, projectile points, thin bifaces, or drills. Most general cutting or scraping tasks could be readily performed with quickly and expediently produced tools from easily procured raw material. It was often as efficient to produce another unhafted tool as to locate and resharpen an existing one, and such items would seldom be transported long distances.

Such very expedient technological systems should develop only in areas of relatively abundant raw material. They should display generally low proportions of well-worked or well-worn items. True quarry sites should be few in number, small in size, and located only at particularly desirable resource availability locations. Reduction of raw material at the quarry sites should not be extensive. Most sites should contain higher proportions of the most readily available, closest raw material.

Within this context of raw material availability, and structured by these general expectations for raw material use, the questions posed by the project general research design (Kane et al. 1983) concerning what resources were used and how they were used may be considered. Several of these questions were addressed in the preceding section with reference to the Archaic or aceramic DAP materials, and the analytic concern here is to examine the distinctly Anasazi aspects of raw material variability. Only subphase and site type data groupings will be used to evaluate raw material variability; basic data for this examination are included in tables 3.4 and 3.7. For these comparisons, raw materials are grouped into 7 major classes: all definitely nonlocal materials are grouped; both Morrison and Burro Canyon formation materials are subdivided into quartzites and cherts, largely on the basis of particle size; the category of local cobbles is composed almost exclusively of a dark gray, medium- to very fine grained metamorphosed shale, or hornfels, which is readily available in the Dolores River gravels; and all other locally available material is lumped as an nfs (not further specified) category.

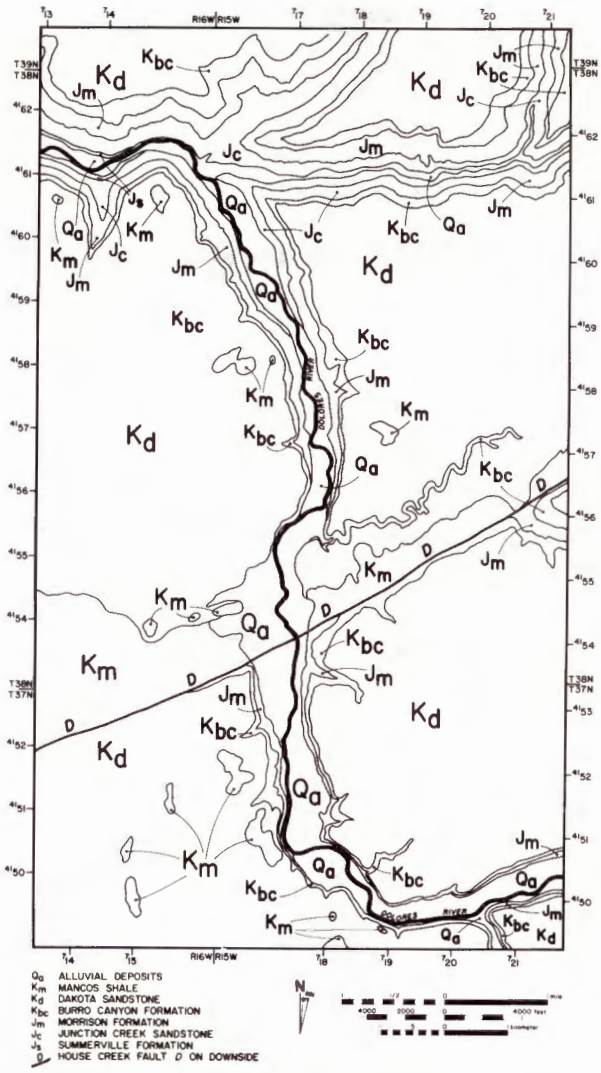

Figure 3.11 – Dolores Archaeological Program geologic formations (after Leonhardy and Clay 1985:fig. 17.).

The FLT distribution of these raw material groups by DAP subphase is graphed in figure 3.13. Little subphase variability occurs in 4 of the raw material groups (nonlocal, Morrison chert, Burrow Canyon quartzite, and local, nfs). To the extent that these subphase data groupings can be interpreted as a generalized temporal sequence, very slight temporal trends are suggested during portions of the sequence for several of these raw material groups, though they are not likely to be statistically significant and should be interpreted very cautiously. The remaining 3 raw material categories demonstrate considerable subphase variability that is clearly not temporally trending and is not particularly susceptible to convincing a posteriori explanation.

Also included with figure 3.13 are values for FLT acquisition and production cost. The calculation of these will be explained later (refer also to Phagan and Maloney 1983). These relative measures of raw material acquisition cost and production-input cost demonstrate no consistent temporal trend. However, an indication that acquisition costs are highest in the 2 earliest subphases does exist, though this hardly constitutes a trend of major importance and may be more directly associated with organizational or site type factors.

Figure 3.14 is a graph of the FLT raw material groups arranged by major site types, and in it a very different pattern of variability is evident. Increasing site size, complexity, and duration of occupation (from left to right on the horizontal axis) is associated with at least a generally trending increase or decrease in 6 of the 7 raw material groups. Limited activity sites are clearly quite different from other site types in raw material

Geologic formations	Description at DAP	DAP coding structure
Mancos Shale	Mostly shale, mudstone; highly variable. Little tool-quality stone	Mancos Shale
Dakota Formation	Upper: thin bedded, tabular, moderately to poorly cemented sandstone; conglomerate	Dakota Sandstone
	Lower: highly variable; includes some material that is fine grained and well silicified; mostly white to buff and light gray	Burro Canyon
Burro Canyon Formation	Upper: very similar to lower Dakota Sandstone; includes some material that is coarser grained but highly silicified. Good flaking quality	
	Lower: thin bedded; fine to very fine grained; variously silicified sediments, including some cherts. Many very suitable tool stones	Morrison
Morrison Formation	Brushy Basin member;* very similar to lower Burro Canyon; many green to purple sediments	
	Salt Wash member; fluvial and flood plain deposits; highly variable in grain size (conglomerate through chert) and silicification. Some rare good quality tool stone	
Junction Creek Sandstone	Massive, wind deposited, cross-bedded	Junction Creek

* The term "Brushy Basin" has been used in the DAP coding structure to indicate the colorful, highly silicified cherts and siltstones that are found to the west, northwest, and southwest of the DAP area.

Figure 3.12 – Stratigraphic description of major geologic formations.

selection. (The differential use of selected raw materials for tool production will be considered later.) Only the proportions of Morrison chert and Burro Canyon chert are quite constant for all site types.

Limited activity sites demonstrate higher proportions of the better quality nonlocal and especially Burro Canyon quartzite materials, and lower proportions of the poorer quality Morrison quartzite, local cobbles (hornfels), and local nfs materials. This is certainly to be accounted for in the specialized range of tasks performed at these sites: specific procurement needs are anticipated, appropriate tools or materials for their production are assembled and taken, and some tools may

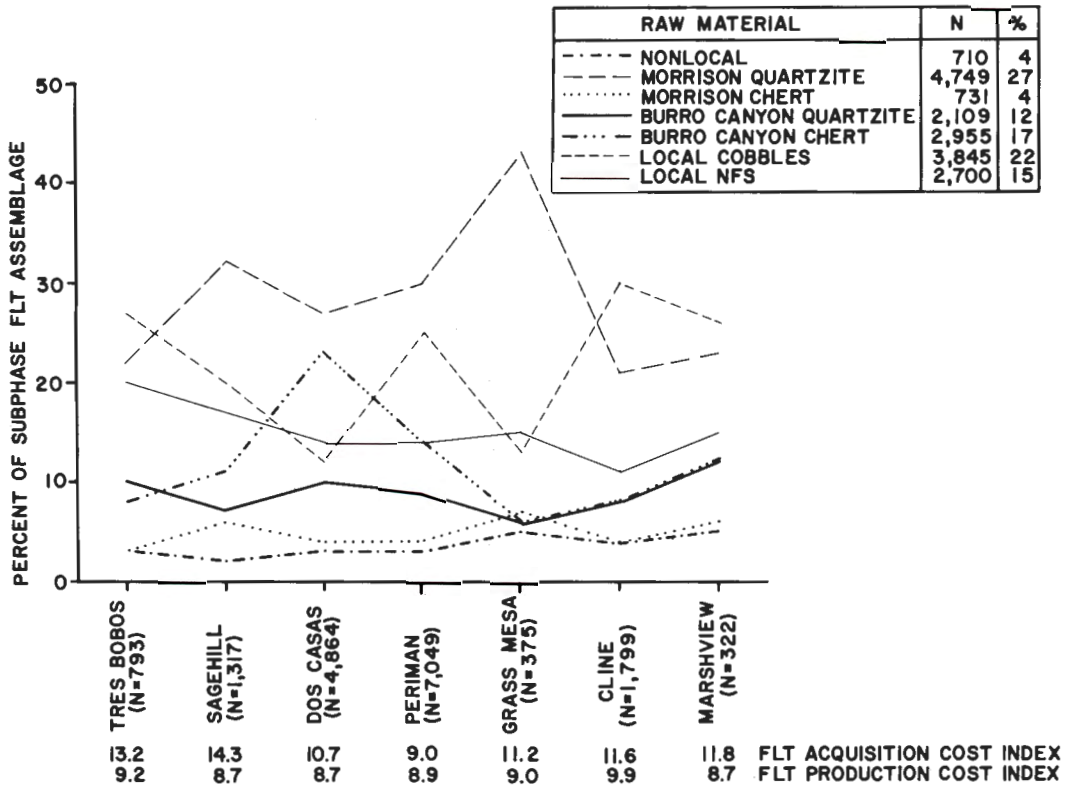

Figure 3.13 – Flaked lithic tool raw materials, by subphase.

be left behind. The relationship between a limited set of specific tasks and the particular toolkit necessary is direct and close.

Seasonal sites are clearly distinguished from limited activity sites in having reduced proportions of the better quality nonlocal and Burro Canyon quartzite materials, and increased proportions of the generally poorer quality Morrison quartzite and materials from the river gravels. This very different pattern of raw material selection is also best explained by differences in the nature and tool requirements of most tasks performed at the 2 site types. Seasonal sites represent a wider range of more generalized tasks, perhaps associated with opportunistic procuring and processing of a variety of small mammals and with maintenance and domestic activities associated with seasonal periods of site occupation. Seasonal sites are differentiated from hamlets primarily in that the later display a further decreased proportion of Burro Canyon quartzite and a further increased proportion of Morrison quartzite, both of which may be viewed as an amplification of the same behavioral/organizational patterns associated with increasing occupation duration and an increased range of generally less specialized tasks. With reference to FLT raw material assemblages, seasonal sites are much more closely related to permanent habitation hamlet sites than to limited activity sites.

Village sites are distinct from hamlets only in that villages display a marked increase in the proportion of local cobbles, or hornfels. This distinction is quite likely the result of settlement pattern factors combined with an Anasazi tendency toward using the most immediately available raw materials for as much of the toolkit as possible. Hamlet sites, which are concentrated in the earlier portion of the DAP sequence, are scattered rather evenly over the entire project area, and are particularly common in the Sagehen Flats-north Sagehen area. Many are located at some distance from the Dolores River, and these gravels are the only source of the local cobbles (hornfels) raw material category. The village sites, however, are all located quite close to the river where hornfels is among the most readily available material. The FLT acquisition cost index seems to reflect quite appropriately the site type distinctions in raw material acquisition patterns previously outlined, particularly when it is recalled that most seasonal sites are generally contemporaneous with villages and share to some extent a focus on low-cost hornfels.

These data, as well as from the lithic profile data in the preceding section, show that the functional/organizational data arrangement by site type provides more useful interpretable variability among Dolores Anasazi FLT assemblages than does the largely temporal arrangement of the same data by subphase.

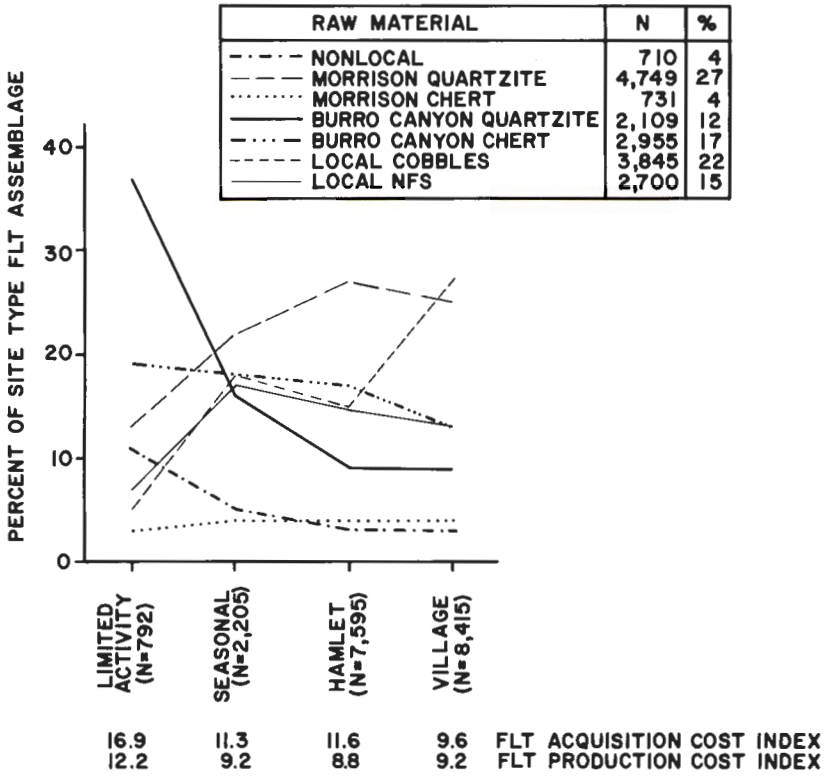

Figure 3.14 – Flaked lithic tool raw materials by site type.

When attention is shifted from the classes of raw materials used for FLT assemblages to how those materials were used, the addition of the tool morpho-use category, or tool type, to the same subphase and site type data groupings is necessary. Figures 3.15 through 3.21 are separate graphs for each major raw material group, in which the proportion of each tool type made from the raw material is plotted for each subphase. The subphase variability of tools made from nonlocal raw materials is shown in figure 3.15. These materials constitute only 2 to 5 percent of FLT subphase assemblages, and several of the samples are quite small for reliable interpretation. Nonlocal materials are clearly concentrated as either used flakes or projectile points in all subphases, with the relationship between the 2 generally inverse: fewer nonlocal used flakes is accompanied by more nonlocal projectile points, and vice versa. There is no indication of a temporal trend in these data. The small Grass Mesa Subphase assemblage of nonlocal materials (N = 17) consists of only bifaces (18 percent) and projectile points (82 percent).

The pattern of Morrison quartzite FLT distribution (fig. 3.16) is very consistent for all subphases, with only some slight variability in the proportion of used flakes, used cores/cobble tools, and thick bifaces. These readily available, medium- to good-quality materials, along with the hornfels materials from the river gravels, consistently make up the greater portion of all subphase FLT assemblages. This reflects the generally expedient nature of the Dolores Anasazi FLT technology, plus its rather low, raw material quality demands. The small Marshview Subphase Morrison quartzite assemblage is somewhat distinct in that it demonstrates clear extremes for cores and thick bifaces. This may indicate a tendency for this later population to leave these particular materials as chunkier cores rather than further reducing them to thick bifacial cores. Again, no suggestion of temporal trends in these data is indicated.

The profiles for Morrison cherts (fig. 3.17) represent much smaller proportions of the FLT subphase assemblages, making up only 3 to 7 percent of these assemblages. These cherts are far less plentiful in the Morrison Formation than are quartzites, and frequently have serious internal flaws or incipient fracture planes. Morrison chert does rarely occur without such internal flaws, and in such instances it is superior material for the production of high-input bifacial items.

The distribution of Burro Canyon quartzite (fig. 3.18) demonstrates less subphase consistency than other local raw material types. Highly variable in quality, it ranges from virtually unflakable to very highly silicified, regular, and predictable. Apart from a marked tendency to occur with greater frequency as either used flakes or

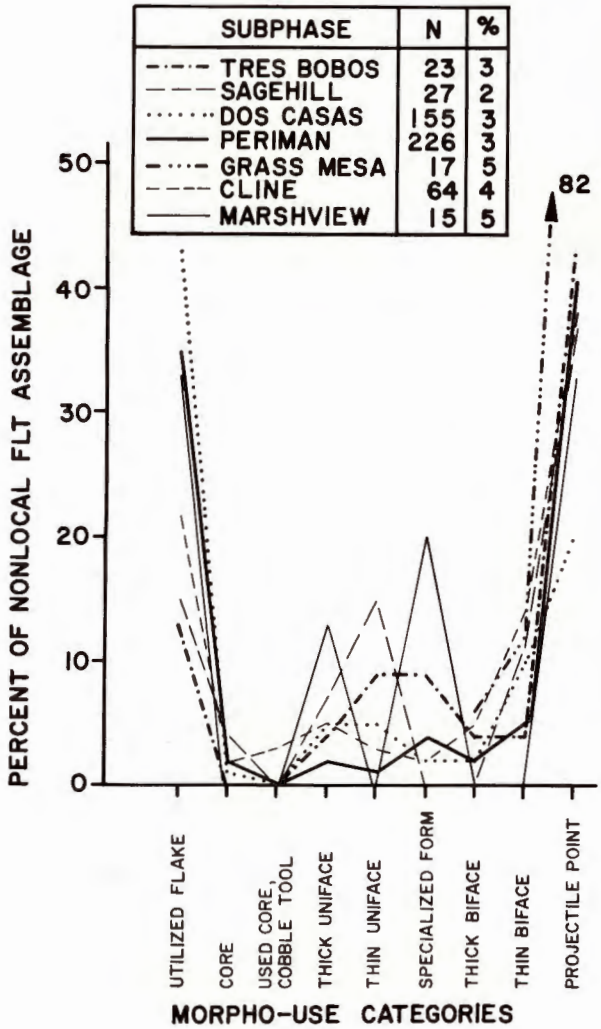

Figure 3.15 – Subphase flaked lithic tool variability, nonlocal raw materials. The percentages provided in the legend box are the proportion of nonlocal materials in the subphase flaked lithic tool assemblage.

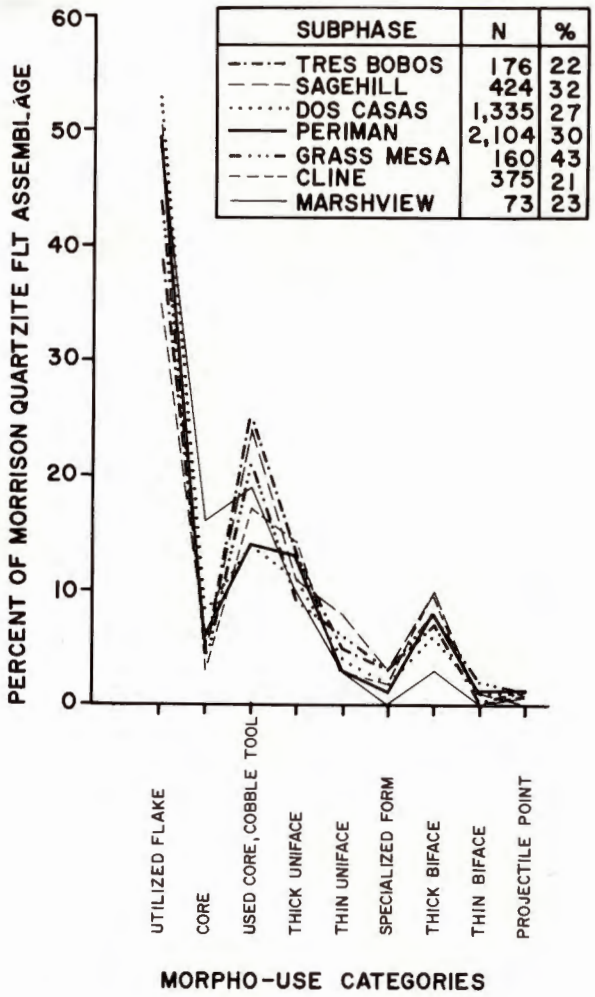

Figure 3.16 – Subphase flaked lithic tool variability, Morrison quartzite raw materials. The percentages provided in the legend box are the proportion of Morrison quartzite in the subphase flaked lithic tool assemblage.

projectile points (with generally an inverse relationship between the 2), Burro Canyon quartzite displays little discerniable pattern of any kind, including that of temporal trends.

The subphase distribution of Burro Canyon chert (fig. 3.19) is almost as variable as for quartzites from the same formation, largely as a result of a similarly extreme variability in the raw material category itself. This Burro Canyon chert is heavily but variably concentrated in the used flake component of the FLT assemblages, with the Sagehill Subphase being especially low and the Dos Casas and Marshview Subphases especially high. In addition, there is a slight but regular tendency for projectile point production with Burro Canyon chert, and the small Grass Mesa Subphase assemblage of this material type is 1/3 projectile points.

The subphase distribution for local cobbles is presented in figure 3.20. Most material coded as local cobbles is a fair to good quality, fine-grained, dark gray hornfels, which is readily available in both ancient and modern river gravels. Consistent with its availability as river cobbles and its less than excellent flaking quality, this material type is almost always used for large, low-production-input items such as used flakes, used cores/cobble tools, and thick bifaces. The small Grass Mesa Subphase assemblage is again somewhat unusual, demonstrating variability extremes for 5 of the 9 morpho-use tool types.

Materials known to occur as minor components of the Dolores River gravels, materials that fall into overlapping ranges of variability for local formations, and materials from the Dakota Sandstone, Junction Creek, or Mancos Shale Formations, which are only rarely of

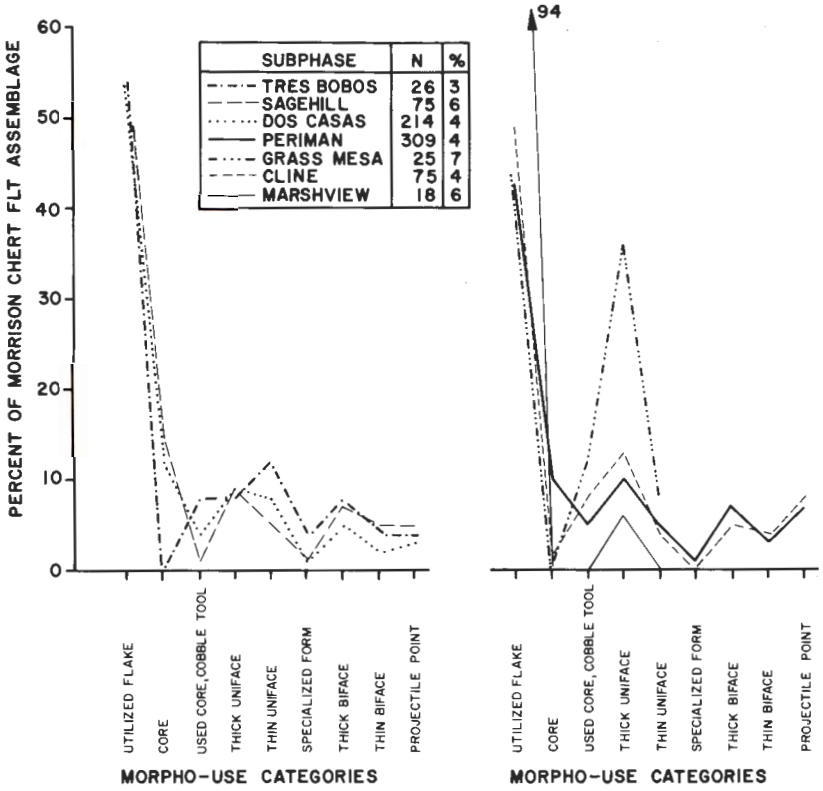

Figure 3.17 – Subphase flaked lithic tool variability, Morrison chert raw materials. The percentages provided in the legend box are the proportion of Morrison chert in the subphase flaked lithic tool assemblage.

flakeable quality, are all recoded here as local materials, nfs. Because they are normally of rather poor flaking quality, their subphase FLT distributions are anticipated to demonstrate increased proportions of low-input items. Figure 3.21 confirms this expected pattern, though the rather extreme subphase variability in used flakes and used core/cobble tools is unexplained.

The preceding series of graphs indicates raw materials were selected and used by the Dolores Anasazi for FLT production in ways that vary considerably according to raw material type, morpho-use tool type, and subphase. The better quality raw material categories tend to demonstrate considerably more subphase variability in morpho-use type, while the poorer quality materials show very little subphase variation in morpho-use type. No indication exists, however, that any of this subphase variability constitutes consistent temporal trends in the selection or use of any particular raw materials for particular tool classes.

Figures 3.22 through 3.28 are separate graphs for each raw material group, in which the proportion of each morpho-use tool type made from the raw material is plotted for each major site type. Figure 3.22 presents the FLT site type distribution for nonlocal raw materials. These materials make up only 3 to 5 percent of seasonal site, hamlet, and village FLT assemblages, but constitute 11 percent of the limited activity site type assemblage. Reasons for this increase may involve the likelihood of an increased proportion of Archaic expressions in this site type, a range of activities performed that required tools to be made to more exacting design requirements, or the presence and use at these sites of more highly curated items of personal gear (Binford 1979), all of which are presumed to have increased tool production input demands and, therefore, greater proportions of better quality nonlocal material. These nonlocal materials demonstrate a very similar distribution among site types, with high proportions of used flakes, thin bifaces, and projectile points, and rather low proportions of all other tool types. The seasonal site distribution demonstrates a minor exception in having an increased proportion of specialized forms and a decreased proportion of thin bifaces. This may be the result of some particular set of subsistence or maintenance tasks performed at field house sites.

The site type distribution of Morrison quartzite flaked lithic tools is presented in figure 3.23. This material type makes up approximately 25 percent of the seasonal site, hamlet, and village FLT assemblages, but only

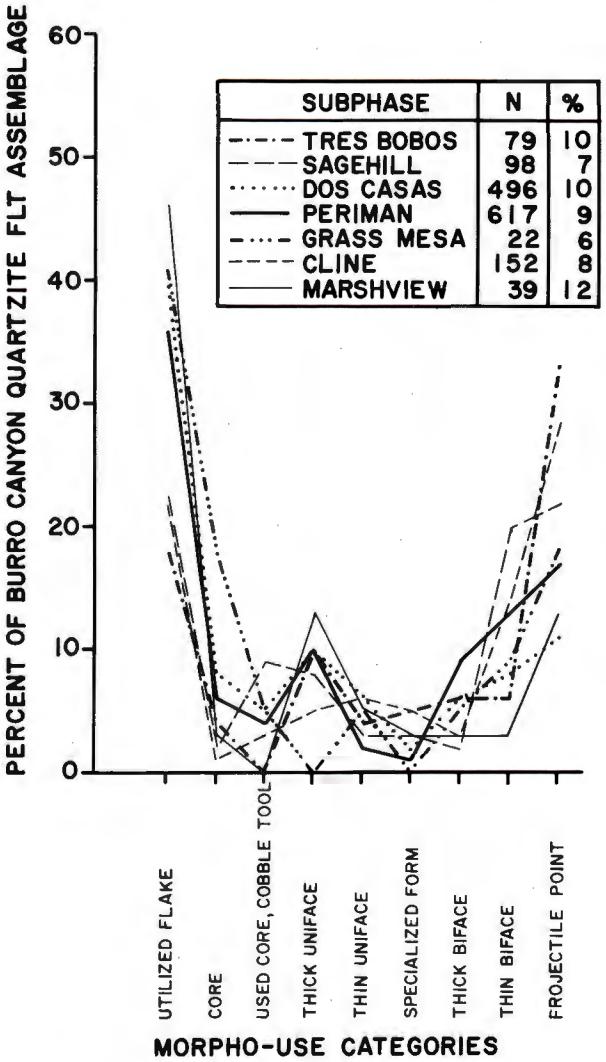

Figure 3.18 – Subphase flaked lithic tool variability, Burro Canyon quartzite raw materials. The percentages provided in the legend box are the proportion of Burro Canyon quartzite in the subphase flaked lithic tool assemblage.

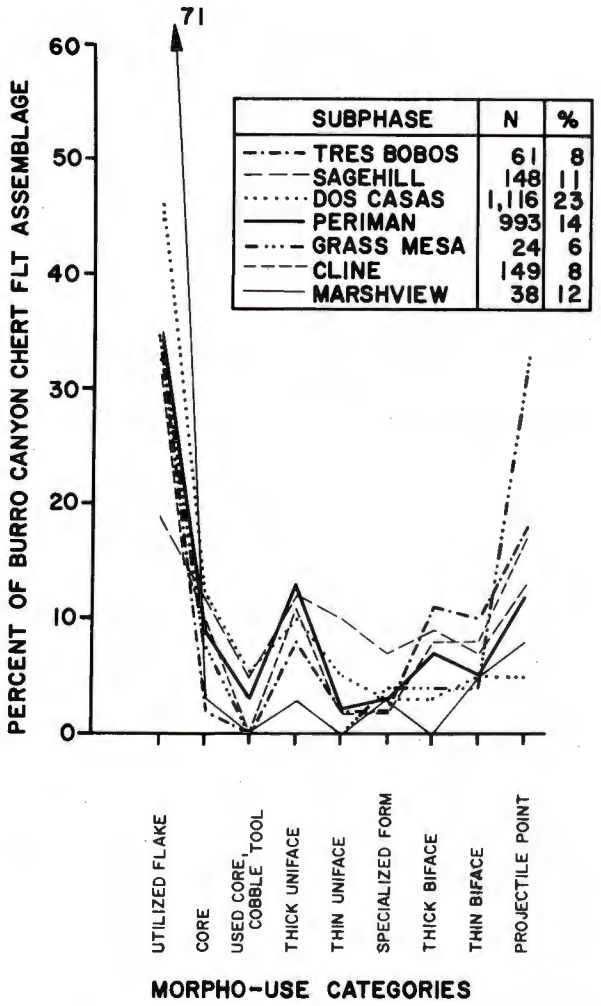

Figure 3.19 – Subphase flaked lithic tool variability, Burro Canyon chert raw materials.

13 percent of the limited activity site type assemblage. It is very consistently used for the low-production-input items: used flakes, used cores/cobble tools, thick unifaces, and thick bifaces. This pattern is especially obvious for the seasonal, hamlet, and village site types. The smaller sample from limited activity sites differs only in having fewer heavy vertical force applying tools and more thin unifacial tools made from Morrison quartzite. This is certainly congruent with the range of activities that are postulated for the site types. The typical Dolores Anasazi selection and use pattern for this readily available, generally fair to good quality raw material is very predominantly as usable flakes, and secondarily for heavier items such as thick bifaces, thick unifaces, and cores, many of which were further used as hammerstones.

The site type distribution of Morrison chert is presented in figure 3.24. This material comprises only 3 to 4 percent of site type FLT assemblages and demonstrates far less consistency than quartzites from the same formation. The tool type distribution of this material indicates a generally similar pattern for seasonal, hamlet, and village assemblages, and a noticeably distinct pattern for limited activity sites, even though the limited activity sample is small. This distribution is best understood when the characteristics and occurrence of the raw material itself are considered. Morrison chert occurs only occasionally and unpredictably in the formation, and is normally of rather poor flaking quality because of numerous interior cracks and incipient fracture planes. However, this material does very rarely occur in fairly large (fist-size) homogeneous pieces that are excellent to superior in flaking quality. The potential for locating this high-quality variant maintains the material in the FLT assemblages as a small and fairly

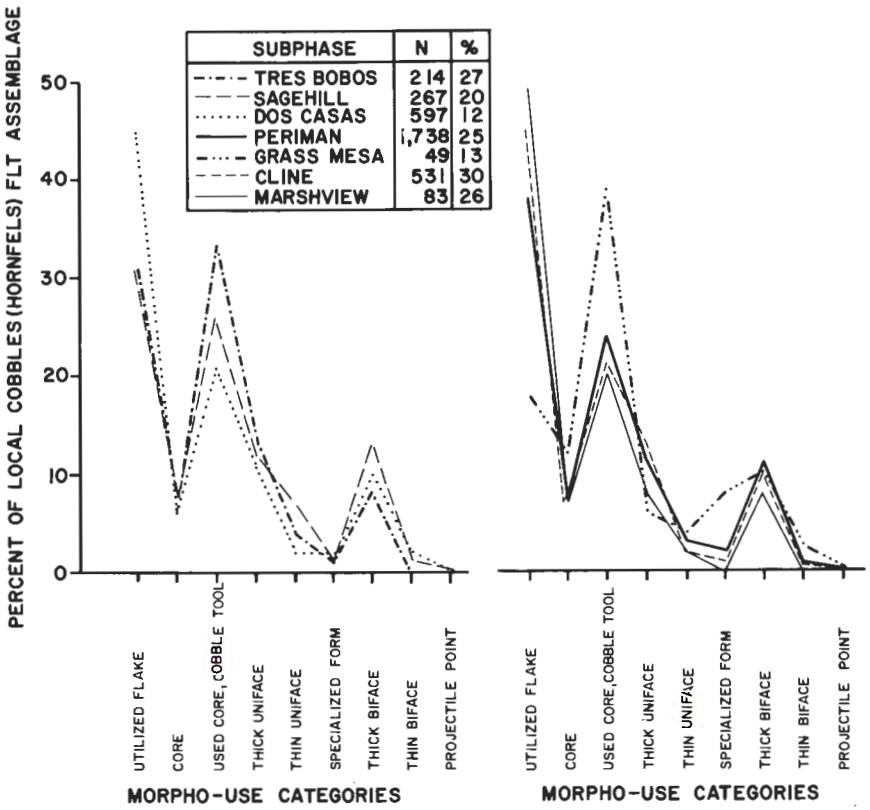

Figure 3.20 – Subphase flaked lithic tool variability, local cobbles (hornfels) raw materials. The percentages provided in the legend box are the proportion of local cobbles in the subphase flaked lithic tool assemblage.

constant proportion, though extended search time makes its cost relatively great. Most Morrison chert collected turns out to be inappropriate for the most technologically demanding tasks and therefore becomes used flakes and other low-input items, but the occasionally superior pieces become thin bifaces or projectile points. This may account for the tentative distribution of Morrison chert among limited activity sites, in which a technologically more specialized and demanding range of tasks results in greater selection for the better raw material, and its use for projectile points rather than used flakes.

Figure 3.25 presents the site type distribution of FLT morpho-use categories for Burro Canyon quartzite. This material is often rather coarse in absolute grain size, but may nevertheless be extremely well silicified, so that fracture occurs very predictably through the included sand grains rather than around them, thus increasing the utility of the material for high-input items. The very consistent distribution for all 4 site types clearly indicates a use pattern congruent with these characteristics. This consistency in FLT use occurs despite extreme differences in the proportion of the site type assemblage constituted by the material type. Burro Canyon quartzites make up only 9 percent of the permanent habitation assemblages and 16 percent of the seasonal site assemblage, but comprise 37 percent of FLT items from limited activity sites, the largest proportion of any material type. It is apparently used in the same basic way for stone tool production, regardless of how much is in the site type assemblages.

The FLT distribution of Burro Canyon chert in site type assemblages is given in figure 3.26. This material type occurs as a much more regular proportion of site type assemblages, varying only between 13 and 19 percent. In addition, its tool type distribution is generally quite similar for all 4 site types, though the limited activity sites assemblage displays a slight tendency toward extreme values for most tool types.

The use of local cobbles in the site type FLT assemblages is shown in figure 3.27. This rather intermediate quality material is only a minor constituent of limited activity sites, is better represented in the seasonal and hamlet site type assemblages, and comprises over 1/4 of the village sites FLT assemblage. This distribution is almost certainly related to the reduced need at limited activity sites for the heavier, low-input tools most

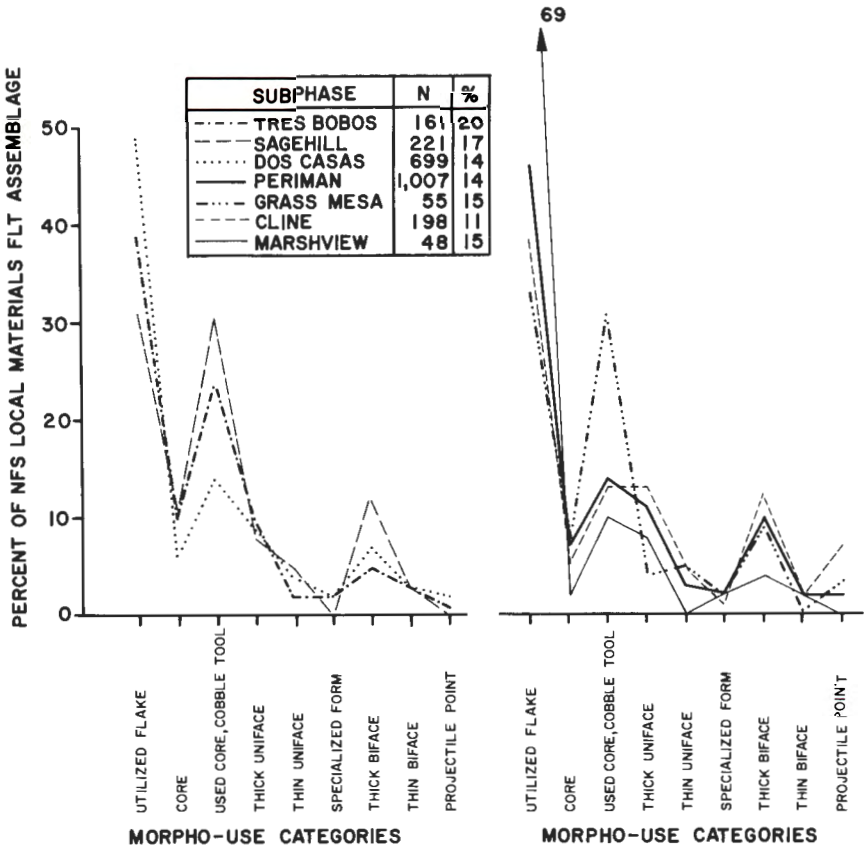

Figure 3.21 – Subphase flaked lithic tool variability, local raw materials, not further specified. The percentages provided in the legend box are the proportion of local materials, not further specified, in the subphase flaked lithic tool assemblage.

suitably made from hornfels cobbles, as well as to the proximity of village sites to the river gravel source of this material. The tool type distribution of this material is quite different from those previously considered and is quite consistent among the site type assemblages, particularly the seasonal, hamlet, and village categories. Cobbles are used quite regularly for larger, heavier, low-input tools regardless of the assemblage proportion they comprise or the site type in which they occur. Hamlet and village assemblages are virtually identical with reference to the proportional occurrence of FLT morpho-use types; the small sample from limited activity sites deviates slightly in its proportion of thick unifaes and thick bifaces.

The site type distribution of local materials, nfs, is presented in figure 3.28. These assorted, locally available materials are normally of rather poor flaking quality, and their FLT distribution is therefore quite similar to the preceding hornfels material type; most tools made from these assorted materials are larger, low-input items. The assemblages from seasonal, hamlet, and village sites are generally quite similar, but the small, limited-activity site type sample is distinct and constitutes a much smaller proportion of the FLT assemblage. Apparently, at limited activity sites the best of these assorted materials have been selected for the production of projectile points.

From the preceding data, the critical organizing variables with reference to both the selection and use of lithic materials are those related to site type rather than subphase. Further, 2 consistent basic patterns for this raw material selection and use are: one for limited activity sites, and another for seasonal, hamlet, and village sites.

Limited activity sites are consistently more distinct from seasonal sites than seasonal sites are from permanent habitation sites. Two factors seem particularly important in explaining this dichotomy in site type variability. First, and probably most important, is the character of subsistence and maintenance activities assumed to have occurred at the site types, especially with reference to a very brief as opposed to a seasonal or year-round occupation, and also with reference to

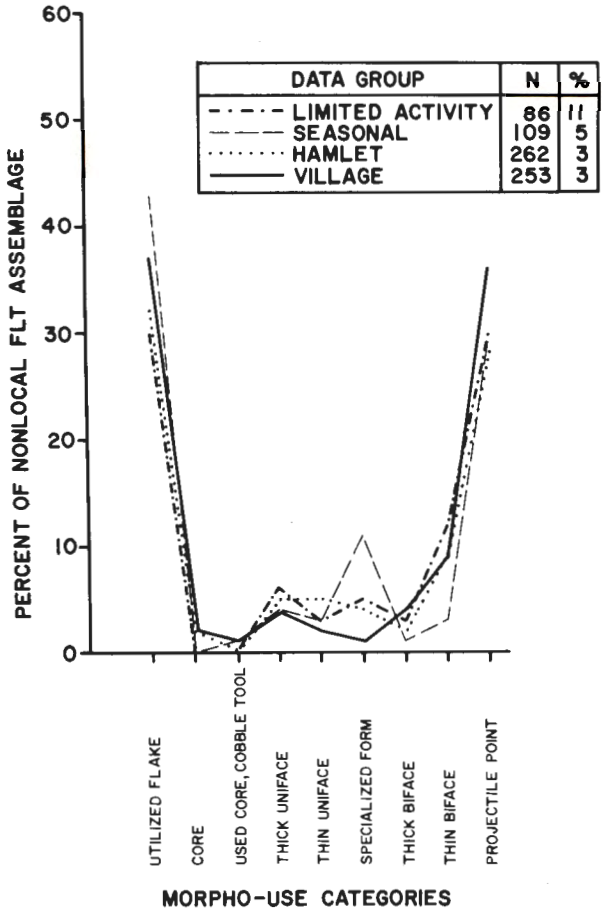

Figure 3.22 – Site type flaked lithic tool variability, nonlocal raw materials. The percentages provided in the legend box are the proportion of nonlocal materials in the site type flaked lithic tool assemblage.

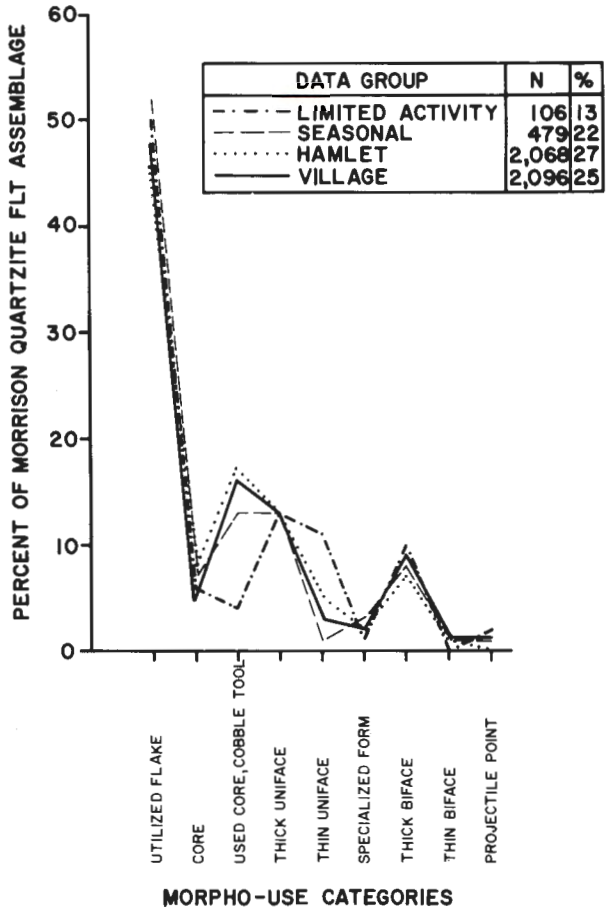

Figure 3.23 – Site type flaked lithic tool variability, Morrison quartzite raw materials. The percentages provided in the legend box are the proportion of Morrison quartzite in the site type flaked lithic tool assemblage.

the proportion of subsistence or extractive behavior as opposed to general maintenance behavior. Limited activity sites, which are presumed to represent brief episodes of individually specialized resource extractive behavior, consistently demonstrate more intense selection and use of better quality lithic materials for the production of more technologically demanding high-input tools. Habitation sites, on the other hand (even those limited to seasonal occupation), consistently demonstrate a much more expedient and technologically less demanding pattern of raw material selection and use.

A second factor involved in explaining the dichotomous pattern of lithic material selection and use is the location of raw materials with respect to site location, or the relative cost of acquiring the material, especially with reference to mobility and transportation. The only indication of temporally associated lithic raw material variability is that which also corresponds with major settlement pattern change: the later movement of the Dolores Anasazi to large villages located close to the river is accompanied by a marked increase in the proportion of gravel-derived materials and the lower input tools produced from them. The more mobile occupants of limited activity sites, regardless of temporality, brought with them for restricted ranges of specialized subsistence-related tasks a flaked lithic tool assemblage heavily focused on better quality materials from a wider geographic range, both local and nonlocal, and on more technologically demanding, high-input items. This variability in the cost of acquiring lithic raw materials, as well as their differential use for tool production, is considered more specifically in the following section.

FLAKED LITHIC TOOLKIT COST

The suggestion of differential lithic raw material acquisition and use patterns associated with (a) the relative locations of raw materials and sites, and (b) the

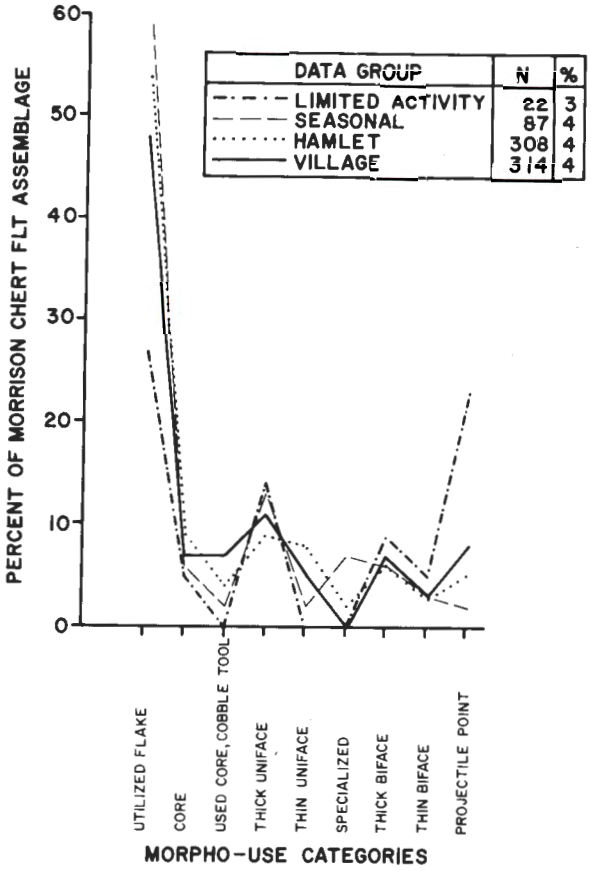

Figure 3.24 – Site type flaked lithic tool variability, Morrison chert raw materials. The percentages provided in the legend box are the proportion of Morrison chert in the site type flaked lithic tool assemblage.

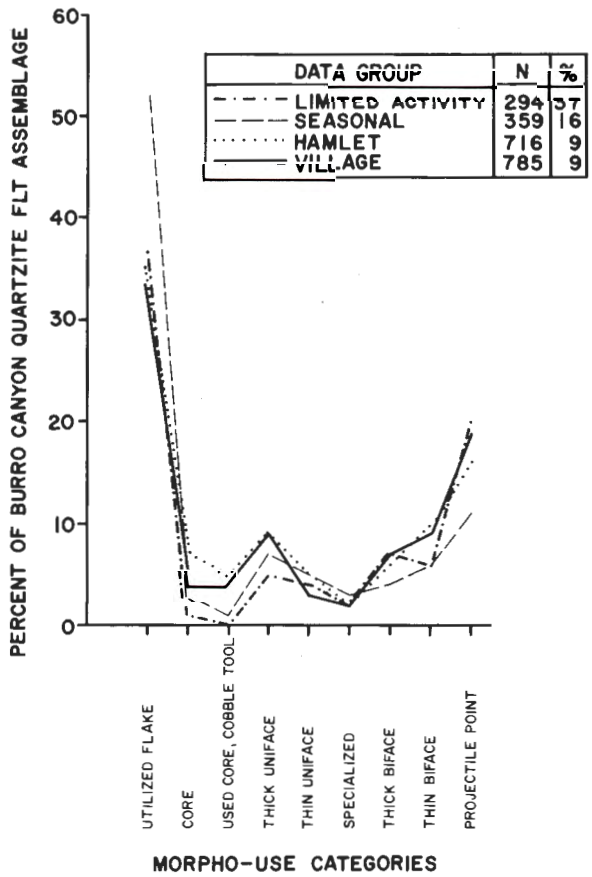

Figure 3.25 – Site type flaked lithic tool variability, Burro Canyon quartzite raw materials. The percentages provided in the legend box are the proportion of Burro Canyon quartzite in the site type flaked lithic tool assemblage.

functional role of tools and assemblages as indicated by differing amounts of technological production input prompted a more detailed examination of these factors in DAP assemblages. Further, the distinctly economic orientation of several project documents and synthetic studies (Kane et al. 1983; Lipe 1984a, 1984b; Phagan 1983) suggested the utility of an economic approach to such a detailed analysis. The study developed has been reported elsewhere (Phagan and Maloney 1983) and is summarized here with the inclusion of complete rather than preliminary data.

An intensive survey of the DAP area was conducted to acquire a detailed understanding of the geological distributions of lithic materials suitable for producing flaked tools (Phagan and Maloney 1981, 1983) as well as a detailed reassessment of all potential lithic quarry sites located by the original project area surveys. An additional aspect of the study was the development of a method for calculating relative lithic resource acquisition cost and tool production cost. These cost calculations may then be collected for spatial clusters of DAP sites, compared, and interpreted in economic terms.

An important aspect of comprehending any economic system is some method of quantifying and comparing the concept of cost, in this case the cost of acquiring or producing flaked stone tools. This cost may in fact be relatively minor with respect to the total Anasazi economic system, and may in addition be a relatively affordable cost, particularly if embedded within larger and more general procurement costs. It is, however, a real cost of time and energy, and is subject to relative measurement. If this cost can also be associated with other economic or noneconomic aspects of the Anasazi system of more general concern, but not be so readily quantifiable, then an indirect measure of these concerns will have been generated as well.

The cost of any flaked lithic tool or group of tools can be separated into the cost of acquiring appropriate raw materials and the cost of producing tools from those

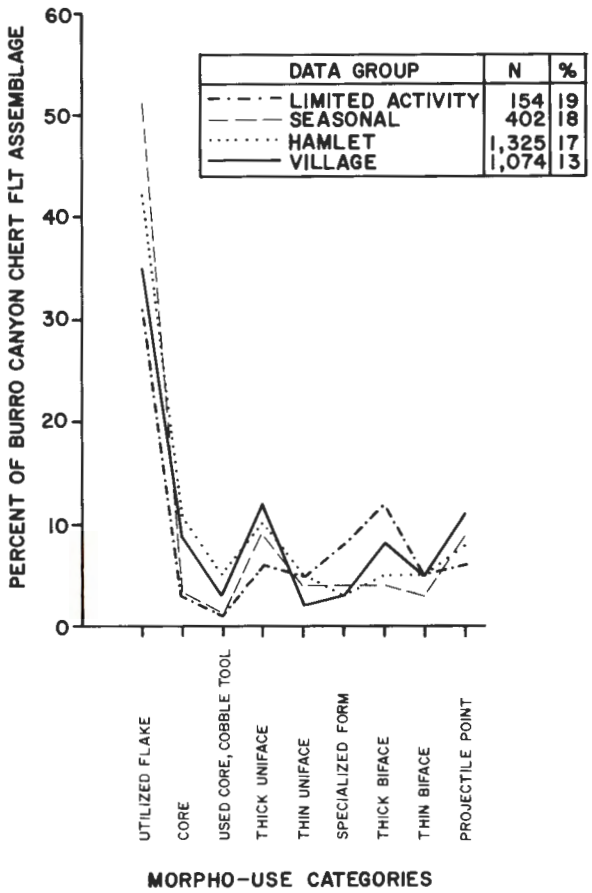

Figure 3.26 – Site type flaked lithic tool variability, Burro Canyon chert raw materials. The percentages provided in the legend box are the proportion of Burro Canyon chert in the site type flaked lithic tool assemblage.

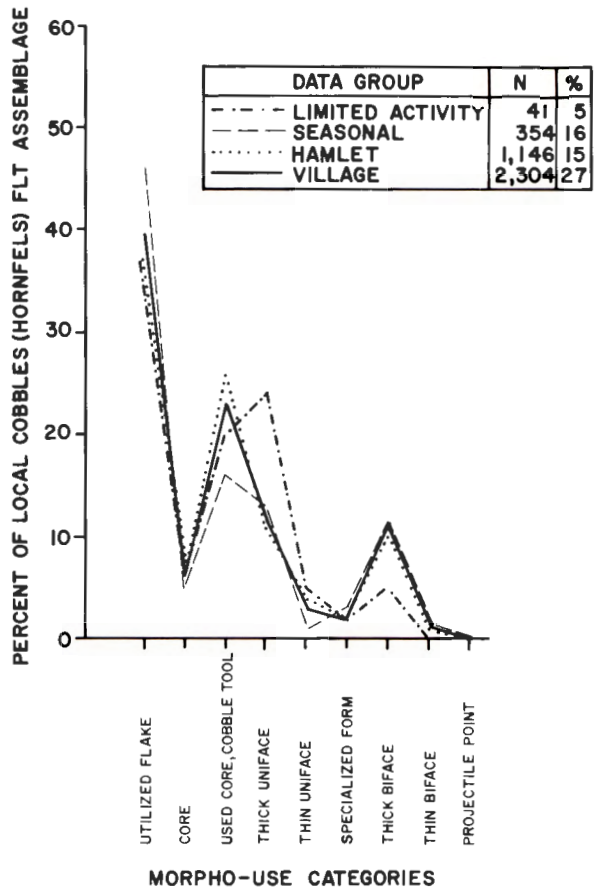

Figure 3.27 – Site type flaked lithic tool variability, local cobbles (hornfels) raw materials. The percentages provided in the legend box are the proportion of local cobbles in the site type flaked lithic tool assemblage.

materials: acquisition cost and production cost. Acquisition cost may vary widely with such factors as the location of appropriate raw materials, the terrain over which they must be transported, quarrying effort, trade or exchange networks, and needs or preference for certain kinds of material. Production cost may or may not be related to acquisition cost and is more directly related to the quality of the material and the design requirements of the tool(s) being produced from it. Only to the (often great) extent that better quality materials may be more expensive, and may therefore be reserved for producing more technologically demanding tools, are acquisition and production costs related.

It is proposed that 3 important factors involved in determining raw material acquisition costs in the DAP context are: (1) the location of the raw material source, (2) the amount of material acquired, and (3) its quality. The first of these – location – is considered to be the most important and is so structured in the cost calculation. The term "location" is used rather than "distance" to indicate that a small factor for vertical relief is included. The DAP area has nearly 1000 ft (305 m) of vertical variability, and transporting rock up or down hill should increase its acquisition cost. Location is therefore calculated as the distance from the archaeological site to the nearest formation outcrop or exposure of the particular raw material type in 0.5-km units, plus the vertical difference between the site and source in 300-ft (91 m) units. This means that a vertical carry of 91 m is the horizontal acquisition equivalent of 500 m. The weight factor in the calculation is simply a ranked grouping (1-3) of item weights where 1 = 1-99 g; 2 = 100-999 g; and 3 = 1000 g or more. It costs more to carry more weight. The quality factor is included in calculating acquisition cost because, at least for the DAP, better materials occur infrequently and unpredictably in all 3 major source formations, and locating these better source areas within the formation exposures increases acquisition cost considerably. This quality factor is also a ranked evaluation (1-3) based on varying combinations of 2 independently observed

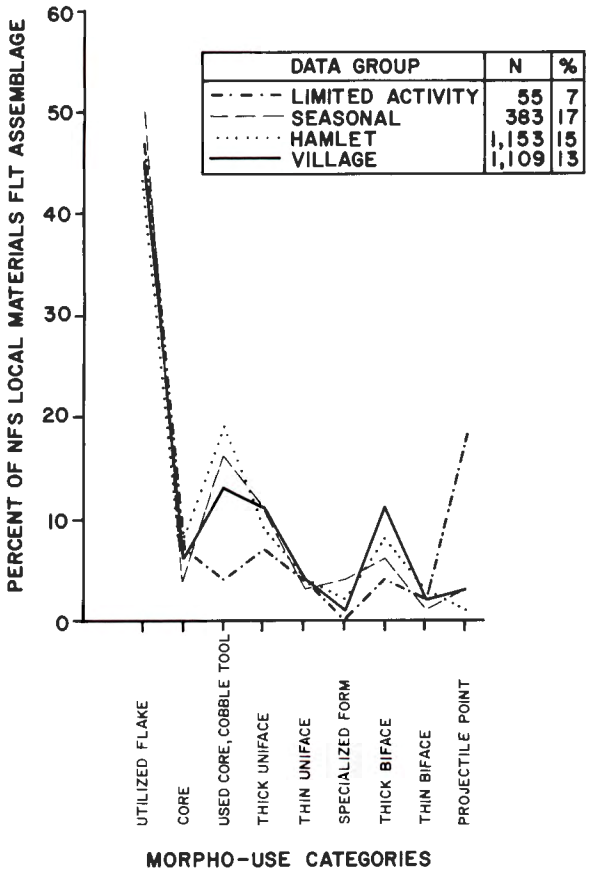

Figure 3.28 – Site type flaked lithic tool variability, local raw materials, not further specified. The percentages provided in the legend box are the proportion of local materials, not further specified, in the site type flaked lithic tool assemblage.

standard DAP analytic variables: specific lithic material identification, such as Morrison chert or Burro Canyon orthoquartzite, and grain size, such as fine or very fine. It costs more to get good Morrison chert than hornfels.

Once the 3 components of the formula are established and appropriate measurement units determined, the acquisition cost itself is simply calculated as follows: location × weight × quality. The result is an acquisition cost score that is meaningless except as a measurement for comparison with other similarly derived scores. Thus, raw material from a tool or an entire assemblage of tools can be evaluated as relatively more or less costly than any other similarly evaluated tool or assemblage. The specifics of the formula are neither difficult nor critically important. What is important is that some consistently observable quantities are specifically related in an understandable and interpretable way.

For the DAP situation presented here, this acquisition formula has a theoretical range of 2-90 for locally available materials but a practical range of only 2-27. For items of nonlocal material, the formula is adjusted by substituting for the location factor a "type/distance category" based on the known or generally suspected relative distances from the DAP to the closest likely sources. In addition, the weight groups are reduced in size by a factor of 10 (e.g., 1 = 1-9 g rather than 1-99 g). A correction factor is also added to the nonlocal calculation so that the maximum practical score for nonlocal acquisition cost is approximately 3 times that for maximum local material acquisition. Total acquisition cost for any assemblage is the average sum of the local and nonlocal costs.

Production cost is calculated from standard DAP preliminary FLT analysis variables (refer to Phagan and Hruby [1984] for definitions of these variables and their values). This cost is evaluated separately for facial and nonfacial items; facial items are those with a distinctly flattened cross section, either selected or produced. Production cost for facial items is calculated by summing a ranked assessment (2-9) of the production input invested into both dorsal and ventral faces, the ranked evaluation (1-3) of the proportion of the tool's edge or margin that has been intentionally produced by either unidirectional or bidirectional flaking, and a ranked evaluation (1-4) of the proportion of unidirectional and bidirectional flaking on the tool's margin.

Production costs for nonfacial items, or cores, are calculated from a technologically ranked estimate (1-3) of each item's produced shape regularity and a correction factor (10x) that allows the maximum production cost of a very regular Anasazi core to be approximately half the maximum production cost of a bifacial tool. Total production cost for any assemblage is the average sum of the facial and nonfacial costs. The total cost of any FLT assemblage is calculated simply by adding the acquisition and production costs.

Throughout this and other DAP reductive technologies volumes, these relative FLT acquisition and production costs have been reported and used to interpret various data groupings. Of particular concern here is an examination of these costs, especially acquisition cost, for spatially defined groups of DAP sites. These 8 site groups are defined by major landform characteristics and are illustrated in figure 3.29.

Relative FLT cost calculations for the groups are presented in table 3.11. Much of the data in table 3.11 will not be examined in great detail. Particular attention will be paid only to several of the cost index figures for local raw materials. These FLT acquisition and production cost figures for major categories of local raw material and total costs for all materials are graphed by spatial group in figures 3.30 and 3.31. In addition,

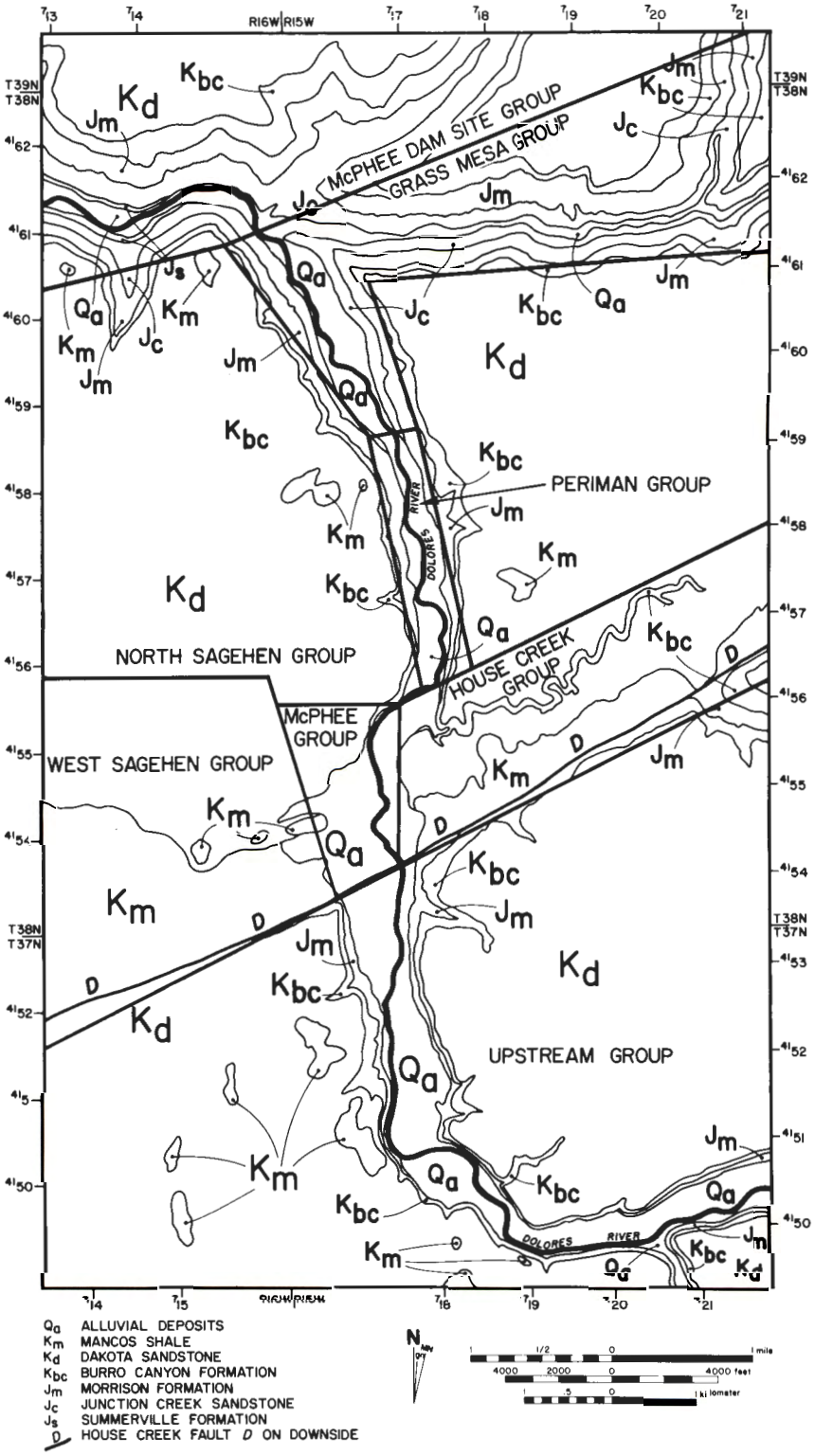

Figure 3.29 – Dolores Archaeological Program spatial site groupings for flaked lithic tool costs (after Leonhardy and Clay 1985:fig. 17).

Table 3.11 – Flaked lithic tool costs indexes, by spatial site grouping

Variable Value	Upstream group (N = 1670)	House Creek group (N = 881)	McPhee group (N = 7894)	West Sagehen group (N = 2396)	North Sagehen group (N = 2260)	Periman group (N = 4759)	Grass Mesa group (N = 5039)	McPhee dam site group (N = 1726)	Total (N = 26 625)
Acquisition, local									
Hornfels	7.8	7.0	6.2	16.7	12.0	4.8	4.8	5.5	7.3
Morrison	5.1	6.4	9.7	15.6	9.0	6.8	9.5	7.5	9.1
Burro Canyon	4.2	4.3	9.4	12.1	6.9	7.3	8.2	7.7	8.0
Total	5.7	5.8	8.0	15.0	9.2	6.2	8.3	7.0	8.2
Acquisition, nonlocal	*69.0	*75.4	69.2	61.2	*65.2	70.3	65.8	*71.0	67.9
Acquisition, total	8.5	6.8	10.2	17.1	10.4	8.6	10.0	9.9	10.3
Production, local									
Hornfels	8.0	8.0	8.1	8.1	7.8	8.1	8.1	8.7	8.1
Morrison	8.0	8.4	8.2	8.3	7.8	7.9	7.9	8.3	8.1
Burro Canyon	9.6	9.3	11.9	13.8	9.4	9.7	12.1	14.8	11.1
Total	8.6	8.7	9.0	9.9	8.3	8.6	8.6	9.4	8.9
Production, nonlocal	*12.1	*16.3	14.4	13.7	*14.4	12.9	17.4	*17.3	14.6
Production, total	8.8	8.8	9.2	10.0	8.4	8.8	8.9	9.8	9.1
Toolkit, local									
Hornfels	15.8	15.1	14.3	24.9	19.8	12.9	13.0	14.3	15.5
Morrison	13.1	14.8	17.9	23.9	16.7	14.7	17.4	15.7	17.2
Burro Canyon	13.8	13.7	21.3	26.0	16.3	17.1	20.4	22.6	19.1
Total	14.3	14.5	17.1	24.9	17.5	14.9	16.9	16.4	17.1
Toolkit, nonlocal	*81.3	*91.7	83.5	73.6	*79.1	84.0	83.2	*88.9	82.6
Toolkit, total	17.2	15.6	19.4	27.0	18.9	17.3	18.9	19.7	19.3

* Calculated on the basis of fewer than 100 items.

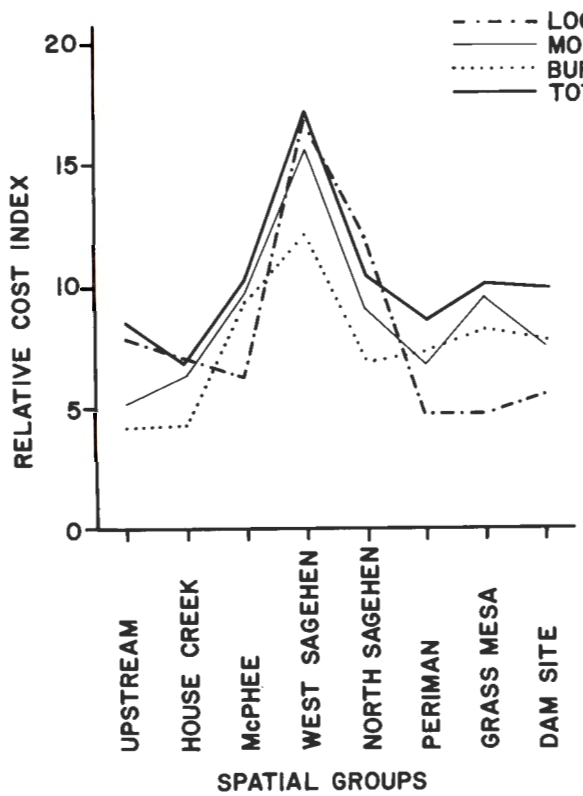

Figure 3.30 – Flaked lithic tool acquisition cost for spatial site groupings.

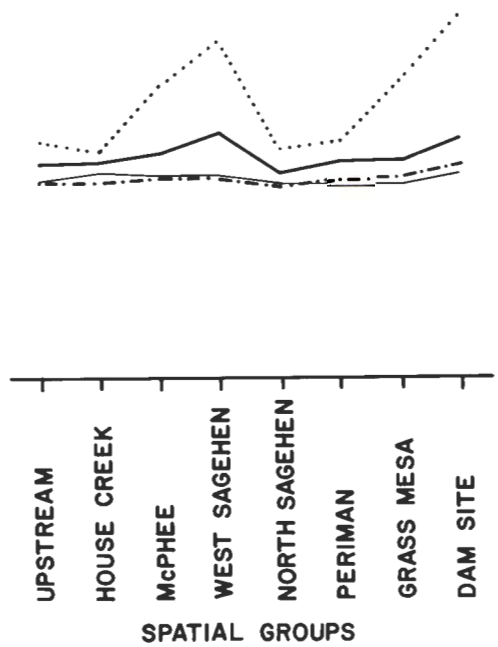

Figure 3.31 – Flaked lithic tool production cost for spatial site groupings.

total acquisition and production costs are graphed in figure 3.32 for phase, subphase, and site type data groups.

Figure 3.30 demonstrates, not unexpectedly, a great deal of spatial variability in FLT acquisition costs, with the west Sagehen group, situated father from the river or a major formation-exposing tributary, paying considerably the highest acquisition costs for all three material categories. Figure 3.31 clearly indicates that the cost of producing flaked lithic tools from the Morrison and hornfels materials is virtually constant for all spatial groups and is unrelated to the cost of acquiring those materials. However, the production cost of tools made from Burro Canyon materials does not demonstrate this constant pattern but varies considerably from group to group. The fact that Burro Canyon production costs are higher than those invested in other local materials is anticipated since it is of better flaking quality and would have been used for more technologically demanding items regardless of its acquisition cost, but its strong variability between spatial groups was not anticipated and is largely unexplained. Some of this Burro Canyon production cost variability may be the result of an uncontrolled correspondence of site type with spatial group. For example, the west Sagehen and the McPhee damsite spatial groups, which have the highest Burro Canyon production costs, contain no villages. However, neither does the upstream group; the McPhee and Grass Mesa groups, which have the next to highest Burro Canyon production costs, contain the largest village site populations. Clearly the relationship between FLT acquisition cost and production cost for these small geographic areas is complex and differential for both area and material type.

When total FLT acquisition and production costs are plotted for phase, subphase, and site type data groups (fig. 3.32 and tables 3.1, 3.4, and 3.7), a general positive relationship between the 2 costs is apparent for both phase and site type, but not for subphase. Lowest acquisition costs occur for the McPhee Phase, the Periman Subphase, and the village site type: all are associated with the maximum population concentration in villages adjacent to the river, where several kinds of raw materials are available. Highest acquisition costs are associated with the Cougar Springs Phase, the group A category, the Tres Bobos and Sagehill Subphases, and the limited activity site type, all of which are either early or functionally specialized, with the population scattered widely in small groups. Increased production costs occur in the same data groupings, with the exception of the 2 earlier subphases in which the year-round nature of occupation keeps the overall production cost low. The general lack of subphase correspondence for the 2 cost indexes is therefore largely because

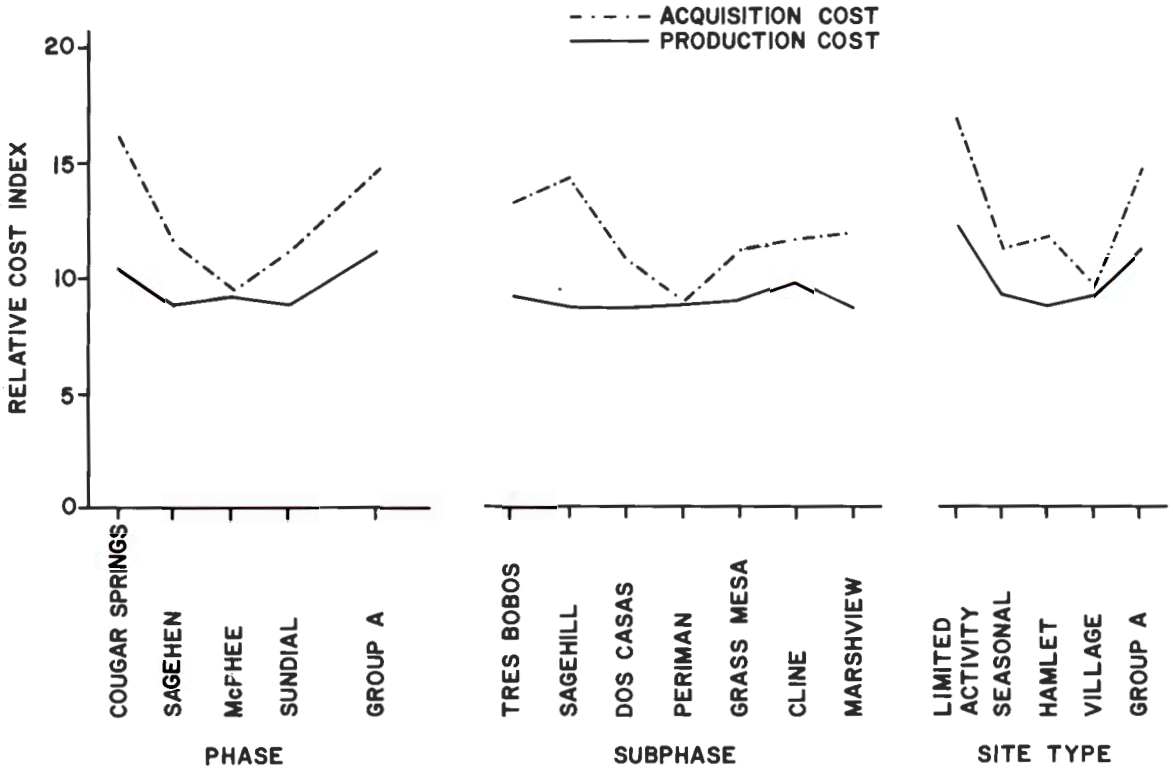

Figure 3.32 – Total flaked lithic tool acquisition and production costs for phase, subphase, and site type data groupings.

the 6 subphase groups do not effectively include or recognize either the dispersed or functionally specialized character of Dolores Anasazi subsistence behavior, which are primary factors in determining the relationship between acquisition and production costs.

INTENSIVE ANALYSIS OF LARGE HAFTED TOOLS

During the reorganization of the DAP reductive technologies analysis procedures in 1980 (Phagan and Hruby 1984), it became apparent that information concerning 1 general class of lithic artifacts was inadequate and poorly organized. This was the class of large hafted items such as axes and mauls. It appeared a considerable number of these artifacts were in the DAP assemblages, that many of them were clearly very high-input items technologically and were likely to be heavily curated tools, and that a more productive analytic approach might be possible. Many of these items were axes with ground bits, and were analyzed as nonflaked tools. Others had only flaked bits and were analyzed as flaked tools. In some cases the hafting element consisted of notches, while in others it was grooves. In all cases detailed description and measurements were largely lacking.

A brief examination of the more relevant literature indicated a very broadly classification approach to such artifacts, with very few generalized classes formed on the basis of haft element characteristics: notched, three-quarter-grooved, full-grooved. Classes were often illustrated but not further defined. In addition, there was little agreement regarding cultural or temporal associations for the classes. Woodbury (1954:26) indicates the three-quarter-grooved characteristic "arrived" about A.D. 600 and was limited up to the Mogollon and Hohokam areas, and the full-grooved characteristic is principally an Anasazi trait. Reed (1951:45) associates axes with domestic plants and indicates that haft element differential simply comes from different hafting techniques: a three-quarter-groove uses a "J-haft," while a full-groove uses a "wrap" haft.

With regard to the function of similar items in ethnographic contexts, Wright (1979:49-50) reports that mauls were used by the Hopi for general pounding and crushing, and that

> in many instances it is difficult to determine whether the original object was shaped as an axe or a maul because of the wear to which the tool has been subjected . . . [In addition,] the tools are normally subjected to such hard use that the axes

are battered into mauls and the mauls into nearly useless modules. The primary cause of the condition is the use of stone axes as metate sharpeners, piki stone grinders, pestles, quarrying tools, and finally as grooved stone anchors for crow traps.

Hill (1982:42, 84, 93) reports for the Santa Clara Pueblo that stone axes were used for both timber and firewood, that both three-quarter-grooved and full-grooved types existed and a few were double bitted, that they were chipped from obsidian or chert (no mention of grinding), and that they were also used to dig clay and to shape stone after no longer useful for cutting wood. Holmes (1919) also mentions the use of axes for dressing stone and quarrying minerals.

In reporting and interpreting these hafted items from archaeological contexts, Rohn (1971) reports 71 stone axes from Mug House on Mesa Verde, 3 of which had no evidence of grinding, with hafting notches or grooves variously made and situated. Cattanach (1980:245-247D) reports no axe heads from Long House on Mesa Verde but describes 27 "hammer heads" (mauls?) as either notched, full-grooved, C-grooved (three-quarter-grooved?), or L-grooved (one-half grooved?). Breternitz (1976) reports only 25 axes found during Chaco Canyon excavations from 1973 to 1976. Roberts (1929:134-136) reports no axe heads from Shabik'eshchee Village, but "a number" of grooved mauls or hammers of 2 types, cylindrical and flat: the first was made on river cobbles; the second on various slabs, including old manos. He further suggests that the absence of axe heads is "characteristic of the earlier phases of the sedentary cultures of the Southwest" (pg. 135-136), despite such early axes reported from the La Plata district by several authors.

Guided by such uncertainty and inconsistency in the archaeological literature, the DAP Reductive Technology Group devised an intensive analysis system, consistent with other project analysis routines (refer to Phagan and Hruby [1984]), that is generally descriptive and attribute-oriented rather than classificatory. This analysis system is admittedly rather exploratory in character, but its variables and values were selected to address, when linked with provenience data and temporal/spatial information, questions of temporal, organizational, and technological variability. This analysis system is presented as tables 3.12 and 3.13.

Variables 1 through 8 either are standard DAP provenience identification variables or are variables taken directly from the preliminary FLT or NFLT analysis (Phagan and Hruby 1984). Variables 9 through 13 are measurements taken directly from each artifact and are illustrated in tables 3.12 and 3.13 and figure 3.33. Variables 14 through 19 are technological variables related to the production and use of the haft element, the bit element, or the opposite poll (butt) element.

A total of 778 complete or nearly complete large hafted tools were analyzed with this system. The proportional occurrence of selected variables and values is presented in table 3.13, for the total analyzed tool assemblage, and for phase, subphase, and site type data groupings. Very small sample size in some of the data groups precludes any interpretation of their proportional variable/value expressions.

By far the most important characteristic of these data is the relatively few values in data units of significant size that can be interpreted as genuinely extreme variability. Further, these values do not appear to indicate the presence of consistent variability in any of the data units, with the possible exception of the seasonal site type. Even though only 29 items are in this data unit, there seems to be a focus on mauls rather than axes, a large proportion of grooved haft elements, heavier items of igneous material, and a low ratio of ground to flaked bits. However, the reason for such a suite of characteristics at seasonal sites with minimal architecture and therefore minimal stone working requirements is unclear. Also, the ratio of ground bits to flaked bits seems consistently highest (i.e., more ground bit axes) in data units associated with villages: the McPhee Phase, the Periman Subphase, and the village site type. The greater construction timber requirements of the contexts might reasonably be expected to require more efficiently resharpenable ground bits. In addition, a sampling factor may be involved in this characteristic, since these 3 data units have considerably larger numbers than all other units.

The data presented in table 3.13 generally seem to lack strongly consistent and interpretable patterns of technological, functional, temporal, or organizational variability. Woodbury's (1954:26) suggestion that the three-quarter grooved characteristic was not particularly Anasazi is supported by the fact that only 3 percent of the DAP large hafted tools have a partial-groove hafting mechanism. However, only 6 percent are completely grooved, while 83 percent display opposite notches rather than grooves of any sort. The norma Dolores Anasazi hafting mechanism for both axes and mauls was not grooves at all but simply notches. Further, there is no positive indication that the rare occurrence of the grooving characteristic, either partial or complete, is temporally trending towards either early or late: nor does the hafting characteristic appear to be clearly structured by site type. It may therefore be an example of spatially rather than temporally or functionally structured variability.

Table 3.12 – Dolores Archaeological Program hafted tools intensive analysis system

Column No.	Variable	Variable description
2	1	State/county designation 1: Colorado, Montezuma County 2: Colorado, Dolores County
3-6	2	Site number: right justified
7-11	3	Field specimen number: right justified
12-14	4	Catalog item number
15-17	5	Point location number
18-19	6	Old morpho-use: copied from preliminary analysis
20-21	7	Raw material: copied from preliminary analysis
22-26	8	Item weight in grams: copied from preliminary analysis
27-29	9	Distance between notches in millimeters
30-31	10	Notch depth in millimeters
32-34	11	Bit length in millimeters
35-37	12	Haft-to-bit distance in millimeters
38-40	13	Total tool length in millimeters
41-42	14	Blank type: (natural form selected for use or modification) 0: Indeterminate 1: Cobble 2: Slab
43	15	Production: bit 0: Indeterminate 1: None evident 2: Flaked 3: Flaked and ground 4: Ground 5: Other
44	16	Production: haft 0: Indeterminate 1: Single notch 2: Opposite notches 3: Partial groove 4: Complete groove 5: Other (document in notes)
45	17	Use: bit 0: Indeterminate 1: None evident 2: Flaked 3: Crushed 4: Striated
46	18	Production: butt or opposite end from bit Same values as variables 15
47	19	Use: butt or opposite end from bit Same values as variable 17

Table 3.13 – Large hafted tool variables, by phase, subphase, and site type

Variable values		Phase		Subphase						Site type			
	Total (N=778) %	Sagehen (N=128) %	McPhee (N=347) %	Tres Bobos (N=7) %	Sagehill (N=15) %	Dos Casas (N=104) %	Periman (N=211) %	Grass Mesa (N=25) %	Cline (N=48) %	Limited activity (N=9) %	Seasonal (N=29) %	Hamlet (N=143) %	Village (N=261) %
Morpho-use													
Flaked axe (FLT)	23	25	19	43	7	27	19	24	17	0	14	25	19
Notched axe (NFLT)	38	45	41	14	60	46	38	48	46	67	38	43	41
Grooved axe (NFLT)	3	5	3	14	0	5	3	0	4	11	3	4	3
Axe, other (NFLT)	2	1	1	0	7	0	1	0	0	0	0	1	1
Notched maul (NFLT)	7	9	9	14	20	7	6	20	13	0	7	11	7
Grooved maul (NFLT)	6	2	7	14	0	1	8	4	4	22	17	4	7
Hafted tool, nfs (NFLT)	21	14	21	0	7	14	25	4	17	0	21	13	23
Raw material													
Igneous	44	44	47	43	27	45	50	28	40	33	52	43	46
Sedimentary	46	48	45	57	47	45	43	48	54	11	38	50	46
Blank type													
Cobble	97	95	98	86	100	95	98	100	98	100	97	96	98
Slab	3	5	2	14	0	5	2	0	2	0	3	4	2
Bit production													
None	24	27	25	43	33	26	24	24	31	33	28	25	26
Flaked	25	31	22	57	27	31	20	36	21	22	24	30	22
Ground	29	27	31	0	20	30	31	40	25	11	17	28	31
Haft production													
Single notch	4	2	5	0	0	2	6	0	4	0	7	1	5
Opposite notches	83	88	81	57	100	89	79	92	88	78	69	86	81
Partial groove	3	2	3	29	0	1	4	4	2	0	10	3	3
Complete groove	6	2	8	14	0	1	10	0	2	11	14	2	8
Bit use													
None	10	12	10	14	0	14	11	8	6	11	7	11	11
Striated	2	2	2	0	7	2	2	0	4	0	0	2	2
Flaked	60	62	60	43	47	66	57	84	58	67	52	63	60
Crushed	14	15	14	43	33	11	14	8	19	0	14	15	15
Butt use													
None	43	45	52	57	60	43	54	56	42	33	45	45	52
Flaked	23	31	22	29	27	32	22	20	23	11	21	30	23
Crushed	15	11	19	0	7	12	20	12	27	11	28	13	21
Mean weight (g)	726	722	730	1147	796	677	726	746	764	477	886	779	717
Standard deviation (g)	451	452	453	536	483	419	406	388	583	197	725	479	432
Mean bit length (mm)	70	73	68	73	77	72	70	71	63	75	71	73	68
Mean haft-to-bit distance (mm)	80	81	79	81	88	81	77	85	83	70	83	84	78
Mean total length (mm)	141	144	141	152	147	143	140	153	144	110	139	148	140
Ratio of ground to flaked bits	1.20	0.85	1.40	n.a.	0.75	0.97	1.51	1.11	1.20	0.50	0.71	0.93	1.40

All data are expressed as percentages except means, weights, and ratios.
nfs – Not further specified.
n.a. Not applicable.

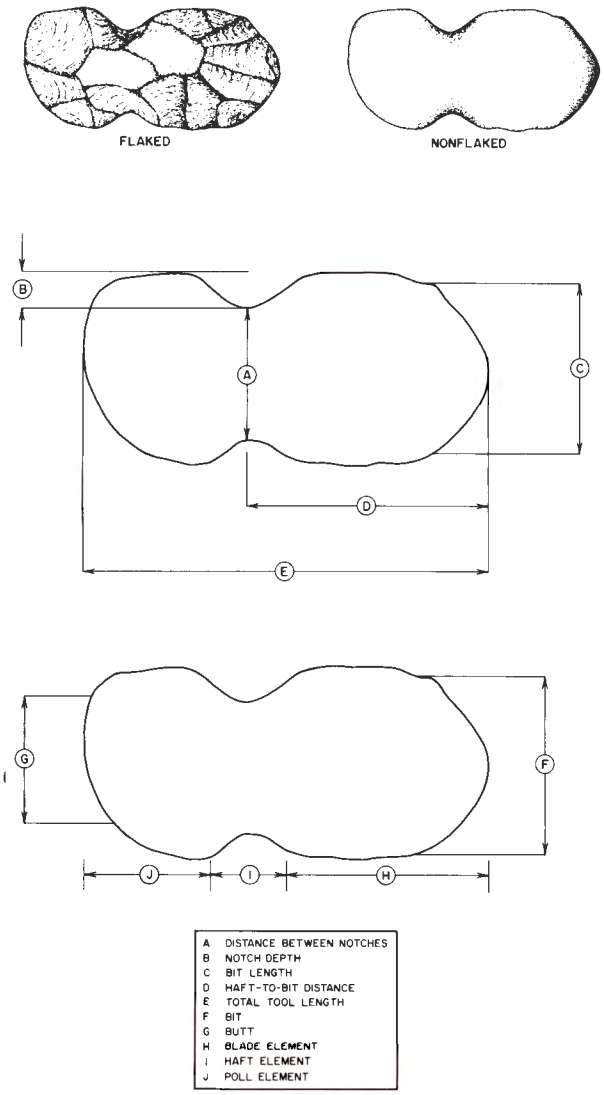

Figure 3.33 – Large hafted tool measurements.

The ethnographic observations of Wright (1979:49-50) and Hill (1982:93) for extremely heavy use of axes, including their use as stone-shaping tools, is supported by consistently high proportions of flaked and crushed axe bits. This also tends to confirm their status as highly curated tools. Roberts' (1929:134-136) report of the cylindrical and flat maul or hammer categories appears not to be appropriate for the DAP materials, and no examples of manos being converted to such hafted tools are present. Further, his suggestion that an absence of mauls or hammers may be characteristic of early Southwestern sedentary cultures (Roberts 1929:135-136) is expressly contradicted by the DAP materials.

The relatively high proportion of axes with only flaked bits, rather than ground bits, in most of the table 3.13 data categories, appears to be a characteristic seldom reported in the relevant literature. Whether such items do not occur in other Southwestern situations or simply are not clearly distinguished as such is not known. Clearly these items would be much easier and quicker to manufacture initially than would ground-bit axes, though it is assumed that hafting input for the 2 axe types would be equivalent. In addition, experimental studies by Glennie (1983) and Varien (1984) indicate very little functional difference in the tree-felling or limb-removal performance of flaked-bit and ground-bit axes. Therefore, any advantage of ground-bit axes that would justify their considerably greater production cost must be in maintaining or resharpening the item. Flaked-bit axes could be resharpened only a few times without the loss of major amounts of stone mass and therefore their uselives are relatively short. Ground-bit axes, on the other hand, could be resharpened many times with the loss of only minor amounts of stone mass and thus retained as functional axes for much longer periods. Flaked-bit axes may therefore be considered somewhat less intensely curated than are ground-bit axes.

Results of this exploratory analysis of large hafted tools are revealing in an overall way with reference to the archaeological literature, which is not extensive. However, statistically reliable variability within and between phase, subphase, and site type data groupings is not strong or consistent and convincing and posteriori explanations of this variability are not immediately apparent. More appropriate and explicitly stated models for the production and use of such tools should provide more adequate interpretive frameworks and analytic structures.

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Chapter 4

ENVIRONMENTAL ARCHAEOLOGY

Kenneth Lee Petersen, Meredith H. Matthews,
and Sarah W. Neusius

Section 1

INTRODUCTION

Kenneth Lee Petersen

The goal of DAP research has been to provide an understanding of the processes responsible for population growth, aggregation, and decline in the Dolores area from A.D. 600 to roughly A.D. 950. Research into these phenomena has been guided by 5 problem areas, or problem domains, originally set forth in the general research design (Kane et al. 1983) and reiterated in chapter 1. The 5 problem domains are: (1) Economy and Adaptation; (2) Paleodemography; (3) Social Organization; (4) Extraregional Relationships; and (5) Cultural Process. The focus of Problem Domains 1 through 4 is the synchronic description of the Dolores Anasazi during several different time periods. The focus of Problem Domain 5 is the diachronic description and explanation of culture, concerns that are treated in detail in the DAP model (part IV, this volume). Reconstruction of the prehistoric environment and assessment of the potential resources available for exploitation by the Dolores Anasazi has been essential to the DAP's attempt to address the 5 problem domains and, specifically, to answer questions relevant to Dolores Anasazi procurement and use of floral, faunal, and abiotic (i.e., water, rock, mineral, soil, clay) resources. Research conducted by the ESG (Environmental Studies Group) and the EAG (Environmental Archaeology Group) has addressed issues and questions pertinent to the environmental data base.

The main responsibilities of the ESG (1979-1981) were to inventory and assess the modern floral, faunal, geological, and hydrological resources within the project area and to analyze archaeological botanical and faunal remains recovered during excavation. The comprehensive modern inventory provided a basis for comparing and contrasting the prehistoric situation with that of the present. The ESG produced soil, landform, surficial geology, stream location, and present and potential natural vegetation maps; the group also described some archaeological site-specific geology. In addition, 2 experimental gardens were grown to document the modern farming potential of the project area. Some of the history and results of the ESG are presented in Petersen et al. (1984) and Petersen et al. (1985, comps.).

The ESG was dissolved 31 September 1981, and the EAG was established 1 October 1981. The research tasks undertaken by the new group are outlined in the EAG midlevel research design (Petersen et al. 1984). As its name suggests, the EAG has focused on interpretation of the archaeological materials recovered by the DAP and on reconstruction of the paleoenvironment of the project area.

ENVIRONMENTAL ARCHAEOLOGY

The interface of archaeology, paleoecology, and geology produces the discipline of environmental archaeology (Butzer 1971, 1975, 1980; Evans 1978; Hardesty 1977, 1980; Jochim 1979). The discipline encompasses a wide variety of research methods and an eclectic approach to data, which allows the study of the past environment from several vantage points. One of the goals of the EAG was to describe and model the prehistoric environment in the Escalante Sector and to reconstruct the relationship between the Anasazi and that environment. Of the resources available, which were used and how were they used?

The relationship between prehistoric peoples and their environment undoubtedly was as complex as is the relationship between people today and their environment (Odum 1971). To aid in understanding these relationships, a "systems" approach has been undertaken by the DAP (refer to part IV). Such an approach considers the Anasazi a critical component in an ecological system. The relationships between the Anasazi and the environment and other components of the system are dynamic; change in 1 variable effects change in another.

The reconstruction of prehistoric lifeways and ecological adaptations requires 2 steps. The first is to gain an understanding of the components and relationships within the present-day ecosystem. This was one of the primary goals of the ESG (Bye 1982). The second step is to glean as much information as possible from the archaeological and fossil records about the nature of the various prehistoric components and their interactions. This was the primary objective of the EAG. Because no direct observation can be made of the prehistoric ecosystem, modeling that system provides a means of organizing the various components that are detected in the prehistoric record.

Detection of the components of the prehistoric environment in which the Anasazi lived is difficult; that paleoecosystem is now extinct. The remains are partially or wholly decayed, mixed, or changed by such processes as diagenesis, transportation, or redeposition operating up to the time of sampling (Gifford 1981). Reconstruction of the paleoecosystem depends on the fortuitous preservation, sampling, and analysis of the remains of various components of that paleoecosystem. The study of the archaeological facilities, artifacts, debris, and environmental evidence within and near an archaeological site can contribute to a better understanding of the relationships between prehistoric peoples and their environment. These relationships can be inferred by considering the condition and context of resources and their historically and archaeologically known uses. The recognition and identification of plant and animal remains at sites can provide an inventory of those items once useful in fulfilling the nutritional, medicinal, ceremonial, and material needs of the Anasazi. In addition, analysis of the temporal and spatial distribution patterns of the plant and animal remains may provide insights regarding changes in use through time and changes in location of activity areas within and between sites.

REPORTS IN THIS CHAPTER

Some of the questions addressed in the sections that follow examine the role that floral, faunal, and geological resources, along with the vagaries in climate, may have played in the rapid Anasazi growth and decline in the Dolores River valley. The following topics are presented in this order: botany, pollen, fauna, geology, and climatic reconstruction. The overview, a conclusion, provides a brief discussion of the findings of the EAG.

Matthews reports on the macrobotanical data base compiled from excavated sites (sect. 2). She discusses the prehistoric botanical resource base in terms of what resources were potentially available, which taxa were used, and apparent changes in resource mix through time. She attempts to evaluate the impact that agricultural intensification would have had on botanical resource procurement strategies, and in so doing, investigates the changing role of pioneer plant resources in the resource mix.

Petersen reports on DAP pollen analysis (sect. 3). Results of analysis provide information on potential economic resources that could have been and were used by the Anasazi, provide details on the prehistoric environment, and provide a test of the climatic reconstruction based on pollen work in the La Plata Mountains that has been applied to the project area. Some of the pollen samples analyzed from the project area were from an intensively sampled pitstructure at Windy Wheat Hamlet (Site 5MT4644). Analysis of these samples was complemented by analysis of corresponding bulk soil samples. The results of this intensive study are briefly discussed.

Neusius reports on the DAP faunal data base (sect. 4). She discusses the types of data available, the data collection procedures used, and the effects of postdepositional processes on the assemblage. Prehistoric resource availability and preference are addressed in a study of relative biomass (using raw data presented in Neusius [1985a]), which in turn is used to rank individual species based on seasonal availability and habitat requirements. An annotated list of taxa in the DAP faunal assemblage is provided as a preliminary step in addressing the topic of prehistoric resource mix.

Petersen summarizes the geological studies conducted in conjunction with archaeological excavations in the Dolores Project area (sect. 5). These geological studies describe geomorphological and geological characteristics of site locations, discuss stratigraphy of archaeological sites and pertinent resource areas, and delineate potential resource areas on project-wide maps of modern bedrock, landforms, stratum order, and soils. Regional maps outline the possible source areas of exotic rocks and minerals. In conjunction with soils maps and chemical and sedimentary studies of soils, maps showing the distribution of the length of the growing season have allowed assessment of the potential for a particular plot of ground to grow corn and other crops to maturity.

Petersen uses pollen data from the La Plata Mountains and a number of tree-ring records to provide proxy records of long- and short-term changes in summer and winter precipitation and growing season length for southwestern Colorado (sect. 6). Long-term changes in the location of the regional potential dry-farming belt

(e.g., the zone that can support routine dry farming) limited the settlement location choices of agriculturalists and provided the impetus for immigration into and out of the Dolores area. The pollen records allow reconstruction of prehistoric vegetation distribution. Differing vegetation distributions have implications for potential floral and faunal resource availability. Short-term climatic effects, as reconstructed from tree-ring records, could have affected potential field location and crop yields within the Dolores area and possibly further affected settlement location and subsistence and organizational strategies.

Finally, in the overview, Petersen recaps some of the major implications of the results outlined in these summaries (sect. 7). More specific applications of these findings are reported in the collection of modeling papers presented later in this volume.

The number of years the DAP was in operation, the large size of the data base, and the constantly evolving approach to research have caused problems in data comparability through time and between reports. The sections that compose this chapter, and in some instances the different discussions within single sections, were written at different times and therefore reflect this comparability problem. Discussions in text were based on the computer data files available at the time the individual sections were being written; because the files subsequently underwent editing and revision, discrepancies are found between data reported in this chapter and in the final DAP data files. (The discussion on pollen, for which the most recent data files were used, is an exception.) In most cases, the differences between old and new data files are believed to be minor enough to not greatly affect overall interpretations.

Similarly, the chronological framework used to structure analysis changed over the years, and reference to 2 different systems will be found in this chapter. Early in the program, a phase/subphase system was used to categorize sites according to approximate time period; although phases and subphases are defined on the basis of site characteristics and are not strictly temporal units, they are associated with general time periods. Late in the program, modeling periods were introduced and then refined; these units are strictly temporal divisions with very specific date ranges. Depending on when a given section or discussion within a section was written, either the phase/subphase or modeling period system might have been used. The fact that modeling periods have absolute calendar dates assigned to them make them especially attractive for diachronic studies; however, if a study was written prior to the introduction of the modeling period concept, the phase/subphase system would have been used instead.

Section 2

THE DOLORES ARCHAEOLOGICAL PROGRAM MACROBOTANICAL DATA BASE: RESOURCE AVAILABILITY AND MIX

Meredith H. Matthews

The DAP macrobotanical data base can be used to address questions presented in the program research design (Kane et al. 1983) and can be applied to a general systems model developed by the DAP (Lipe et al. 1983; part IV, this volume) to examine the variables that effected change in the socioeconomic structure of the Dolores Anasazi. This data base includes modern environmental data as well as data collected from excavated prehistoric sites. Modern environmental data were gathered to assess the present vegetation communities, to provide a baseline for reconstructing the prehistoric vegetation community structure, and to compile a botanical comparative collection to aid in analysis. Macrobotanical data from excavated sites were compiled to assess the prehistoric environment, to reconstruct the prehistoric botanical resource base, and to evaluate the impact of socioeconomic change on botanical resource procurement strategies.

The major responsibility of the Botanical Studies Section has been to collect and analyze prehistoric botanical remains. Results of analyses have been used for DAP descriptive site reports and synthetic studies. Besides this task, several subsidiary projects have been completed either in conjunction with botanical studies activities or by using botanical studies data. These projects are listed in table 4.1. Because all of these projects have been documented elsewhere, they will not be discussed here; however, data from some of these studies will be used in several of the following discussions.

In this section, that portion of the DAP botanical data set relevant to the prehistoric occupation of the project area is discussed as it pertains to aspects of the program research design and the general DAP model. The prehistoric botanical resource base is discussed in terms of what was potentially available for exploitation, what was actually used, and what changes in the pattern of resource use are evident in the archaeological record. Completely describing the total range of application of the DAP macrobotanical data base in this summary report is not feasible. The scope of this section is limited to discussion of the major categories of macrobotanical remains in the context of the DAP research design and general model.

Table 4.1 – Botanical studies subsidiary projects

Study/project	Reference
Modern vegetation reconnaissance; construction of modern vegetation distribution map	Bye 1985
Floristic inventory	Benz 1985; Matthews 1985a
Modern floristic voucher and ethnobotanical specimen collection for analytical comparative collection	*
Data collection, pinyon pine reproductive biology study	Floyd 1981
Experimental garden study	Shuster 1981; Shuster and Bye 1983,1984
Harvester ant disturbance study	Nelson 1980
Bulk soil (flotation) sample apparatus evaluation	Matthews 1985a
Bulk soil (flotation) sample analysis, food processing activity areas.	Matthews 1984a
Catastrophically burned structure intensive sampling analysis	Matthews 1984b
Pioneer plant remains study, spatial distribution using SYMAP	Matthews and Benz 1983
Wood resource depletion studies	Kohler et al. 1984; Kohler and Matthews 1984
Agricultural intensification and pioneer plant procurement study	Matthews 1985b
Coprolite analysis	Jones 1983
Secondary analysis, Cucurbitaceae remains	Fleming 1983
Secondary analysis, *Phaseolus* remains	Griffitts 1985
Packrat midden study	Van Devender (1985)

* Specimens retained by the Anasazi Heritage Center with duplicate vouchers on file at the University of Colorado Museum herbarium, Boulder.

STRUCTURE OF THE MACROBOTANICAL DATA BASE

Two categories of remains, differentiated by size of material and mode of collection, make up the macrobotanical data base compiled from remains from excavated DAP sites. The first category is small-scale remains, which usually are too small to be seen during excavation and are retrieved through bulk soil, or flotation, sample processing (throughout the remainder of this chapter, DAP bulk soil samples will be referred to by the more commonly used term, flotation samples). This category consists primarily of small seeds, fruits, wood charcoal fragments, and fragments of cultivated plants. The second category is vegetal remains, or botanical material visible during excavation and collected in a manner similar to that used for other artifact classes. Typical materials within this category are wood, worked vegetal artifacts (e.g., basketry), yucca leaves, bark, reeds, stems, and remains of cultigens.

Generally, these 2 categories of remains can be considered to represent different classes of subsistence resources, although not to the point of being mutually exclusive of one another. The small-scale remains are predominantly the disseminules of pioneer and wild plants, most of which are ethnographically documented as economic plants commonly used for food, medicine, or ceremonies (cf. Elmore 1944; Pennington 1963; Robbins et al. 1916; Stevenson 1915; Whiting 1939). The vegetal remains are believed to be evidence of construction materials, fuel resources, utilitarian items, and domesticated plants.

Flotation samples were collected from excavated sites according to a standardized sampling strategy (Litzinger 1979). The extent of collection was dictated by the degree of preservation of the context and the intensity of excavation procedures. The strategy was oriented toward collection of samples from comparable cultural contexts believed to potentially contain remains related to subsistence activities, such as features with undisturbed cultural fills, living surfaces, and midden deposits. Vegetal remains were collected on a more arbitrary basis, depending on their context and condition, and, to some degree, on the discretion of the excavator. Vegetal remains usually were collected from structure fills, roof fall, surfaces, structural features, fire-related features, and trash deposits. Since a standardized collection mode for vegetal remains was not available, interpretation of these remains is more susceptible to biases inherent in collection mode than is interpretation of remains from flotation samples.

The macrobotanical assemblage used for most of the analyses reported here consists of remains from 60 excavated sites. Vegetal remains from 2375 proveniences at 54 sites, and small-scale remains from 1908 flotation samples at 52 sites, have been analyzed. Included in the vegetal remains assemblage are materials recovered from 91 proveniences at Site 5MT5106 by water-screening in the field prior to being submitted to the laboratory. The number and type of contexts from which these remains were recovered are described, by modeling period, in tables 4.2 and 4.3.

Macrobotanical remains were analyzed according to procedures developed by the Botanical Studies Section (Matthews and Benz 1981). Although analytic procedures for flotation sample remains differed somewhat from those for vegetal remains, a number of standard common variables and measurements were recorded for each item analyzed. These included taxon, plant part, condition, and quantity. Results of analysis were recorded, and the information was entered into the DAP computer files (Udick and Gross 1985). All analyzed macrobotanical remains were cataloged and packaged by site; the materials will be archived in the Anasazi Heritage Center, Dolores, Colorado.

Table 4.4 is a list of all the plant types identified in the DAP macrobotanical assemblage indigenous to the general project area. Some of these plants are represented only by uncharred plant parts, which may mean they are contaminants in the archaeological deposits and are not associated with the prehistoric occupation. The controversy concerning the interpretation of noncharred botanical remains from open air sites has been discussed in the literature and in other DAP macrobotanical reports (cf. Lopinot and Brussell 1982; Keepax 1977; Minnis 1981a; Matthews 1984b, 1985a, 1985b; Matthews and Benz 1983) and need not be reiterated here. Because it is beyond the scope of this section to adequately evaluate the integrity and status of uncharred botanical remains, they will not be used in the final synthesis of the botanical resource base, except in analyses of cultigens and in the wood resource depletion study.

On a site level, and on a context by context basis, the integrity of macrobotanical remains retrieved from flotation samples has been evaluated using control samples collected as part of the standard sampling strategy. Control samples were systematically collected above and below cultural surfaces. If similar remains were found both in control samples and in samples collected from features or surfaces, then the integrity of the remains from the cultural samples was decreased. This applied to both charred and uncharred materials. The interpretive value of this control sampling strategy was reduced because a test of the extent of the seed rain in onsite and offsite deposits (Minnis 1981a) was never made. Furthermore, control samples collected above surfaces often were from some type of cultural or mixed cultural deposit. Therefore, similarity in remains from control samples and noncontrol samples could reflect mixing (contamination) of deposits, or it could be an accurate reflection of the contents of separate, distinct, and uncontaminated deposits with similar contents. The control samples and their utility in discerning contamination in cultural samples has never been adequately evaluated and will not be evaluated here. Collection of control samples was established to assess the integrity of macrobotanical remains on a context by context basis (Litzinger 1979); the remains from these control samples will not be included in the following analysis of the resource base because they could bias the data presentation.

The sampling strategy for macrobotanical remains has allowed for comparability within and between sites across the project area. The integrity of the macrobotanical assemblage has been enhanced by this comparability in the structure of the data base. Nonetheless,

Table 4.2 – Type and number of sampled study units from which macrobotanical remains were analyzed, by modeling period*

Study unit type	Period 1 A.D. 600-720	Period 2 A.D. 720-800	Period 3 A.D. 800-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Period 7 A.D. 980-1250	Other†	Total
Surface structure	10	18	33	47	88	23	6	34	259
Pitstructure	14	29	22	41	78	7	2	13	206
Kiva						3	4	2	9
Great kiva			1					1	2
Plaza			1	3	3	1		2	10
Courtyard					1	1			2
Use area		11	9	6	8	7	5	7	53
Midden			3	2	2		1	4	12
Other	29	42	49	36	28	5	26	153	368
Total	53	100	118	135	208	47	44	216	921

* Numbers of study units are tallied according to the modeling period to which the macrobotanical materials recovered from the study units have been assigned. The study units themselves might not be assigned to the same modeling periods as the macrobotanical remains, because the latter may represent cultural activity earlier than or later than the use of the study unit.
† Other – Not assigned to period; not included in subsequent analyses.

the integrity of the data used in this section has not been scrutinized, and, except for the deletion of uncharred remains from most analyses, measures have not been taken to control for data integrity (i.e., factors such as feature fill/assemblage type or structure abandonment mode were not taken into consideration). However, in an in-house and undocumented test of the assemblage, the contents of a subsample that was restricted to high-integrity proveniences were compared with the contents of an unrestricted subsample, and the differences in data tabulation appeared to be insignificant. This is not to say that the macrobotanical data base is pristine and can be considered an accurate representation of the prehistoric botanical resource mix. Imperfections in the data base, the sampling design, and the analysis system do exist. Nonetheless, this data base is considered adequate for addressing the issues presented in this section. However, the data base remains to be investigated further, and its integrity and suitability will best be tested not only by addressing DAP research questions, but by applying the data to theory testing of prehistoric human adaptation in general.

APPLICABILITY OF THE MACROBOTANICAL DATA BASE TO THE GENERAL RESEARCH DESIGN

At this time, the macrobotanical data base can best be used to address Problem Domains 1 and 5 (Economy and Adaptation, and Cultural Process). It is beyond the scope of this section to address topics relevant to Problem Domains 2 and 3 (Paleodemography and Social Organization), such as carrying capacity, catchment area analysis, social and economic structure of resource procurement processes, and nutritional analysis of resource mix. Some of these topics have been addressed in other reports (cf. Wiener Stodder 1984; Orcutt 1984a, 1984b, 1985a, 1985b, 1985c, and chap. 10, this volume; Schlanger, chap. 8), although without direct reference to the macrobotanical data base. Similarly, little information in the macrobotanical data base is applicable to Problem Domain 4 (Extraregional Relationships), because exchange of perishable items is difficult to document archaeologically. Except for domesticated plants, most plants represented in the macrobotanical assemblage are indigenous to the DAP area. Statements cannot be made about exchange of this group of plants since extraregional procurement of these botanical resources cannot be proven. Although domesticated plants are not indigenous to the area, and the technology for agriculture was brought into the area, the botanical analysis of domesticates was not sophisticated enough to distinguish between in situ hybridization and introduction of new species through time.

PROBLEM DOMAIN 1: ECONOMY AND ADAPTATION

It is assumed that the Dolores Anasazi were subsistence agriculturalists, and therefore, the subsistence system focused on agricultural activities. However, the Anasazi could not have maintained themselves on agricultural products only. Neusius (sect. 4, this chap.) discusses the

Table 4.3 – Type and number of specific sampled proveniences from which macrobotanical remains were analyzed, by modeling period*

Specific provenience	Period 1 A.D. 600-720	Period 2 A.D. 720-800	Period 3 A.D. 800-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Period 7 A.D. 980-1250	Other†	Total
Hearth or fireplace	11	40	38	48	105	20	21	17	300
Ash pit or ash pile	2	6	4	7	19	2	4		44
Warming pit		2	3	1	4	1	1		12
Pit with burning	7	3	5	7	4	4	7	6	43
Pot rest	1	2							3
Pit without burning or slab-lined pit	7	15	30	37	55	6	3	9	162
Floor cist	1	7	3	7	15			2	35
Bin	3		2	5	8	1			19
Floor vault				1	2				3
Central pit				6	5				11
Sipapu		1	2	2	2	1			8
Complex pit		1	1	1	2				5
Posthole	11	36	61	78	167	6	2	9	370
Bench, other wall feature, and wingwall	7	8	12	8	18	4	1	4	62
Burial	1	2	2	3	7		1	5	21
Artifact feature		11	2	7	10	1	2	1	34
Borrow area		2	4	3	5	2		1	17
Other feature		1	5	1	1			2	10
Surface	17	22	29	31	61	19	3	18	200
Other (not feature)	28	93	126	88	191	37	38	246	847
Total	96	252	329	341	681	104	83	320	2206

* Numbers of proveniences are tallied according to the modeling period to which the macrobotanical materials recovered from the proveniences have been assigned. The proveniences themselves might not be assigned to the same modeling periods as the macrobotanical remains, because the latter may represent cultural activity earlier than or later than the use of the provenience.

† Other – Not assigned to period.

faunal resource base and the variability in the availability and mix of this resource category. This section examines the botanical resource mix of the Dolores Anasazi economic system.

Available Resources

To understand the prehistoric economy and to model adaptive economic strategies, an assessment was made of the botanical resources available and used prehistorically. Although, not feasible to make a complete inventory of all the resources available, several maps were produced in an effort to assess vegetation distributions prior and subsequent to historic disturbance. A modern vegetation map of the project area illustrates the major vegetation zones under the influence of historic disturbance (Bye 1985:fig. 1); 2 additional maps reconstruct the major vegetation types prior to disturbance, and illustrate the influence of different precipitation regimes on these vegetation zones (Petersen 1985a:figs. 1 and 10; and figs. 4.16 and 4.18, sect. 6). These maps are useful in evaluating vegetation changes resulting from disturbance and climatic variability and in estimating such factors as vegetation diversity in catchment areas (Orcutt 1984b, 1985a, 1985c).

The range of specific resources available is defined by the component species within the broadly defined vegetation areas. A best-guess estimate of plants that may have occurred prehistorically in the project area can be made by referring to a list of plants identified during the botanical studies vegetation reconnaissance (Benz 1985) and are known to be associated with the defined vegetation areas or zones, although it is acknowledged that a one-to-one correlation between the modern and prehistoric environment cannot be made. The list of

Table 4.4 – Indigenous plants identified in the macrobotanical assemblage

Family	Genus/species	Common name
Aceraceae	*Acer* sp.	Maple
Alliaceae	*Allium* sp.	Onion
Amaranthaceae	*Amaranthus* sp.	Pigweed
Anacardiaceae	*Rhus aromatica*	Squawbush
Asclepiadaceae	*Asclepias* sp.	Milkweed
Berberidaceae	*Mahonia repens**	Oregon grape
Boraginaceae	Indeterminate	Borage family
	Cryptantha sp.*	Cryptantha
	Lappula sp.*	Stickseed
Cactaceae	*Opuntia* sp.	Pricklypear
	*O. fragilis**	Brittle pricklypear
Capparidaceae	*Cleome serrulata*	Beeweed
Caryophyllaceae	Indeterminate*	Pink family
Chenopodiaceae	Indeterminate	Goosefoot family
	Atriplex sp.	Saltbush
	Chenopodium sp.	Goosefoot
	Sarcobatus vermiculatus	Black greasewood
Chenopodiaceae/ *Amaranthus*	–	Cheno-am
Compositae	Indeterminate	Composite family
	Artemisia sp.	Sagebrush
	*Artemisia tridentata**	Big sagebrush
	*Bidens**	Bidens
	Chrysothamnus sp.	Rabbitbrush
	Helianthus sp.	Sunflower
	Iva sp.*	Sumpweed
Cornaceae	*Cornus stolonifera*	Red-osier dogwood
Cruciferae	Indeterminate	Mustard family
	Descurainia sp.	Tansymustard
Cucurbitaceae	Indeterminate	Gourd family
	Cucurbita sp.	Squash
	C. pepo	Summer squash
	Lagenaria siceraria	Bottle gourd
Cupressaceae	*Juniperus* sp.	Juniper
	J. osteosperma	Utah juniper
	J. scopulorum	Rocky Mountian juniper
Cyperaceae	Indeterminate	Sedge family
	Scirpus sp.	Bulrush
Elaeagnaceae	*Shepherdia* sp.	Buffaloberry
	Shepherdia argentea	Silver buffaloberry
Ephedraceae	*Ephedra* sp.	Mormon tea
Equisetaceae	*Equisetum* sp.	Horsetail
Fagaceae	Indeterminate	Oak family
	Quercus gambelii	Gambel oak
Gramineae	Indeterminate	Grass family
	Agropyron sp.*	Wheatgrass
	Oryzopsis sp.	Indian ricegrass
	Oryzopsis hymenoides	Indian ricegrass
	Phragmites sp.	Reed
	Zea mays	Corn
Grossulariaceae	*Ribes* sp.*	Currant
Hydrangeaceae	*Fendlera* sp.	Cliff fendlerbush
	Fendlera rupicola	Cliff fendlerbush
Juncaceae	Indeterminate*	Rush
Labiatae	*Moldavica parvilflora**	American dragonhead
	Scutellaria sp.	Skullcap
Leguminosae	Indeterminate	Pea family
	Dalea sp.*	Dalea
	Lupinus sp.*	Lupine
	Phaseolus spp.	Bean
	Phaseolus vulgaris	Common bean

Table 4.4 – Indigenous plants identified in the macrobotanical assemblage – Continued

Family	Genus/species	Common name
Liliaceae	Indeterminate	Lily family
	Calochortus sp.	Mariposa lily
	Yucca sp.	Yucca
	Y. baccata	Datil yucca
Loasaceae	*Mentzelia albicaulis*	Blazing star
Malvaceae	Indeterminate	Mallow family
	Sphaeralcea sp.	Globemallow
Pinaceae	Indeterminate	Pine family
	Abies sp.	Fir
	A. concolor	White fir
	Picea sp.	Spruce
	Pinus spp.	Pine
	Pinus edulis	Pinyon pine
	P. ponderosa	Ponderosa pine
	Pseudotsuga menziesii	Douglas-fir
Plantaginaceae	*Plantago* sp.*	Plantain
Polygonaceae	Indeterminate	Buckwheat family
	*Eriogonum racemosum**	Redroot eriogonum
	Polygonum sp.	Knotweed
	Rumex sp.	Dockweed
Portulacaceae	*Portulaca* sp.	Purslane
Potamogetonaceae	*Potamogeton* sp.	Pondweed
Ranunculaceae	Indeterminate	Buttercup
Rosaceae	Indeterminate	Rose family
	Amelanchier sp.	Serviceberry
	Cercocarpus montanus	True mountain mahogany
	Crataegus sp.*	Hawthorn
	Peraphyllum ramosissimum	Squaw apple
Rosaceae (cont.)	*Prunus* sp.	–
	Prunus virginiana	Chokecherry
	Purshia sp.	Bitterbrush
	Purshia tridentata	Bitterbrush
	Rosa sp.	Rose
	Rubus sp.	Raspberry
Salicaceae	Indeterminate	Willow family
	Populus sp.	Cottonwood
	*P. angustifolia**	Narrowleaf cottonwood
	Salix	Willow
Scrophulariaceae	Indeterminate	Figwort family
	Cordylanthus sp.	Birdbeak
	Penstemon sp.	Penstemon
Solanaceae	Indeterminate	Nightshade family
	Datura sp.	Datura
	Nicotiana attentuata	Wild tobacco
	Physalis sp.	Groundcherry
	Solanum sp.	Nightshade
Typhaceae	*Typha* sp.	Cattail
Ulmaceae	*Celtis* sp.	Hackberry
Umbelliferae	Indeterminate*	Parsley family
Verbenaceae	*Verbena* sp.	Verbena
Dicotyledoneae†	Indeterminate	Dicot
Gymnospermae†	Indeterminate	Gymnosperm
Monocotyledoneae†	Indeterminate	Monocot

* Recovered only in an uncharred condition.

† Dicotyledoneae and Monocotyledoneae are subclasses; gymnospermae is a class.

plant genera in table 4.5 is not an exhaustive list of plants that occur in the project area. This table is restricted to those plants indigenous to Dolores and Montezuma Counties, according to the *Plant Information Network Guide* (Plant Information Network 1980), and positively identified or collected during the reconnaissance. Furthermore, since the vegetation reconnaissance was discontinued before completion, this plant list cannot be considered exhaustive. Plants listed in table 4.5 are supplemented by taxa that were not recorded during the reconnaissance but identified in deposits from a packrat midden that was sampled by the DAP and found to range in age from 1450 ± 160 B.P. to 580 ± 90 B.P. (Van Devender 1985).

Resource Mix

The diversity, or mix, of botanical resources actually exploited by the Dolores Anasazi can be assessed through the representation of plant genera in the macrobotanical assemblage, although it is not assumed that the macrobotanical assemblage presents the total range of botanical resources used. Evidence of some genera of plants will not be present in the assemblage because of preservation factors, prehistoric harvesting and preparation techniques, and sampling bias. Table 4.6 presents a temporal breakdown, by modeling period, of those plants represented by charred reproductive or vegetative parts in the macrobotanical assemblage. Reproductive parts (or parts considered to be associated with reproductive parts) include seeds, fruits, cotyledons, cupules, infloresences, infructescences, cones, peduncles, and stamens. These plant parts are quantified by count, with the exception of *Zea mays* kernels, which are weighed because they occur in such large quantities that it is not time efficient to count them. Vegetative parts include leaves, foliage, needles, spines, thorns, twigs, branches, sapwood, bark, and other woody parts. Wood and stem fragments are weighed, and all other vegetative parts are quantified by count.

Table 4.6 is divided into 4 main plant type categories: cultigen, pioneer, wild, and woody. These categories are considered to be the 4 basic botanical resource groups available for prehistoric exploitation. The cultigen and woody categories are assumed to be self-explanatory. Pioneer and wild categories were separated based on the ecological behavior of the constituent plants. Pioneer plants are colonizers of early successional communities, i.e., disturbed communities in which the climax vegetation has been disrupted, causing reversion to an immature state (Odum 1969). Human alteration of the environment, the result, for instance, of clearing or building activities, will create an early successional sere, and pioneer plants will colonize the area. Once the perturbation ceases, the community will start to return to a climax state, and pioneer plants will be succeeded by herbaceous and woody perennial plants. Agriculture fields provide an ideal habitat for pioneer plant colonization. Annual pioneer plants are prodigious seed producers whose seeds can remain dormant in the soil bank until favorable germination conditions occur, at which time they can populate an area rapidly, aggressively, and with great seeding vigor (de Wet and Harlan 1975). Many wild plants are perennials and do not have the germination capabilities of pioneers. The division between pioneer and wild in table 4.6 was based on descriptions of the genera in the literature (cf. Harrington 1954; Kearney and Peebles 1960; Plant Information Network 1980; Thorton et al. 1974; United States Department of Agriculture 1971). However, some of the assignments were to a certain degree arbitrary, and it can be argued that some of the genera (e.g., *Allium, Opuntia, Verbena*) are inappropriately categorized.

From table 4.6 some broad generalizations concerning the botanical resource mix through time can be made. Within the group of culitgens, *Zea mays* is ubiquitous and the most abundant domesticate represented. Remains of *Phaseolus vulgaris* also are ubiquitous, although not as consistently abundant. Remains of *Cucurbita* sp., *C. pepo*, and *Lagenaria siceraria* occur sporadically and only in low quantities. During much of the Anasazi occupation of the Dolores area, these domesticates probably were more important in the subsistence economy than suggested by their minimal appearance in the macrobotanical assemblage. Destructive preparation techniques and lack of preservation are assumed to have obscured representation of both Cucurbitaceae and *Phaseolus* remains. Ethnographically, both resources most commonly were prepared by boiling, a process not conducive to preservation. Also, results of experiments conducted by Gasser and Adams (1981) indicate that the edible or storable parts of Cucurbitaceae and *Phaseolus* are extremely susceptible to microbial infestation and destruction. However, after A.D. 900, prehistoric environmental factors within the project area (sect. 6) may have affected the productivity of *Cucurbita* and *Lagenaria*. Cucurbits require high levels of moisture and warmth for successful maturation and production (Shuster 1981:411; Wetterstrom 1976), and Shuster (1981) noted that productivity of cucurbits grown in the DAP experimental gardens was hindered by late spring and early fall frosts. Unfavorable growing conditions within the project area, especially after A.D. 900, may have made it increasingly difficult to successfully grow cucurbits, and these plants decreased in importance in the subsistence system.

Of the 21 plant taxa categorized as pioneers, 66.7 percent (14 taxa) occurred in at least 6 of the 7 time periods. There is a correlation between abundance

Table 4.5 – Indigenous plants identified in the study area

Trees

Acer negundo
Betula occidentalis
Crateagus sp.
Juniperus osteosperma
Juniperus scopulorum
Pinus edulis
Pinus ponderosa
Populus angustifolia
Populus tremuloides
Pseudotsuga menziesii
Quercus gambelii
Salix sp.

Shrubs

Amelanchier sp.
Amelanchier pumila
Amelanchier utahensis
Artemisia tridentata
Ceanothus fendleri
Cercocarpus montanus
Chrysothamnus sp.
Chrysothamnus nauseosus
Chrysothamnus viscidiflorus
Clematis hirsutissima
Clematis ligusticifolia
Clematis occidentalis grosseserrata
Cornus stolonifera
Elaeagnus sp.
Fendlera rupicola
Holodiscus sp.
Mahonia repens
Pachistima myrsinites
Pentaphylloides floribunda
Peraphyllum ramosissimum
Potentilla gracilis
Prunus virginiana
Purshia tridentata
Rhamnus sp.
Rhus aromatica
Ribes aureum
Ribes leptanthum
Rosa woodsii
Shepherdia argentea
Symphoricarpos sp.
Toxicodendron rydbergii
Vitis riparia

Herbs

Achillea millefolium lanulosa
Allium sp.
Allium acuminatum
Amaranthus sp.
Amaranthus graecizans
Apocynum cannabinum
Arabis sp.
Arenaria congesta
Artemisia dracunculus
Artemisia frigida
Artemisia ludoviciana
Aster chilensis
Aster falcatus
Aster rubrotinctus
Astragalus sp.
Brickellia grandiflora
Calochortus nuttallii
Campanula sp.
Castilleja linariaefolia
Chenopodium sp.
Lathyrus sp.
Lepidium sp.
Lesquerella sp.
Leucanthemum vulgare
Leucelene ericoides
Linum lewisii
Lithospermum multiflorum
Lotus sp.
Lotus wrightii
Lupinus sp.
Lupinus kingii
Machaeranthera pinnatifida
Mentha arvensis
Moldavica parvilflora
Monardo sp.
Nicotiana attenuata
Oenothera sp.
Oenothera coronopifolia
Opuntia sp.
Opuntia polyacantha

Table 4.5 – Indigenous plants identified in the study area – Continued

Herbs (continued)

Chrysopsis villosa
Cicuta douglasii
Cleome serrulata
Collomia linearis
Comandra umbellata
Cordylanthus sp.
Descurainia pinnata
Epilobium paniculatum
Erigeron divergens
Erigeron flagellaris
Erigeron subtrinervis
Eriogonum sp.
Eriogonum lonchophyllum
Eriogonum racemosum
Eriogonum umbellatum
Equisetum laevigatume
Frasera speciosa
Galium boreale
Gayophytum diffusum
Glycyrrhiza lepidota
Grindelia squarrosa
Hedysarum boreale
Helianthus annuus
Helianthus nuttallii
Heliomeris multiflora
Heterotheca villosa
Hymenopappus filifolius
Ipomopsis sp.
Ipomopsis aggregata
Iris missouriensis
Iva xanthifolia
Kochia sp.
Lactuca tatarica pulchella
Orthocarpus luteus
Orthocarpus purpureo-albus
Penstemon barbatus
Penstemon bridgesii
Penstemon strictus
Petradoria pumila
Phlox sp.
Physalis sp.
Plantago patagonica
Polygonum sp.
Polygonum douglasii
Pseudocymopterus sp.
Pyrrocoma crocea
Ranunculus aquatilis
Rudbeckia laciniata
Rumex crispus
Sedum sp.
Senecio sp.
Senecio eremophilus ssp. *kingii*
Senecio multilobatus
Solanum sp.
Solanum americanum
Solidago nana
Sphaeralcea sp.
Sphaeralcea coccinea
Stellaria sp.
Thalictrum fendleri
Thermopsis montana
Typha latifolia
Verbena bracteata
Vicia americana
Wyethia arizonica
Xanthocephalum sarothrae
Yucca baccata

Grasses and grass-like plants

Agropyron desertorum
Agropyron smithii
Agropyron trachycaulum
Blepharoneuron tricholepis
Bromopsis inermis
Bromus anomalous
Carex sp.
Eleocharis sp.
Eleocharis macrostachya
Elymus canadensis
Elymus cinereus
Hordeum jubatum
Juncus sp.
Koeleria cristata
Oryzopsis hymenoides
Poa sp.
Scirpus lacustris
Sitanion hystrix
Stipa sp.

Plants from packrat midden deposits that were not noted during reconnaissance*

Berberis fendleri
Datura sp.
Helenium sp.
Mirabilis multiflora
Sclerocactus mesa-verdae
Verbesina encelioides

* *Based on analysis of packrat midden samples collected at Site 5MT4654 (Van Devender 1985).*

Table 4.6 – Abundance of selected charred plant remains in the macrobotanical assemblage by modeling period*

Taxon	Period 1 A.D. 600-720	Period 2 A.D. 720-800	Period 3 A.D. 800-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Period 7 A.D. 980-1250	Other†	Total
Cultigen:									
Cucurbitaceae									
repro 1	2				1				3
Cucurbita sp.									
repro 1	2	1	4x	2x	2x			x	11x
C. pepo									
repro 1	x			9	29x			2	40x
Lagenaria siceraria									
repro 1	x	x			x			1	1x
Phaseolus vulgaris									
repro 1	384x	45x	1570x	48x	227x	11x	1	20x	2 306x
Zea mays									
repro 1	833x	828x	1127x	1315x	8 736x	720x	109x	231x	13 899x
repro 2	628g	554g	1161g	1058g	10 426g	430g	8g	391g	14 656g
Pioneer:									
Amaranthus sp.									
repro 1	4	15x	68	44	1 137	4	77	16	1 365x
Chenopodium sp.									
repro 1	23	73x	134x	165x	1 958x	250x	28	501x	3 132x
Cheno-am									
repro 1	9	56x	116x	43x	1 255x	47x	63x	58	1 647x
Cleome serrulata									
repro 1		2	1	2	21				26
Compositae									
repro 1	2	3	7	5	76x		1	6	100x
Cruciferae									
repro 1	2	12	10	52	882	38x	12	6	1 014x
Datura sp.									
repro 1				1					1
Descurainia sp.									
repro 1		82	8	55	441x	8	2	10	606x
Gramineae									
repro 1	6	16	57	24	270x	36x	13	31x	453x
Helianthus									
repro 1	5	20x	6	2	80x	2	6	2	123x
Malvaceae									
repro 1	1	2	8	3x	3				17x
Mentzelia albicaulis									
repro 1	1	4	37	19x	74	1	6	3	145x
Nicotiana attenuata									
repro 1	1	16	237x	10	23	1	2	1	291x
Oryzopsis hymenoides									
repro 1	1	7	2				7		17
Physalis									
repro 1	3	40x	26x	67x	480x	20	10	32	678x
Polygonaceae									
repro 1		1	3	14	14				32
Polygonum sp.									
repro 1	6		6x	3	1 015x	2	2	5x	1 039x
Portulaca sp.									
repro 1	28	1030	484x	54	312x	329	13	17	2 267x
Solanaceae									
repro 1		5x	3	6	14	2	1	2	33
Solanum sp.									
repro 1		1		7	11	3			22
Sphaeralcea sp.									
repro 1	1	1	5		1	1			9
Wild:									
Allium sp.									
repro 1					x				x
Asciepias									
repro 1								1	1
Cactaceae									
veg 1		2		2x	55x	2	4	5	70x
Chenopodiaceae									
repro 1			2		1 001			2	1 005
Cordylanthus sp.									
repro 1		1							1
Cyperaceae									
repro 1	1	2	10	10	1 037	3	6	1	1 070
Ephedra sp.									
veg 2					<1g				<1g
Iva sp.									
repro 1			2	2	1	2		7	14
Leguminosae									
repro 1	26x	3	5	2x	5	2			43x
Opuntia sp.									
repro 1		2	1	2	24	1		17	47
veg 1				11x	32x				43x
Penstemon sp.									
repro 1			2	1	1				4

Table 4.6 – Abundance of selected charred plant remains in the macrobotanical assemblage by modeling period* – Continued

Taxon	Period 1 A.D. 600-720	Period 2 A.D. 720-800	Period 3 A.D. 800-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Period 7 A.D. 980-1250	Other†	Total
Phragmites sp.									
veg 1					x				x
veg 2	24g	13g	3g	1g	128g	1g		3g	173g
Ranunculaceae									
repro 1	1								1
Rubus sp.									
repro 1				2	1	2			5
Rumex sp.									
repro 1					1				1
Scirpus sp.									
repro 1			1		1				2
Scutellaria sp.									
repro 1					26x				26x
Typha sp.									
veg 2		1g						2g	3g
Verbena									
repro 1		1							1
Yucca sp.									
repro 1		5		20x	10x	1	4x	5	45x
veg 1	2	3	1x	6x	12x	1x	x	2x	27x
Y. baccata									
repro 1	10x	10x	x	9x	x	3	1	13	46x
Woody:									
Abies concolor									
veg 1		6							6
veg 2			1g	4g					5g
Acer sp.									
veg 2			1g	<1g	1g			<1g	2g
Amelanchier sp.									
repro 1				3	24x			2	29x
veg 2	<1g	4g	4g	8g	16g	73g	4g	5g	114g
Artemisia sp.									
repro 1	6	10	221x	13	712x	8	2	4	976x
veg 1	1	4x	41x		4				50x
veg 2	198g	782g	792g	73g	208g	198g	43g	78g	2 372g
A. tridentata									
veg 1			11x	12x	302x			2	327x
Atriplex sp.									
repro 1			1						1
veg 2	<1g		1g	2g	17g	32g		2g	54g
Celtis									
repro 1								1	1
Cercocarpus montanus									
repro 1					7				7
veg 1					3x				3x
veg 2	<1g	24g	18g	79g	509g	45g	4g	81g	760g
Chrysothamnus									
veg 2		2g		2g	17g	<1g	61g	1g	83g
Cornus stolanifera									
veg 2			1g	1g	3g			7g	12g
Fendlera rupicola									
veg 2		1g	1g	3g	8g	5g	1g	2g	21g
Juniperus sp.									
repro 1	1	1x	1	2x	6x				11x
veg 1	6	108	687x	240	975x	43	60	38	2 157x
veg 2	129g	1218g	358g	228g	1829g	289g	321g	172g	4 544g
J. osteosperma									
repro 1	1	6x	1	27x	45	1		9	90x
veg 1	5	7	154	26	497x	28	19	210	946x
J. scopulorum									
repro 1					1			1	2
veg 1	7	4		6		4	24	5	50
Peraphyllum ramosissimum									
veg 2			1g	4g	2g			1g	8g
Pinaceae									
veg 1			1						1
veg 2			1g		3g				4g
Pinus sp.									
repro 1				2x	8x			1	11x
veg 1			2	1	1				4
veg 2	105g	1039g	792g	2 407g	2 597g	74g	107g	454g	7 575g
P. edulis									
repro 1	33x	5x	4x	20x	100x	2x	6	8x	178x
veg 1	2	4x	111x	34x	349x	3x	6x	110x	619x
veg 2	3g	75g	568g	124g	926g	69g	37g	302g	2 104g
P. ponderosa									
repro 1		1	1x	6x	28x			2x	38x
veg 1		4x	184x	15x	88x	3x	x	5x	299x
veg 2	20g	1424g	11 417g	2955g	1085g	616g	7g	662g	18 186g
Populus									
veg 2	139g	4484g	1901g	594g	6722g	1706g	99g	112g	15 757g
Prunus virginiana									
repro 1			1x	2x	29x	1		13	46x
veg 2			8g	2g	4g		4g	<1g	18g
Pseudotsuga menziesii									
repro 1					2				2
veg 1		2x	29x	3x	35x			1x	70x
veg 2		24g	5g		461g				490g

Table 4.6 – Abundance of selected charred plant remains in the macrobotanical assemblage by modeling period* – Continued

Taxon	Period 1 A.D. 600-720	Period 2 A.D. 720-800	Period 3 A.D. 800-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Period 7 A.D. 980-1250	Other†	Total
Purshia tridentata									
veg 2		<1g			2g			<1g	2g
Quercus gambelii									
repro 1				1	4x	1		8x	14x
veg 2	8g	37g	80g	803g	183g	26g	28g	80g	1245g
Rhus aromatica									
repro 1		120	1	5	40x	1	2	2	171x
veg 2				1g	6g	<1g	<1g		7g
Rosa sp.									
veg 2					1g			<1g	1g
Rosaceae									
repro 1			1	1	11	7	1	1	22
veg 2	6g	52g	23g	37g	67g	13g	34g	24g	256g
Salicaceae									
veg 2	10g	27g	27g	100g	140g	11g	3g	27g	345g
Salix sp.									
veg 2	8g	3g	51g	25g	75g	6g		1g	169g
Sarcobatus vermiculatus									
veg 2					1g	1g			2g
Shepherdia argentea									
veg 2				5g	10g		4g	1g	20g
Other:									
Dicotyledoneae									
repro 1	9x	30	90x	76x	224x	43x	84x	63x	619x
veg 1	x	2x	8x	8x	95x	1x	1x	3x	118x
veg 2	19g	34g	72g	175g	139g	13g	12g	283g	747g
Gymnospermae									
repro 1					2				2
veg 2	33g	74g	238g	130g	134g	12g	9g	57g	687g
Monocotyledoneae									
repro 1					x				x
veg 1			5		4			x	9x
veg 2		1g	5g	1g	3g	2g		2g	14g
Fungi									
repro 1				1					1

* The following have been excluded from this table: materials from upper and lower control samples, nonindigenous taxa, uncharred remains, and occurrences of species as parts of worked vegetal items.

† Other not assigned to period.

x – Fragments present; whole count not possible.

repro 1 – Counted reproductive parts. For "cultigen" and "pioneer" groups. Includes infructescences, seeds, fruits, cotyledons, cupules, and inflorescences. For "wild" and "woody" groups, includes cones, pedunclies, and stamens in addition to the parts just listed.

repro 2 – Weighed reproductive parts. Consists of *Zea mays* kernels only.

veg 1 – Counted vegetative parts. Includes leaves, foliage, needles, spines, and thorns.

of remains and their distribution through time: plants recovered from 6 or 7 time periods usually are represented by at least 100 reproductive parts and frequently by more than 400 reproductive parts. There are 13 017 charred pioneer plant remains accounted for in the selected assemblage. When the total number per taxon is compared against total taxa for all pioneers in the 7 periods, 4 divisions of percent representation can be defined (table 4.7). Although abundance measures and percent of total abundance can be used as one means of assessing relative importance of a resource within the resource mix, it can also be misleading because of variable reproductive strategies of plants, preservation, sample bias, and what part of the plant was actually used (Dennell 1976; Minnis 1981a; Munsen et al. 1971). The pioneer plants not frequently or abundantly represented in the assemblage may not have occurred in the resource area in quantities worth exploiting intensively, or they may not have been economic plants. In the latter case, the inclusion of these plants in small quantities in archaeological deposits might be the result of inadvertent harvesting. Also, the use, time period in the growth cycle during which the plant was harvested, and preparation technique may not have been conducive to preservation. An example of the latter situation is the low percentage of *Cleome serrulata*. This species features as an important economic plant in Southwestern ethnobotanies (Winter

Table 4.7 – Pioneer plant taxa grouped by percentage of plant abundance*

≤1%	>1% but <5%	>5% but <10%	>10%
Cleome serrulata	*Mentzelia albicaulis*	*Polygonum*	*Chenopodium*
Compositae	*Descurainia*	Cruciferae	*Amaranthus*
Datura	*Nicotiana attenuata*		*Portulaca*
Helianthus	Gramineae	*Physalis*	Cheno-am
Malvaceae			
Oryzopsis hymenoides			
Polygonaceae			
Solanaceae			
Solanum			
Sphaeralcea			

* Uncharred materials and materials from upper and lower control samples omitted. Only materials assigned to modeling period considered.

1975) and is strongly represented in the DAP pollen assemblage. If this plant was collected prior to seed development (and it is most frequently noted for being harvested for its herbaceous parts), then little evidence of this plant would occur in the macrobotanical assemblage, although it may have been an important resource. One means of countering the interpretational biases inherent in abundance measure is using ubiquity of occurrence (Gasser 1982; Minnis 1981b). This measure of resource importance will be explored later in this section.

Of the plant taxa that can be considered wild resources, only 21 are listed under the wild category in table 4.6. The remainder, which are represented in the assemblage by both reproductive and woody parts (e.g., *Rhus aromatica*), are listed in the table under the woody heading. However, taxa represented by reproductive parts in this latter category are included in this discussion on wild plants.

Temporally and quantitatively, wild plant resources are generally less well represented compared to the other categories of remains listed in table 4.6. Wild resources used by subsistence agriculturalists are those that do not compete with agricultural activities for energy expenditures, and the greater the importance of agriculture within the subsistence system, the lesser the importance of wild plant resources (Christenson 1980:37; Ford 1968:176). Another probable reason for their lower frequency and abundance is that many wild resources are exploited for fruits or other parts that do not preserve well in the archaeological record.

Interpreting temporal patterns in wild plant resources is difficult. Based on the assumption that an inverse correlation exists between diversity and richness of wild resources and agricultural intensification, it was originally expected that both diversity and richness of wild plants represented would decrease during Periods 3 through 5 (A.D. 800-920), when population is growing and agriculture becomes an intensified strategy to meet energy needs (Orcutt 1984b, 1985a, 1985c, and chap. 10). However, as indicated in table 4.6, this generally is not true. The limited occurrence of some genera may be a result of factors already discussed. The increase in wild plant resource representation through time may be a result of sample size, a factor more closely evaluated later in this section.

The remains of wood charcoal indicate that a wide variety of wood resources (24 genera) was exploited. Of the 32 taxa listed in table 4.6, 16 (50.0 percent) occur in 6 or more of the time periods. Eight woody taxa are represented by more than 1000 g of wood charcoal.

The abundance measures for wood can easily be skewed. Genera such as *Populus, Pinus edulis, P. ponderosa*, and *Juniperus* sp. were the predominant woods used in construction. Remains of support posts and beams sent in for identification contributed considerably to the abundance measure (weight) of any particular genus of wood used for construction, since these types of remains usually were larger and heavier than remains retrieved from hearths. Other genera of wood, such as some of the rosaceous shrubs and trees that might have been used as closing material on roofs and would have been found in the roof fall of structure, were not consistently collected by excavators, who favored structural wood that could potentially yield tree-ring dates. This arbitrary collection method also affected the representation of *Populus* sp., which does not date well and therefore frequently was discarded in the field. Therefore, abundance measures based on weight are of minimal value in assessing the relative importance of woody genera in the resource mix, and other measures need to be used to assess the relative importance of the different woody taxa in the resource mix. A preliminary

study (Kohler et al. 1984; Kohler and Matthews 1984) using, in part, ubiquity data from Grass Mesa Village (Site 5MT23) has indicated that changes in wood resource use do take place and may be the result of resource depletion. This possibility is explored further later in this section.

PROBLEM DOMAIN 5: CULTURAL PROCESS

Problem Domain 5 is concerned with the processes underlying cultural change and continuity in the Dolores Project area (Kane et al. 1983). In an effort to address this problem domain, the DAP has developed an explanatory model discussed in chapter 6. This model provides a theoretical and operational framework within which other models or submodels have been developed. These other models address particular variables, such as population size and growth, settlement behavior, technology, exchange, social organization, resource cost, and resource mix, identified in the process model to be important within the sociocultural system. The process model is broad and general; the submodels provide the particularistic elements of the overall model. A submodel of agricultural intensification, as it has been applied by Orcutt (1984b, 1985a, 1985c) to the DAP area, provides a framework within which several expectations concerning temporal change in botanical resource utilization strategies can be generated.

Change in Botanical Resource Use: Expectations

The botanical resource mix of the Dolores Anasazi is viewed as the result of the energy requirements of the population, resource abundance and availability, and cultural preference. Factors that affect the resource mix or the costs involved in procuring that mix would require alteration of subsistence strategies. Two factors that would have affected the resource mix and costs of the Dolores Anasazi are population pressure and climatic stress (Lipe et al. 1983; Orcutt 1985a and chap. 10; Petersen, chap. 4, sect. 6; Schlanger, chap. 8). The expected response to the influence of these 2 variables on the subsistence system is a reduction in resource diversity and intensification or expansion of existing agricultural strategies (Christenson 1980; Cordell 1982; Earle 1980; Orcutt 1985c; Turner and Doolittle 1978). The direction of this response would have repercussions on the botanical resource mix and on the composition of the macrobotanical assemblage.

Intensification of an agricultural system implies expanding the area under cultivation or increasing the yield of the cultivated area. Reduction in resource diversity as a result of intensification would mean decreasing procurement of resources that take too much time and energy away from agricultural activities. For the Dolores area, a strategy of agricultural intensification is expected to be pursued during Period 4 (A.D. 840-880) and Period 5 (A.D. 880-920) because of increasing population size combined with climatic stress in Period 5 (Orcutt 1984b, 1985a, 1985c). Several changes are expected to be visible in the macrobotanical data base as the result of intensification:

1. An increase in the quantity of cultivated plant remains for Periods 4 and 5 (A.D. 840-920) should occur, and possibly evidence for change in varieties or strains of domesticated plants.

2. There should be an increase in the diversity and abundance of pioneer plant remains for Periods 4 and 5 as the result of intensifying a multiple-cropping strategy.

3. A decrease in the abundance and diversity of wild plant remains for Period 4 (A.D. 840-880) should occur.

4. There should be an increase in both diversity and abundance of wild plant remains in Period 5 (A.D. 880-920) as a result of increased storage (to provide a "buffer"), and as a result of the expansion of catchment areas.

5. Changes in wood remains should result from increased building and clearing activities during Periods 4 and 5.

The remainder of this section tests these expectations for change in the macrobotanical assemblage. Each of the 4 major plant categories (cultigen, pioneer, wild, and woody) is examined with reference to change through time in diversity and abundance.

Change in Botanical Resource Use: Results

Cultigens: Cucurbitaceae and *Phaseolus*

Analysis of the remains of Cucurbitaceae and *Phaseolus* shows no change in varieties over time. Remains of cucurbits were recovered from only 13 sites; remains from 9 of these sites were analyzed (Fleming 1983). Genera of Cucurbitaceae were identified through analysis of seeds, rinds, and peduncles. Based on seed measurements or recognition of distinctive morphological characteristics described by Cutler and Whitaker (1961) and Whitaker and Bohn (1950), 2 species of cucurbits were recognized: *Cucurbita pepo* and *Lagenaria siceraria* (Fleming 1983). Some specimens could not be positively identified beyond the level of family or the genus *Cucurbita*, but given the predominance of *C. pepo* in

the assemblage, these cucurbits are probably also *C. pepo*.

The number of *Phaseolus* sp. remains recovered was substantially greater than that of cucurbit remains, but *Phaseolus* sp. representation was low compared to *Zea mays*. Remains of *Phaseolus* were collected from 22 sites; remains from 16 sites were analyzed. A subsample of 361 whole beans and 850 cotelydons was selected for analysis. Kaplan's (1956) type system, based on measurement of several morphological characteristics, was used for analysis of the remains (Griffitts 1985). Using this system, the remains were assigned to *Phaseolus vulgaris*. Five noncharred beans could be further identified, according to Kaplan's types, as either Hopi Blue Dye or Red Kidney beans.

Under a strategy of agricultural intensification, the production of cucurbits and beans should increase. Increased production hypothetically would increase the amount of material in the archaeological record because more material would be deposited as increased quantities were brought into a site. However, as indicated in table 4.6, this is not consistently the case. Remains of *Phaseolus vulgaris* and *Lagenaria siceraria* generally are more abundant during Periods 1 through 3 (A.D. 600-840) than during Periods 4 through 7 (A.D. 840-1250), although *Cucurbita pepo* is more abundant during Periods 4 and 5 (A.D. 840-920) than at any other time. Nonetheless, this discrepancy between the expected and the actual trends in abundance values does not necessarily refute the idea of increased production during Periods 4 and 5 for a variety of reasons. The representation of these cultigens is expected to have been detrimentally affected by prehistoric preparation techniques and preservation factors, possibly more so than other types of remains would have been, such as seeds of pioneer plants. Therefore, the abundance of beans and cucurbits may not be an accurate means of gauging fluctuations in their contribution to the economic system over time. A case in point is the quantity of *Phaseolus* associated with Period 3 (A.D. 800-840). Of the 1570 bean specimens recovered, 1537 were retrieved from a few proveniences from 1 site. Anomalous incidences such as this can obviously bias interpretations. Furthermore, the somewhat inconsistent occurrence of cucurbits over time may also indicate that preservation and sampling biases are affecting representation rather than reflecting the significance of these resources. The idea of agricultural intensification cannot be substantiated or refuted based on remains of cucurbits and beans. Too many uncontrolled factors in the archaeological record have affected the representation of these types of remains to confidently use them as an index of intensification.

Cultigens: *Zea mays*[1]

One general expectation concerning cultivated resources in the Dolores area is that these resources will increase in importance with increasing population during the early to late A.D. 800's. The increased importance of these resources would be the result of increased intensification of the agricultural subsistence strategy to offset the impact of a larger population on the general subsistence system. An expected form of agricultural intensification would have been selection of high-yield varieties of domesticated plants. Varieties that had characteristics such as large fruits, high yield per plant, early maturation, or tolerance of various environmental factors were expected to have been selected for cultivation. This selection process would have been most significant for *Zea mays*, which would have had the greatest potential for providing the highest yield of usable product per unit area of land under cultivation. During the optimal climatic years of Period 4 (A.D. 840-880), selection of *Zea mays* types may have concentrated on varieties with large row number (equivalent to high kernel count), large ears, flour versus flint kernels, and high yield per plant or hill. Coincident with the climatic deterioration that began in the late A.D. 800's and continued through the A.D. 900's (Petersen, sect. 6; Orcutt 1984b, 1984c, 1985a), stress-tolerant varieties of cultigens may have been selected over high-producing but less stress tolerant varieties.

Abundance of *Zea mays* remains. – It is assumed that with the increased population during the early to late A.D. 800's in the project area (with the highest population during Period 4, or from A.D. 840 to 880) (chap. 8), production of corn had to increase to meet demand. The question of interest is whether increased production of corn was a conscious cultural response in the form of intensification, or whether production simply increased concomitant with the influx of more subsistence agriculturalists into the project area as the dry-farming belt narrowed (sect. 6; chap. 8). It is assumed that the former is the case.

Table 4.8 illustrates the difference in abundance of corn kernels by modeling period. As is apparent from this table, when all cases are considered, a large difference in the quantity of corn remains between Period 5 and all other periods; a smaller but still noticeable difference occurs when aberrant cases are excluded. At least 3 considerations must be taken into account when evaluating these differences.

The first consideration is the amount of time represented by each of the DAP periods. With all other variables being equal, a period that is longer than another

[1]Discussion of corn remains provided by Kenneth Lee Petersen, DAP.

Table 4.8 – Abundance of *Zea mays* kernels, by modeling period*

Period and date range (A.D.)		Kernels			
		weight (g)†		Number of sites§	
1	(600-720)	629.6	(629.6)	5	(5)
2	(720-800)	506.8	(506.8)	14	(14)
3	(800-840)	1 141.0	(1141.0)	8	(8)
4	(840-880)	1 012.8	(1012.8)	15	(15)
5	(880-920)	10 216.9	(3833.3)	14	(14)
6	(920-980)	430.7	(9.4)	3	(2)
7	(980-1250)	8.9	(8.9)	6	(6)

* Includes charred and uncharred remains.
† Numbers in parentheses indicate total weights of corn kernels when aberrant cases removed. For Period 5, kernels from Surface Structure 13, Site 5MT4477, removed. For Period 6, kernels from Site 5MT4475 removed.
§ Number of sites with kernels. Numbers in parentheses indicate numbers of sites when aberrant cases removed, as specified above.

period would be expected to be represented by more corn remains. This bias can be partly overcome by focusing attention on Periods 3, 4, and 5, because each of these periods is 40 years long. Period 6 also is examined, although at 60 years in length, it is longer than the preceding 3 periods.

The second consideration is the number of sites represented within a period. Even if Periods 3, 4, and 5 span the same number of years (i.e., 40), if any 1 period is represented by a greater number of contexts (for instance, the number of sites yielding corn remains almost doubles from Period 3 to Period 4 and then decreases slightly from Period 4 to Period 5), then differences in the amount of corn kernels recovered could be attributed to the number of sites analyzed. To overcome this problem, grams of corn kernels were divided by the number of sites (table 4.8) to provide an estimate of the average amount of corn kernels per site (fig. 4.1).

In figure 4.1, Period 5 (A.D. 880-920) has the greatest amount of corn kernels per site. At first, the trend evident in figure 4.1 appears to fit the anticipated trend of increasing population and increasing dependence on corn. However, the peak occurs in Period 5, when population levels have begun to decrease in the project area (chap. 8), instead of in Period 4, when initially expected.

To insure that aberrant cases did not unduly influence the trend illustrated in figure 4.1, the amount of corn

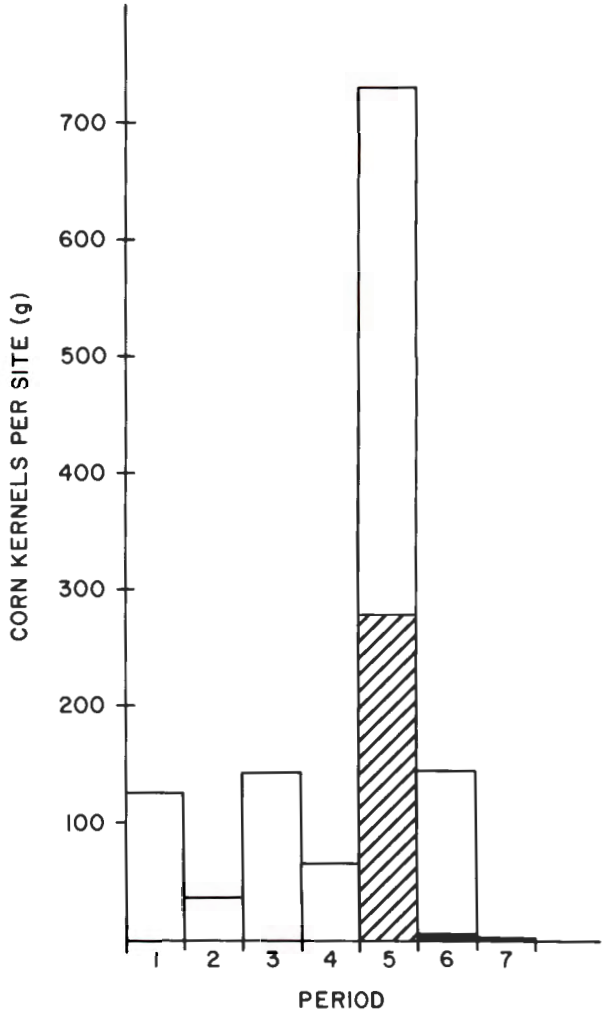

Figure 4.1 – Average amount of corn kernels (grams) per site, by modeling period. Hatching shows average when kernels from Surface Structure 13 at Site 5MT4477 are excluded; solid bar shows average when kernels from Site 5MT4475 are excluded.

kernels at specific sites was examined. Most of the Period 5 corn kernels came from Surface Structure 13, a room at Site 5MT4477 that had been full of corn when it burned and from which special efforts were made to collect much of the material found within. When the Surface Structure 13 kernels are excluded in figure 4.1 (as indicated by hatching), the peak in Period 4 is still evident, although less pronounced. At least some of the remaining peak may be attributable to previously unrecognized cases less aberrant than Surface Structure 13, but still anomalous enough to cause distortion. Most of the Period 6 corn remains came from Site 5MT4475. When this site is excluded from the analysis (as shown by the solid bar in fig. 4.1), the overall trend is still evident: the average amount of corn kernels is

still highest during Period 5 and drops drastically in Period 6. However, the sample size for Period 6 is small (3 sites).

The third and final factor to be considered when evaluating the increased abundance of corn kernels during Period 5 is related to DAP excavation and research priorities. A greater number of contexts that date to Period 5 may have been excavated within each site. A test for this would be to examine some other artifact category in relationship to corn remains to see if it changes in the same manner as the corn remains.

Ceramics were selected to be evaluated against the amount of corn remains because sherds are relatively ubiquitous. If it can be assumed that the rate of breakage and discard remained relatively constant through time, then changes in corn remains may be evaluated independently of the length of a DAP period and the number of sites excavated.

Table 4.9 shows the abundance of sherds for each modeling period. Two data categories are presented. The first is the number of sherds recovered from the sites that contained corn kernels. The second category consists of total sherds recovered from all DAP sites assigned to modeling period. Because most of the differences between each of the ceramic categories in table 4.9 are relatively small, total sherds from the entire project was the category selected for this discussion. This measure allows the ceramic data to be used against other macrobotanical remains.

Tables 4.8 and 4.9 indicate that the total number of sherds roughly doubles between Periods 4 and 5, while at the same time, the amount of corn kernels (excluding Surface Structure 13 at Site 5MT4477) increases nearly 4 times. Since these 2 periods are of equal length, it is clear that more contexts were excavated. Even if the rate of ceramic breakage and disposal had changed during Period 5 (which is unlikely), it still would seem that Period 5 is represented by many more excavated contexts than any other period. It then would logically follow that the increase of corn kernel remains evident in figure 4.1 could simply be a product of more extensive excavation. To test for this, the corn kernels listed by period in table 4.8 were divided by the numbers of total sherds listed by period in table 4.9 and the ratio plotted in figure 4.2.

The most obvious difference between figure 4.1 and figure 4.2 is the high Period 1 ratio of grams of corn kernels to total sherds in figure 4.2. Other than that, the general trend evident in figure 4.1 is still evident in figure 4.2. Period 5 is characterized by much more corn than any of the other periods when Surface Structure 13 at Site 5MT4477 is included. When this structure is excluded, Period 5 is no longer characterized by a strong overall peak, although the Period 5 ratio is nearly twice that of Period 4. In short, some evidence indicates that the large number of Period 5 corn kernels recovered might not be strictly the result of a greater number of Period 5 sites or contexts having been excavated. The length of time represented by a period is not a factor in this method of presentation.

Table 4.9 – Abundance of sherds, by modeling period

Period and date range (A.D.)		Sherds			
		Group 1*		Group 2†	
1	(600-720)	11 187	(11 187)	14 837	(14 837)
2	(720-800)	34 125	(34 125)	35 335	(35 335)
3	(800-840)	48 461	(48 461)	52 534	(52 534)
4	(840-880)	68 676	(68 676)	70 532	(70 532)
5	(880-920)	145 230	(145 010)	146 032	(145 812)
6	(920-980)	27 341	(279)	27 903	(841)
7	(980-1250)	6 150	(6 150)	7 728	(7 728)

* Group 1 – Number of sherds recovered from table 4.8 sites that yielded corn kernels. Numbers in parentheses indicate total sherds when aberrant cases removed. For Period 5, sherds from Surface Structure 13, Site 5MT4477, removed. For Period 6, sherds from Site 5MT4475 removed.

† Group 2 – Total number of sherds recovered from all DAP sites that could be assigned to modeling period. Numbers in parentheses indicate total sherds when aberrant cases removed, as specified above.

The fact that the increase in the amount of corn kernels lags behind the trend seen in population (chap. 8) may be the most convincing argument for agricultural intensification. Figure 4.1 shows that Period 5 has the highest average amount of corn kernels per site. Figure 4.2 shows that, except for Period 1, Period 5 has the highest ratio of corn kernels to total sherds (when Surface Structure 13 at Site 5MT4477 is excluded). This pattern is also evident in the faunal data (chap. 7, fig. 7.3.). Period 5 has a significantly greater average ratio of bone remains (minimum number of individuals) to gray ware sherds than do other periods. The differences between all the other periods are not significant.

As judged by the faunal results just discussed and by figures 4.1 and 4.2, the evidence for both increased faunal procurement and agricultural intensification is strongest for Period 5, as opposed to Period 4. This may be because population pressure alone may not have brought about enough stress to force intensification during Period 4. However, with deteriorating climate during Period 5, which continued into Period 6 (sect.

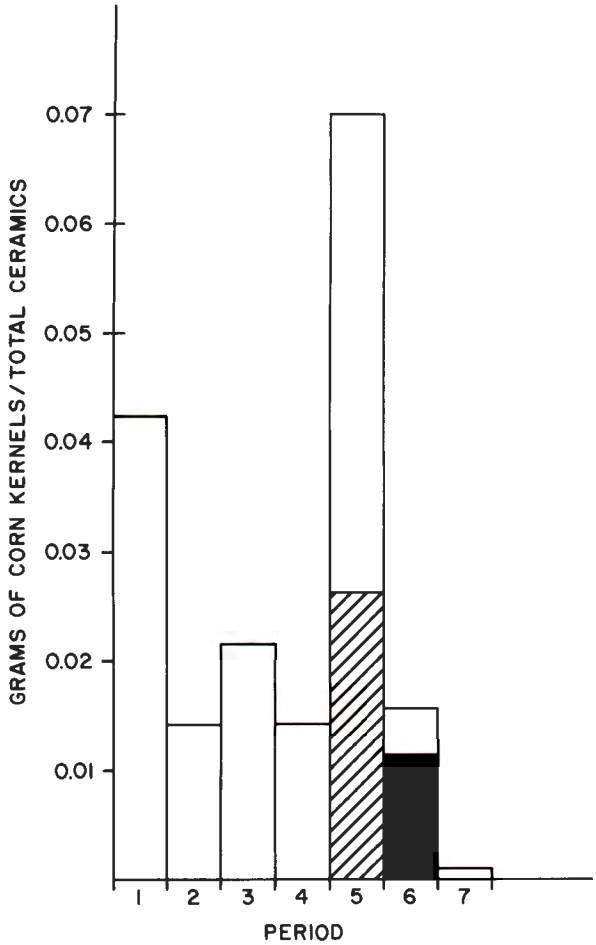

Figure 4.2 – Ratio of grams of corn kernels to total number of sherds recovered from the project area. Hatching shows ratio when kernels and ceramics from Surface Structure 13 at Site 5MT4477 are excluded. Solid bar shows ratio when kernels and ceramics from Site 5MT4475 are excluded.

6), agricultural intensification (and the concomitant increase in faunal procurement) seems to have been undertaken. But, the steps taken by the Anasazi evidently were not adequate, and the project area was largely abandoned in the early A.D. 900's. When the area was again occupied during Period 6 (A.D. 920-980), corn remains were much less abundant (figs. 4.1 and 4.2) than during Period 5, although they may have occurred in quantities similar to those noted for earlier periods. The reduced abundance of corn kernels between Periods 5 and 6 is mirrored by the low ubiquity of *Zea* pollen during the A.D. 900-975 period (Cline Subphase), as discussed in section 3 of this chapter.

The contrast in corn remains between Periods 5 and 6 is also clearly shown by Matthews (1985c) in her study of the McPhee Community Cluster corn remains. She also found that remains of other cultigens (i.e., *Phaseolus vulgaris, Cucurbita pepo*, and *Lagenaria siceraria*) were sharply reduced in Period 6, and she notes that this reduction is best explained by the less favorable climate for cultigens that existed in the project area during this period. Her explanation is supported by the results of pollen analysis (sect. 3), but the reduction in *Zea* ubiquity during Period 6 is not as evident in figures 4.1 and 4.2, unless Site 5MT4475 is excluded from consideration.

Varieties of *Zea mays*.[2] – Several morphological attributes can be measured to determine race or varietal differences in archaeological corn populations. Cob or ear diameter and number of kernel rows are used for gross classsification; finer measurements focus on alicole characteristics (Benz 1981). Measurements taken on the cob remains from the project area included kernel row number, cob diameter, cupule width, and glume width. Forty-four whole cobs and 9306 cob fragments, most of which were charred, were recovered during DAP excavations. A subsample of 552 cob specimens was selected for measurement because the cobs were in adequate condition. Of these cobs, 336 were collected from proveniences with secure temporal assignments; this subsample was used in the present study.

The results of the corn measurements are presented in table 4.10. The row number for all samples that could be assigned to modeling period ranges from 8 to 18; however, it is only in Period 3 and later (i.e., after A.D. 800) that row numbers of 16 and 18 occur. (Although 6-row cobs do occur in the DAP assemblage, none were assigned to modeling period.) The percent of cobs with each of the different row numbers represented per modeling period is also shown. Except for Period 1 (represented by only 6 cobs), cobs with 12 rows always represent more than 50 percent of the samples from a period.

In table 4.10, 10-row corn cobs make up less than 19 percent of the cob remains for all periods except Period 5, where it increases to 26.2 percent. The increase in Period 5 results in a mean row number that averages less than 11 mm (i.e., 10.9 mm), whereas all other mean row numbers (except for Period 1) average 11 mm or more. Although this slight change in mean row number falls well within one standard deviation,

[2]The data files upon which this study is based are earlier than the data files used for much of the rest of this section. Therefore, some of the numbers presented in text and in tables might not correspond exactly to data presented elsewhere in this section, this volume, or the DAP report series. For instance, at the point at which this study was undertaken, no corn remains had been assigned to Period 7. Subsequent to the completion of the study, the data file was reviewed and edited, and some corn remains were assigned to Period 7. This revision is not reflected in the discussion of *Zea mays* varieties presented here.

Table 4.10 – corn cob summary by modeling period*

Period and date range (A.D)†	Row No. 6 N	Row No. 6 %	Row No. 8 N	Row No. 8 %	Row No. 10 N	Row No. 10 %	Row No. 12 N	Row No. 12 %	Row No. 14 N	Row No. 14 %	Row No. 16 N	Row No. 16 %	Row No. 18 N	Row No. 18 %	Row No. Total N	Row No. Total %	Row No. $\overline{X}$	Row No. N	Row No. *SD*	Cob diameter (mm) $\overline{X}$	Cob diameter (mm) N	Cob diameter (mm) *SD*	Cupule width (mm) $\overline{X}$	Cupule width (mm) N	Cupule width (mm) *SD*	Glume width (mm) $\overline{X}$	Glume width (mm) N	Glume width (mm) *SD*
1 (600-720)			3	50.0	1	16.7	2	33.3							6	100.0	9.7	6	2.0	14.0	6	4.0	6.0	1	0.0	10.2	5	4.8
2 (720-800)			4	21.1	1	5.3	12	63.2	2	10.5					19	100.0	11.3	19	1.9	14.1	19	2.7	6.3	7	1.7	7.1	12	1.1
3 (800-840)			1	3.7	5	18.5	17	63.0	2	7.4	2	7.4			27	100.0	11.9	27	1.7	14.7	27	2.3	5.7	3	0.8	6.5	24	1.9
4 (840-880)			6	23.1	4	15.4	14	53.8	1	3.8	1	3.8			26	100.0	11.0	26	2.1	15.1	26	2.9	4.8	1	0.0	8.0	25	2.1
5 (880-920)			33	17.3	50	26.2	100	52.4	7	3.7	1	0.5			191	100.0	10.9	191	1.7	15.7	191	2.8	7.2	20	1.4	8.0	170	1.2
6 (920-980)			6	9.0	11	16.4	40	59.7	7	10.4	2	3.0	1	1.5	67	100.0	11.7	67	1.9	16.4	67	3.3	6.8	9	1.3	8.2	58	1.4
Period totals			53	15.8	72	21.4	185	55.1	19	5.7	6	1.8	1	0.3	336	100.0	11.1	336	1.8	15.6	336	3.0	6.8	41	1.4	7.9	294	1.6
Other§	2	0.9	28	13.0	56	25.9	118	54.6	9	4.2	3	1.4			216	100.0	11.1	216	2.2	15.8	216	4.2	6.1	41	1.7	8.6	175	3.8
Total	2	0.4	81	14.7	128	23.2	303	54.9	28	5.1	9	1.6	1	0.2	552	100.0	11.1	552	2.0	15.7	552	3.5	6.4	82	1.6	8.2	469	2.7

* The data file used was edited subsequent to the preparation of this table and accompanying text. Therefore, the numbers presented here and in text might not correspond exactly to data presented elsewhere in this volume or elsewhere in the DAP report series.

† Period 7 is not listed because, at the point at which this study was undertaken, no corn cob remains had been assigned to this period.

§ Other – Not assigned to period.

Includes both charred and uncharred remains.

$\overline{X}$ – Mean.

SD – Standard deviation.

and so is not significant, a 2 × 2 chi-square test was performed to see if a significant difference occurred between the number of 10-row corn cobs in Period 4 versus Period 5. The results, with a chi-square value of 1.43, indicate that the difference is also not significant at the 0.5 level of probability. However, even though the magnitude of change cannot be shown to be significant, the direction of change might be important. The direction of change may be what could be expected with agricultural intensification and selection for 10-row corn.

Assuming that corn cultivation was the focus of agricultural intensification, increased productivity could be managed through expansion of agricultural fields under cultivation and increased energy input into cultivation. This may be what is evidenced by the high proportion of corn kernels in Period 5 already discussed. Another means of intensification could be the cultural selection for high-yield varieties of corn. Although numerous cultural factors affect the types of corn grown (e.g., color, use, size), environmental variables would certainly be determining factors in selection of corn varieties. The major limiting environmental factors in the project area are frost-free period and precipitation, with the former believed to have been the more influential of the 2 (sect. 6; Shuster 1981). These environmental factors would encourage cultural selection for varieties of corn that would mature within 110 to 120 days and were tolerant of water stress and cool temperatures.

An early type of flint corn (a variety of corn with a hard endosperm) in the prehistoric Southwest was a 12-row Chapolote variety. During late Basketmaker III-early Pueblo I times, a new race, Maiz de Ocho, was integrated into the Southwest (Galinat et al. 1970). This 8-row corn is believed to have been a more productive, easier-to-mill flour corn (a variety of corn with a soft endosperm) better adapted to higher elevations and cooler temperatures (Galinat and Gunnerson 1963; Galinat et al. 1970). The cross of Maiz de Ocho and Chapolote is thought to have resulted in a productive 10-row hybrid, often referred to as Pima/Papago (Cutler 1966; Doebly and Bohrer 1980), that could reproduce as a flint or flour corn. Although analytical methods were not sophisticated enough to determine races or varieties within the DAP collection, the above races can be used as analogs. The 8-row cobs from the project area are believed to be related to the Maiz de Ocho complex, since one of the distinguishing characteristics of this race is row number. It would, however, be overly simplistic to assign the other corn cob remains to a race or variety based only on row number similarities to Chapolote or Pima/Papago corn. The morphological differences in the DAP corn population indicate that 3 or more varieties are represented, but more positive identifications cannot be made based on the measurements taken.

Nonetheless, except for during Period 1, 12-row corn clearly is the dominant cob through all time periods in the Dolores River valley. The slight increase in 10-row cobs during Period 5 (table 4.10) is consistent with the evidence already presented that the greatest intensification in the project area may have occurred during Period 5. Excluding Period 1 (because of small sample size), the highest percentage of 8-row cobs occurs in Period 4, immediately preceeding Period 5, which has the highest percentage of 10-row cobs. A possible scenario is that a Maiz de Ocho type was popular in the project area during Period 4, and that with the agricultural intensification in Period 5, a cultural selection for the cross between the Maiz de Ocho type and the Chapolote type, resulted in the slightly greater proportion of 10-row cobs for this period.

Although agricultural production during Period 5 may have been limited to low-risk areas (Orcutt 1985a), the 10-row variety may have been preferred over the 12-row variety because of potential higher yield. The overall predominance of the 12-row corn may be attributed to the fact that flint kernels would store better than flour kernels. As Whiting (1939:11) has pointed out, flint corn is advantageous to grow when it is desirable to store an extra year's supply, because flint corn is not as easily attacked by corn weevils.

Although measurements were not taken for kernels, they were taken for cupule or glume widths on some of the cob fragments (table 4.10). Glume widths were measured if it was not possible to adequately measure the cupule. Cupule and glume width measurements represent the average for a cob specimen. Approximately 5 cupules or glumes per cob were measured. The measurement was taken at the middle of the cob or at the widest section of the cob for the average. Cupule and glume widths are related to the size of the kernel: large cupule (glume) size is equivalent to large kernel size. Kernel size can be affected by environmental or genetic factors. Genetically, factors such as row number will affect kernel size. Environmentally, factors such as water stress, abnormally cool growing season, and short growing season will prove detrimental to kernel size.

In table 4.10, the clearest trend is the increase in mean cob diameter from 14.0 mm in Period 1 to 16.4 mm in Period 6. Also, a general trend of increasing mean glume width from early periods through late periods is present. As cob diameter increases through time, so does glume width (and therefore kernel size). Bye (1978:17) suggests an inverse relationship between cupule size and row number. Cobs with low row counts will have larger kernels, implying larger cupule widths. In table 4.10, the highest mean cupule width occurs during Period 5, when the lowest mean row number

(except for Period 1) and the largest frequency of 10-row cobs occurs, reinforcing the argument that there was a real increase in cultural selection for the 10-row variety of cobs during that period.

Summary. – In summary, there is a general trend for corn cob diameters and glume widths to increase in size through time. Also, an increase in the range in the number of rows seems to occur. Period 1 has a range of 8 to 12 rows, and Period 6 has a range of 8 to 18 rows. On the other hand, 12-row corn almost always dominates, and the mean row number averages slightly less than 12, with the most pronounced departures occurring during Periods 1 and 5. The departure in Period 1 can be attributed to small sample size, whereas the departure in Period 5 seems to be due to a greater occurrence of 10-row cobs. Cupule width is inversely related to row number, and as expected, the mean cupule width in Period 5 is the highest of all periods. Possibly, cultural selection associated with greater agricultural intensification is manifested during Period 5 in both the kind and amount of corn remains. The relative amount of corn remains recovered from Period 5 contexts seems to outstrip the other periods, providing the strongest suggestion that agricultural intensification was being practiced.

Pioneer Plants

Change in the occurrence of pioneer plant remains in the assemblage may be a better index of agricultural intensification than change in the occurrence of some cultivated plants. Given the ecological behavior of pioneers, their presence in the macrobotanical assemblage is assumed to be primarily a function of agricultural activities. Amplification of environmental disturbance through agricultural intensification should result in increased diversity and abundance of pioneer plants. That is, by expanding the area under cultivation, a larger area would have been opened for pioneer plant colonization. Studies of pioneer colonization strategies have indicated the size of open area increases the diversity of taxa, the density of the standing population, and frequently the size of the individual plants (Davis and Cantlon 1969).

The occurrence or change in the pattern of occurrence of pioneers would not just be the result of increased disturbance. Increased representation of pioneer plant resources could result from greater procurement and utilization of pioneer resources as a least cost strategy of agricultural intensification. The contribution of pioneers to the subsistence base would depend to some degree on their value to the agriculturalist. As Ford (1968:191) points out in his study of San Juan Pueblo (New Mexico), pioneer plants considered useful in the subsistence system are left in the fields by the San Juan farmers, but pioneers not of value are weeded out. Even the pioneers left in the fields have to be monitored because of the intercrop competition between pioneers and domesticated plants for growth resources (Bye 1981). Therefore, pioneers left in a field and harvested can be considered to have been encouraged pioneer crops. Pioneer plants that were encouraged would increase in density under the influence of agricultural intensification. The productivity from these resources would increase the edible biomass of a cultivated area, increase the predictability of yield, and also improve the nutritional basis of the population (Ford 1984:137). Agricultural intensification is expected to result in higher diversity and abundance of pioneer plant remains in the DAP assemblage. Furthermore, as a part of an intensification strategy, select genera of pioneer plants would become more important within the subsistence system and would be intentionally intercropped with domesticates. These pioneers would be characterized as high yielding, multifunctional (i.e., producing edible greens and seeds), nutritional, culturally preferred, stress tolerant, and requiring low-energy maintenance. This is not to suggest that the Dolores Anasazi were domesticating select genera of pioneers, but that some form of conscious manipulation of some genera may have taken place to ensure crop production.

Since the disseminules of pioneer plants are so small, averaging 1 mm or less, they usually are recovered only from flotation samples, or in rare cases, from water-screened vegetal samples. Table 4.11 illustrates the diversity of pioneer taxa from flotation samples; low frequency taxa (one occurrence in a period) are included in the third column of the table, but are omitted from the last column. Generally, an increase in diversity occurs during periods of expected intensification, and diversity drops during periods when intensification is not predicted to be a necessary strategy. However, as pointed out by Leonard (1985) and others (cf. Grayson 1984), diversity indices need to be tested for sample size bias, since larger sample size will increase the probability of encountering taxa that occur in low frequencies. Such testing has not been undertaken for this study; therefore, the diversity noted may reflect only relative sample size and not temporal variation.

The abundance values for pioneers does not necessarily follow the expectation of increased quantity during the predicted periods of intensification. The values for pioneers as a group (table 4.12) or the values by individual taxa do increase in Period 5, but the same is not true for Period 4. The Period 4 value not only is substantially lower than the Period 5 value, but is less than 1/2 the values for Periods 2 and 3 and is slightly lower than the value for Period 6. In some cases, the discrepancy in abundance values between periods is the result of single samples containing large quantities of

Table 4.11 – Diversity of pioneer plant taxa from flotation samples, by modeling period*

Period and date range (A.D.)	No. of flotation samples	No. of pioneer plant taxa	Adjusted No. of pioneer plant taxa†
1 (600-720)	48	15	10
2 (720-800)	146	19	16
3 (800-840)	544	18	17
4 (840-880)	202	20	19
5 (880-920)	450	19	17
6 (920-980)	61	16	12
7 (980-1250)	47	15	13

* The following have been excluded from this table: fragments, uncharred remains, and materials from upper and lower control samples.
† Taxa represented by 1 item in a period are deleted; taxa represented by 2 or more items are included.

Table 4.12 – Abundance of pioneer plants, by modeling period*

Period and date range (A.D.)	Abundance	Adjusted abundance†
1 (600-720)	93	93
2 (720-800)	1386	386
3 (800-840)	1215	850
4 (840-880)	582	582
5 (880-920)	8217	1717
6 (920-980)	744	744
7 (980-1250)	243	243

* Includes flotation sample and vegetal remains. Charred, reproductive parts only are included; materials from upper and lower control samples are omitted.
† Selected concentrations of remains deleted where it was judged that such concentrations strongly biased the sample.

seeds (Periods 2 and 5) or unusual sampling situations (Period 3; cf. Matthews 1984b). Even when these cases are excluded from consideration, the abundance value for Period 4 is still lower than that for Periods 3, 5, and 6 (table 4.12).

Abundance values can be skewed by numerous factors (some of which were mentioned in the preceeding discussion of corn remains), and although abundance can be used as 1 indicator of importance or change, ubiquity indices are believed a more accurate means of assessing change in an assemblage (Gasser 1982; Hubbard 1980; Minnis 1981a). A ubiquity index is a measure of the frequency with which a subject of interest occurs within a set population or unit of measure. For the purpose of assessing relative change through time in pioneer resources as a group, an index was established using fire-related features as the sampled population. Fire-related features include hearths, ash pits, warming pits, and pits that show evidence of burning but are not considered to be hearths. This feature category was selected because the features included are assumed to have been associated with food preparation and consequently are likely locations for debris from preparation activities. Change in mix composition could therefore be detected in this type of feature. Using fire-related features may be considered restrictive, but these features actually provide the best-controlled, highest-quality proveniences sampled. Fire-related features were consistently sampled, if disturbance was minimal, and hearth fills usually were composed of primary, secondary, de facto, or some combination of mixed cultural debris.

Table 4.13 gives the ubiquity index for pioneer plants in fire-related features. This index indicates that, as a

Table 4.13 – Ubiquity of pioneer plant taxa in selected fire-related features, by modeling period*

Period and date range (A.D.)	N	T	U (%)
1 (600-720)	7	20	35.0
2 (720-800)	29	51	56.9
3 (800-840)	28	47	59.6
4 (840-880)	46	62	74.2
5 (880-920)	98	131	74.8
6 (920-980)	16	27	59.3
7 (980-1250)	12	31	38.7

* The feature types included in this table are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. All macrobotanical materials (flotation sample and vegetal remains) are included except for uncharred remains and materials from upper and lower control samples. Macrobotanical materials are considered whether or not they are interpreted to be related to the use of the feature.

N – Number of fire-related features with charred pioneer plant remains.

T – Number of fire-related features that yielded macrobotanical materials that were analyzed and were assigned to the specific period.

U – Ubiquity index, or N/T, expressed as a percent.

group, pioneer resources increase in frequency among this group of features through Period 5. If the assumption concerning the functions of these features is valid, then table 4.13 may be interpreted as indicating increased relative importance of this category of resources during Periods 4 and 5. The general trend toward increased representation of pioneer plants during these 2 periods was first documented by analyses of the macrobotanical assemblages from McPhee Village and Grass Mesa Village (Site 5MT23) (Matthews 1985c, 1985d). The repetition of this trend using project-wide data is believed to further support the interpretation that agricultural intensification occurred during Periods 4 and 5.

The macrobotanical assemblages from McPhee Village and Grass Mesa Village were used to test the hypothesis that, if agricultural intensification took place during portions of the Anasazi sequence, certain pioneer plant genera would have become more important in the subsistence economy during those times. Several points of these studies will be used in the following discussion.

The hypothesis was tested using abundance values, ubiquity of each pioneer taxon in flotation samples and the ubiquity of the same in fire-related features (tables 4.14 through 4.18). Based on these analyses, the data suggest that 7 pioneer taxa were preferred pioneer resources. These pioneer taxa are *Amaranthus, Chenopodium,* cheno-am, Cruciferae, *Descurainia, Physalis, and Portulaca.* The inclusion of cheno-am and Cruciferae may seem inappropriate, because neither was identified to genus and both taxa consist of more than 1 genus. These 2 taxa were included because indicating the relative importance of particular plants within the subsistence system was believed to be of value to the study, even if these plants could be identified on only a gross level.

Since abundance values can be affected by samples size, and Periods 4 and 5 were represented by the greatest number of samples, a Spearman rank correlation coefficient was calculated to test abundance of each taxon against sample size. The results of the test indicate that the variability in abundance of pioneer plants between and within periods was not necessarily the result of sample size (Matthews 1985b:appendix A). Although the 2 ubiquity indices do show these 7 taxa are significant over all time periods (tables 4.16 and 4.18), some variability in taxon representation exists within each period. Some of the variability in representation is undoubtedly due to factors inherent in the archaeological record, such as differential preservation or sampling bias. Nonetheless, the variability is also believed to indicate some change in agricultural practices. That is, in Period 6, *Amaranthus* and *Descurainia* appear to decrease in importance, which may imply reduction in an intensification strategy. The evidence for continued importance of *Chenopodium, Portulaca,* and *Physalis* may mean that even though intensification was not an expected strategy in Period 6, elements of the intensification system were maintained, such as continued encouragement of some pioneer taxa. *Chenopodium* was the most abundant and ubiquitous pioneer taxon represented within each period and through all periods.

Two problems with this study may have influenced interpretations. First, the presence or absence of charred seeds or fruits was used as the means of establishing economic importance. If a plant was predominantly used for its greens, little evidence of it would be in the macrobotanical assemblage, and interpretation of its importance would be negatively biased. This may be the case with *Cleome serrulata*, ubiquitous in the pollen record (sect. 3), but minimally represented in the macrobotanical data base for this study. Second, the use of abundance values and ubiquity indices to estimate economic importance may not be a strong enough test. Nonetheless, supporting evidence for the importance of the 7 taxa was found in other archaeological investigations, in ethnographic documentation, and in the literature concerning the nutritional value and seasonal availability of these taxa (cf. Adams 1980;

Table 4.14 – Abundance of pioneer plant taxa for selected sites, by modeling period*

Taxon	Periods 2-3 A.D. 720-840	Period 4 A.D. 840-880	Period 5 A.D. 880-920	Period 6 A.D. 920-980	Total
Amaranthus	14	24	1107	4	1 149
Cheno-am	33	18	1233	49	1 333
Chenopodium	56	57	2923	357	3 393
Cleome serrulata			20		20
Compositae		3	77		80
Cruciferae		44	882	40	966
Descurainia	19	43	442	8	512
Gramineae	2	3	267	37	309
Helianthus	21	1	80	1	103
Malvaceae	2	1	3		6
Mentzelia albicaulis	1	17	70	1	89
Nicotiana attenuata	3	4	20	1	28
Physalis	20	33	475	20	548
Polygonum/Polygonaceae		2	1019	1	1 022
Portulaca	26	25	305	327	683
Solanaceae	1	4	11	2	18
Solanum		5	10	3	18
Sphaeralcea				1	1
Total	198	284	8944	852	10 278

* Only materials (flotation sample and vegetal remains) from Grass Mesa Village and McPhee Village are included in this table. Periods 1 and 7 are not listed because no contexts from these sites were assigned to Periods 1 or 7. Periods 2 and 3 were combined to provide a large enough sample size. Charred, reproductive parts only are included in this table; materials from upper and lower control samples are excluded.

Harrington 1967; Kearney and Peebles 1960; Niethammer 1974; Schopmeyer 1974; and Leung 1961). Therefore, based on this study (with the understanding of its limitations), the data indicate that the importance and procurement of particular pioneer resources changed through time. Although adequately presenting all of the substantive information in this section is not possible, a strategy of agricultural intensification is believed responsible for altering pioneer plant procurement strategies and the economic status of some pioneer taxa.

Wild Plants

Since the Dolores Anasazi are considered to have been subsistence agriculturalists, it is assumed that wild plants did not constitute a significant proportion of the total edible resource base. Ethnographic documentation of wild plant resources, except pinyon nuts, in the subsistence economies of many Southwestern Indian groups tends to substantiate this assumption (Elmore 1944; Ford 1968; Stevenson 1915; Whiting 1939; Winter 1975). In a study of the subsistence agriculturalists of San Juan Pueblo, Ford (1968:176) pointed out that 2 factors affected wild plant procurement. First, wild resources were collected only at times that did not conflict with energy expenditure or scheduling for cultivated resources. Second, many wild resources either did not occur in sufficient quantities to provision many people, or large stands of a resource occurred sporadically and usually at energy-consuming distances from the central village. Except for high-yield resources, such as pinyon nuts, a review of the literature (Elmore 1944; Ford 1968; Stevenson 1915; Whiting 1939) indicates that wild plant food gathering by agriculturalists is a small-scale, often opportunistic, procurement strategy.

According to Christenson (1980), agricultural intensification entails reduced time and labor expenditures for wild plant resources. If this is correct, a decrease in the diversity and abundance of wild plants should be represented in the macrobotanical record during Period 4 and possibly during Period 5. However, Orcutt (1984b, 1985a, 1985c) and Minnis (1981b) have proposed that climatic stress will precipitate intensification in production and collection of storable foodstuffs, using storage as a buffer. A logical corrollary to this hypothesis

Table 4.15 – Ubiquity of pioneer plant taxa in selected flotation samples, by modeling period*

Taxon	Periods 2-3 (T = 58)		Period 4 (T = 82)		Period 5 (T = 374)		Period 6 (T = 49)		Total (T = 563)	
	N	U (%)	N	U (%)	N	U (%)	N	U (%)	N	U (%)
Amaranthus	5	8.6	12	14.6	47	12.6	2	4.1	66	11.7
Chenopodium	17	29.3	25	30.5	109	29.1	20	40.8	171	30.4
Cheno-am	10	17.2	11	13.4	55	14.7	13	26.5	89	15.8
Cleome serrulata										
Compositae			3	3.7	19	5.1			22	3.9
Cruciferae			8	9.8	27	7.2	6	12.2	41	7.3
Descurainia	7	12.1	10	12.2	35	9.4	5	10.2	57	10.1
Gramineae	2	3.4	3	3.7	21	5.6	10	20.4	36	6.4
Helianthus	2	3.4	1	1.2	12	3.2	1	2.0	16	2.8
Malvaceae	1	1.7	1	1.2	3	0.8			5	0.9
Mentzelia albicaulis	1	1.7	4	4.9	17	4.5	1	2.0	23	4.1
Nicotiana attenuata	3	5.2	1	1.2	14	3.7	1	2.0	19	3.4
Physalis	3	5.2	14	17.1	69	18.4	11	22.4	97	17.2
Polygonum/Polygonaceae			2	2.4	16	4.3	1	2.0	19	3.4
Portulaca	6	10.3	12	14.6	72	19.3	12	24.5	102	18.1
Solanaceae	1	1.7	4	4.9	10	2.7	2	4.1	17	3.0
Solanum			2	2.4	6	1.6	3	6.1	11	2.0
Sphaeralcea							1	2.0	1	0.2

* Only materials from Grass Mesa Village and McPhee Village are included in this table. Periods 1 and 7 are not listed because no contexts from these sites were assigned to Periods 1 or 7. Periods 2 and 3 were combined to provide a large enough sample size. Periods 2-3: A.D. 720-840; Period 4: A.D. 840-880; Period 5: A.D.880-920; Period 6: A.D. 920-980. Charred, reproductive parts only are included in this table; materials from upper and lower control samples are excluded.

N – Number of analyzed flotation samples with charred, reproductive pioneer plant part remains.

T – Number of flotation samples (excluding upper and lower control samples) that yielded macrobotanical materials that were analyzed.

U – Ubiquity index, or N/T, expressed as a percent.

is that during Period 5, wild plant procurement may increase in the attempt to increase stored resources. This response should be reflected in the macrobotanical assemblage. Furthermore, diversity of wild plants may be expected to increase in Period 5 in response to increased mobility. Climatic stress late in Period 5, which frequently was characterized by a shortened frost-free period, would have affected the project area in general, but would have had the greatest impact on areas subject to the effects of localized cold air drainage; the main impact would have been a reduction in the amount of arable land available (Petersen and Clay 1984). This reduction in the amount of arable land would have required farmers to move away from the central village during the growing season and return after harvest. Seasonal mobility, combined with decreased population in Period 5, would have increased catchment area and thus the available resources (chap. 6).

For the purpose of this investigation, only those plants believed to have possibly been used as food resources and represented by charred reproductive parts in the macrobotanical assemblage will be considered (table 4.19). This includes taxa listed under both the wild and woody categories in table 4.6, with the exception of *Artemisia*. Although *Artemisia* fruits were recovered, this genus is excluded because it is believed that the fruits more often than not are incidentally incorporated into a sampled context through the use of *Artemisia* vegetative parts for closing material (construction) or fuel (Matthews 1984b). Limiting this discussion to taxa represented by reproductive parts is restrictive and potentially biasing. The rationale for this restriction is that food resources and the effect of intensification on procurement of these resources is of interest here. Excluding plants possibly procured for utilitarian items (e.g., *Phragmites*) serves to reduce the "background noise" in data presentation.

As demonstrated in table 4.19, diversity of wild plant resources (as judged by reproductive parts) increases through Period 5 and decreases in Period 6 and 7. A similar trend is observed for the abundance measure,

Table 4.16 – Pioneer plant taxa in selected flotation samples, grouped by ubiquity value for each modeling period*

Ubiquity group	Periods 2-3 (A.D. 720-840)	Period 4 (A.D. 840-880)	Period 5 (A.D. 880-920)	Period 6 (A.D. 920-980)	Periods 2-6
Group I ≤5 percent	Gramineae *Helianthus* Malvaceae *Mentzelia albicaulis* Solanaceae	Compositae Gramineae *Helianthus* Malvaceae *Mentzelia albicaulis* *Nicotiana attenuata* *Polygonum*/Polygonaceae Solanaceae *Solanum*	*Helianthus* Malvaceae *Mentzelia albicaulis* *Nicotiana attenuata* *Polygonum*/Polygonaceae Solanaceae *Solanum*	*Amaranthus* Compositae *Helianthus* *Mentzelia albicaulis* *Nicotiana attenuata* *Polygonum*/Polygonaceae Solanaceae *Sphaeralcea*	Compositae *Helianthus* Malvaceae *Mentzelia albicaulis* *Nicotiana attenuata* *Polygonum*/Polygonaceae Solanaceae *Solanum* *Sphaeralcea*
Group II >5 percent but <20 percent	*Amaranthus* Cheno-am *Descurainia* *Nicotiana attenuata* *Physalis* *Portulaca*	*Amaranthus* Cheno-am Cruciferae *Descurainia* *Physalis* *Portulaca*	*Amaranthus* Cheno-am Compositae Cruciferae *Descurainia* Graimineae *Physalis* *Portulaca*	Cruciferae *Descurainia* *Solanum*	*Amaranthus* Cheno-am Cruciferae *Descurainia* Gramineae *Physalis* *Portulaca*
Group III >20 percent	*Chenopodium*	*Chenopodium*	*Chenopodium*	Cheno-am *Chenopodium* Gramineae *Physalis* *Portulaca*	*Chenopodium*

* Only materials from Grass Mesa Village and McPhee Village are included in this table. Periods 1 and 7 are not listed because no contexts from these sites were assigned to Periods 1 or 7. Periods 2 and 3 were combined to provide a large enough sample size. Charred, reproductive parts only are included in this tablet materials from upper and lower control samples are excluded.

although the pattern is not as clearcut. The higher representation of wild plants in Period 5 may be partially the result of the greater number of structures and contexts investigated. Compensating for the overall larger sample size is difficult because, unlike pioneer plant remains, which usually are collected in flotation samples, wild plant remains are collected in a nonstandard, arbitrary manner, contingent on the suitability of specific contexts and on the discretion of the excavator. Therefore, it is difficult to determine whether increased quantities of remains are the result of cultural activity or of large sample size.

In an effort to compensate for variable sample size, a ubiquity index for wild plant resources in fire-related features was compiled, by modeling period (table 4.20). The indices show the same general trend as does the abundance and diversity listing: wild plant resources increase through Period 5, then decrease. However, the ubiquity values for Periods 4, 5, and 6 are roughly the same, ranging from 64.5 percent to 66.7 percent. The trend in the ubiquity index for wild plants mirrors, to some degree, that seen for pioneer plants (table 4.13). An exception is that the ubiquity of pioneers is slightly higher than that of wild plants through Period 5, but in Period 6, the ubiquity of wild plants is higher than that of pioneers.

According to the ubiquity index of wild plant resources, procurement of these resources appears to have increased during Period 4, contrary to the expected economic response for this period. The data support the idea that wild plant procurement increased in importance through Period 5 and remained relatively important during Period 6. Additional evidence for increased importance of wild resources in Period 5 is the presence at Grass Mesa Village of a large pit (Feature 458) that has been interpreted to have been a roasting pit for processing pinyon seeds, based on the large quantity of *Pinus edulis* seeds, bracts, and cone fragments recovered (Lightfoot et al. 1985). This feature, which dates to Period 5, is the only roasting pit of its type recorded in the project area.

In summary, the evidence for change in wild plant procurement is weak and unclear. The methods used to collect this type of botanical material complicate making accurate comparisons. Also, as with squash, processing techniques or the practice of consuming many wild plant products raw is expected to have affected

Table 4.17 – Ubiquity of pioneer plant taxa in selected fire-related features, by modeling period*

Taxon	Periods 2-3 (T = 15)		Period 4 (T = 31)		Period 5 (T = 112)		Period 6 (T = 16)		Total (T = 174)	
	N	U (%)	N	U (%)	N	U (%)	N	U (%)	N	U (%)
Amaranthus	2	13.3	9	29.0	22	19.6			33	19.0
Chenopodium	6	40.0	12	38.7	57	50.9	10	62.5	85	48.9
Cheno-am	5	33.3	7	22.6	34	30.4	5	31.3	51	29.3
Cleome serrulata					1	0.9			1	0.6
Compositae			1	3.2	7	6.3			8	4.6
Cruciferae			5	16.1	19	17.0	3	18.8	27	15.5
Descurainia	5	33.3	6	19.4	18	16.1			29	16.7
Gramineae	1	6.7	2	6.5	12	10.7	2	12.5	17	9.8
Helianthus	3	20.0	1	3.2	8	7.1	1	6.3	13	7.5
Malvaceae	1	6.7			1	0.9			2	1.1
Mentzelia albicaulis	1	6.7	3	9.7	14	12.5			18	10.3
Nicotiana attenuata	2	13.3			8	7.1	1	6.3	11	6.3
Physalis	1	6.7	9	29.0	28	25.0	2	12.5	40	23.0
Polygonum/Polygonaceae			1	3.2	11	9.8	1	6.3	13	7.5
Portulaca	2	13.3	7	22.6	38	33.9	5	31.3	52	29.9
Solanaceae	1	6.7	3	9.7	4	3.6	1	6.3	9	5.2
Solanum			2	6.5	5	4.5			7	4.0
Sphaeralcea							1	6.3	1	0.6

* Only materials from Grass Mesa Village and McPhee Village are included in this table.
Periods 1 and 7 are not listed because no contexts from these sites were assigned to Periods 1 or 7. Periods 2 and 3 were combined to provide a large enough sample size. Periods 2-3: A.D. 720-840; Period 4: A.D. 840-880; Period 5: A.D. 880-920; Period 6: A.D. 920-980.
The feature types included in this table are hearth, fireplace, ash pit, warming pit and pit (not further specified) with burning. All macrobotanical materials (flotation sample and vegetal remains) are included except for uncharred remains and materials from upper and lower control samples. Macrobotanical materials are considered whether or not they are interpreted to be related to the use of the feature.
N – Number of fire-related features with charred pioneer plant remains.
T – Number of fire-related features that yielded macrobotanical materials that were analyzed.
U – Ubiquity index, or N/T, expressed as a percent.

their representation in the archaeological record. The increase in wild plants during Period 5 may be the result of procurement being intensified. Greater diversity of these resources may also be the result of increased seasonal mobility during this period. While the abundance and diversity measures of these resources decrease during Periods 6 and 7, the Period 6 ubiquity index remains relatively high. This can be interpreted several ways. In both periods, population is low and settlements are scattered. The ubiquity of wild resources may indicate that a more diversified subsistence strategy is being practiced; that is, energies are being more evenly distributed among the different resource categories. The decrease in population may have resulted in larger potential catchment areas to exploit, and a decrease in agricultural intensification would allow more mobility for procurement. However, even if catchment areas remain the same, the lower population level would automatically increase the quantity of or evenness with which wild resources could be distributed among individuals. If this were the case, then opportunistic collecting alone may account for the distribution of wild plant resources in the macrobotanical assemblage.

Wood Resources

Probably more than any other category of macrobotanical material, wood has suffered the most from collection bias and the lack of research questions directing collection techniques. This factor has created problems in using the wood resource data base, although reference to the DAP dendrochronological data file compensates to some extent for some of the gaps in the macrobotanical data.

Diversity. – Twenty-four genera of woody plants could be positively identified in the macrobotanical assemblage (table 4.6). Many of these genera are represented by several plant parts, such as wood, fruits, seeds, bark, needles, and scales. The variety of plant parts indicates

Table 4.18 – Pioneer plant taxa in selected fire-related features, grouped by ubiquity value for each modeling period*

Ubiquity group	Periods 2-3 (A.D. 720-840)	Period 4 (A.D. 840-880)	Period 5 (A.D. 880-920)	Period 6 (A.D. 920-980)	Periods 2-6
Group I ≤5 percent		Compositae *Helianthus*	*Cleome serrulata* Malvaceae Solanaceae *Solanum*		*Cleome serrulata* Compositae Malvaceae Solanaceae *Solanum* *Sphaeralcea*
Group II >5 percent but ≤10 percent	Gramineae Malvaceae *Mentzelia albicaulis* *Physalis* Solanaceae	Gramineae *Mentzelia albicaulis* *Polygonum/* Polygonaceae Solanaceae *Solanum*	Compositae *Helianthus* *Nicotiana attentuata* *Polygonum*/Polygonaceae	*Helianthus* *Nicotiana attentuata* *Polygonum*/Polygonaceae *Sphaeralcea*	Gramineae *Helianthus* *Mentzelia albicaulis* *Nicotiana attentuata* *Polygonum*/Polygonaceae
Group III >10 percent but ≤20 percent	*Amaranthus* *Helianthus* *Nicotiana attentuata* *Portulaca*	Cruciferae *Descurainia*	*Amaranthus* Cruciferae *Descurainia* Gramineae *Mentzelia albicaulis*	Cruciferae Gramineae *Physalis* Solanaceae	*Amaranthus* Cruciferae *Descurainia*
Group IV >20 percent	Cheno-am *Chenopodium* *Descurainia*	*Amaranthus* Cheno-am *Chenopodium* *Physalis* *Portulaca*	Cheno-am *Chenopodium* *Physalis* *Portulaca*	Cheno-am *Chenopodium* *Portulaca*	Cheno-am *Chenopodium* *Physalis* *Portulaca*

* Only materials from Grass Mesa Village and McPhee Village are included in this table. Periods 1 and 7 are not listed because no contexts from these sites were assigned to Periods 1 or 7. Periods 2 and 3 were combined to provide a large enough sample size. Periods 2-3: A.D. 720-840 Period 4: A.D. 840-880 Period 5: A.D. 880-920 Period 6: A.D. 920-980.
The feature types included in this table are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. All macrobotanical materials (flotation and vegetal remains) are included except for uncharred remains and materials from upper and lower control samples. Macrobotanical materials are considered whether or not they are interpreted to be related to the use of the feature.

the functional multiplicity of wood resources. The consistency with which individual taxa occur over time may denote which were preferred resources, although variable destruction through charring (Zalucha 1977), differential preservation, and sporadic indentification of hard-to-distinquish genera may have affected accurate representation of resources. A core group of taxa is well represented in most periods by wood remains. This group includes *Artemisia, Cercocarpus montanus, Juniperus, Pinus, Populus, Quercus gambelii,* and *Salix.* As with other categories of macrobotanical remains, diversity of woody taxa is greatest during Periods 4 and 5 (table 4.6). This increased diversity may in part be the result of increased demand for fuel, construction materials, and utilitarian implements, although the increase in sample size for these two periods would have influenced diversity as well.

Change in wood resource use through time.[3] – Wood remains in the macrobotanical assemblage should change through time as the result of increased building and clearing activities. Agricultural intensification would require that more land be cleared for crop production (cf. Turner and Doolittle 1978). Given the shrubby/woody vegetation cover of much of the project area, expansion of cleared areas would affect the occurrence and distribution of some wood resources. The greatest impact on wood resources is expected to have resulted from the increase in population and concurrent increase in construction of habitations beginning during Period 3 (A.D. 800-840) and peaking during Period 4 (A.D. 840-880).

Natural vegetation distribution maps for the project area (Petersen 1984a) and vegetation reconstructions for the different time periods based on plant macrofossil and pollen evidence (Petersen 1985a, 1985b; and figs. 4.15 and 4.17, this chap.) are used to assess the potential availability of various wood types during the Anasazi occupation. A mosaic of sagebrush-juniper-pinyon-oak is believed to have characterized most of the uplands within the project area throughout the Anasazi occupation, although the relative importance of

[3]This study of wood resource depletion was compiled and reported by Kenneth Lee Petersen, DAP.

Table 4.19 – Selected wild plant taxa represented by charred reproductive parts, by modeling period*

Taxon	Period 1 (A.D. 600-720)	Period 2 (A.D. 720-800)	Period 3 (A.D. 800-840)	Period 4 (A.D. 840-880)	Period 5 (A.D. 880-920)	Period 6 (A.D. 920-980)	Period 7 (A.D. 980-1250)
Allium sp.					x		
Amelanchier sp.				3	24x		
Cordylanthus sp.		1					
Cyperaceae	1	2	10	10	†1037	3	6
Iva sp.			2	2	1	2	
Juniperus sp.	1	1x	1	2x	6x		
J. osteosperma	1	6x	1	27x	45	1	
J. scopulorum					1		
Leguminosae	26x	3	5	2x	5	2	
Opuntia sp.		2	1	2	24	1	
Penstemon sp.			2	1	1		
Pinus edulis	33x	5x	4x	20x	100x	2x	6
Quercus gambelii				1	4x	1	
Rhus aromatica		120	1	5	40x	1	2
Rosaceae			1	1	11	7	1
Rubus sp.				2	1	2	
Rumex sp.					1		
Scirpus sp.			1		1		
Scutellaria sp.					26x		
Yucca sp.		5		20x	10x	1	4x
Y. baccata	10x	10x	x	9x	x	3	1
Total	72x	155x	29x	107x	1338x	26x	20x
Diversity	6	10	12	15	20	12	6

* Included in this table are wild and woody taxa represented by counted charred reproductive parts and believed to have possibly served as food resources. Excluded are the following: taxa judged to have served as nonfood resources, nonreproductive parts, uncharred remains, nonindigenous taxa, materials from upper and lower control samples, and occurrences of species as part of worked vegetal items.

† 1000 achenes were recovered from one water-screened hearth.

these 4 major cover plants may have changed at different times. In addition to these 4 vegetation types, cottonwood (*Populus*) and willow (*Salix* sp.) would have been located in the canyon bottom, and ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) would have been found on the canyon slopes.

In studies of wood resource use at Grass Mesa Village (Site 5MT23), Kohler et al. (1984) and Kohler and Matthews (1984) present evidence of the possibility of wood resource depletion in the Grass Mesa area. In contexts dating from about A.D. 775 to 800, juniper (*Juniperus*) is the only construction wood represented; from A.D. 800 to 850, other wood appears as construction material, including ponderosa pine and Douglas-fir (Kohler et al. 1984). During the peak of occupation, in the last half of the ninth century, cottonwood and pinyon (*Pinus edulis*) first appear as building materials, and the use of juniper continues to decrease. Finally, during the last years of occupation at the site (the site was abandoned shortly after A.D. 900), cottonwood remains an important source of construction material and Douglas-fir increases in relative importance, while juniper remains at about the same level as during the previous period. Kohler et al. (1984) note that the most apparent trends are an increase in the use of cottonwood, Douglas-fir, ponderosa pine, and pinyon pine, and a decrease in the use of juniper during the occupation of the site. They attribute these changes to wood resource depletion in the immediate vicinity of Grass Mesa.

The present study uses a larger data base in an effort to detect similar trends that might be manifested over a longer period of time. All postholes that contained identified wood at DAP sites were examined. To avoid inclusion of wood that might have washed into a posthole after abandonment, only wood specimens that weighed more than 1g and that were recovered from fill interpreted to be related to the original use of a specific posthole were selected for this study. The selected group was subdivided by age assignment and by wood taxon represented, which allowed examination of the kind of construction wood used during various time periods. To ascertain the possible influence that site location may have had on the kind of wood used, the archaeological sites were separated on the basis of their proximity to specific vegetation types (table 4.21). Sites in or within about 1 km of the Dolores River canyon were separated from all other archaeological sites because of the greater availability of ponderosa pine,

Table 4.20 – Ubiquity of wild plant taxa in selected fire-related features, by modeling period*

Period and date range (A.D.)		N	T	U (%
1	(600-720)	5	20	25.0
2	(720-800)	26	51	51.0
3	(800-840)	21	47	44.7
4	(840-880)	40	62	64.5
5	(880-920)	89	131	67.9
6	(920-980)	18	27	66.7
7	(980-1250)	11	31	35.5

* The feature types included in this table are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. Table includes all macrobotanical materials (flotation sample and vegetal remains). Only charred reproductive parts considered; materials from upper and lower control samples excluded. Macrobotanical materials are considered whether or not they are interpreted to be related to the use of the feature.

N – Number of fire-related features with charred wild plant remains (reproductive parts).

T – Number of fire-related features that yielded macrobotanical materials that were analyzed.

U – Ubiquity index, or N/T, expressed as a percent.

Douglas-fir, and riparian trees in the vicinity of canyons. These sites are designated sites "in or near canyon" in table 4.21, while all other sites are designated as sites "in uplands."

Table 4.22 presents the posthole data by site location and modeling period. The occurrence of each taxon is expressed as a proportion of the number of postholes in which the taxon was identified during each period. This gives a measure of relative ubiquity of each taxon's occurrence in sites in the uplands and sites in or near the canyon. Also calculated is the total proportion of each taxon for both upland and canyon sites for the periods represented, and finally, the combined total proportions.

The data presented in table 4.22 indicate site location does make a difference in the taxa used. The canyon locations for Periods 2 through 6 have a greater percentage of *Pinus ponderosa* and *Populus* indentified from postholes than do upland sites for Periods 1 through 5. The 95 percent confidence intervals for identified ponderosa pine wood in the upland and canyon sites do not overlap. A chi-square test shows that the difference is significant at the 0.01 level. Although no *Populus* was identified in the upland site sample, and 10 *Populus* pieces were identified in the canyon site sample, the difference is not judged to be significant because of the overlap of the 95 percent confidence intervals.

Table 4.21 – Sites with postholes containing identified wood

Location	Site No.
In uplands	5MT2191
	5MT2193
	5MT2198
	5MT2226
	5MT2320
	5MT2378
	5MT2848
	5MT2854
	5MT4545
	5MT4644
In or near canyon (within 1 km of Dolores River canyon)	5MT23
	5MT2151
	5MT2161
	5MT2182
	5MT2336
	5MT4475*
	5MT4477*
	5MT4479*
	5MT4480*
	5MT4650
	5MT4671
	5MT4683
	5MT5106*
	5MT5108*
	5MT5863

* McPhee Village sites are included here because of their proximity to the Dolores River.

Unexpectedly, only 2 pieces of *Pinus edulis* wood (4.2 percent) were identified in the postholes at upland sites, while 6.4 percent of the postholes at canyon sites had identified pinyon (11 pieces). This could be an artifact of preservation or identification, because 43.8 percent of the postholes in upland sites are identified to *Pinus*. Judging from the greater occurrence of ponderosa pine in the postholes in canyon sites, the likelihood that the *Pinus* in the upland site postholes is actually *Pinus edulis* is enhanced.

Upland sites show no discernible trend suggestive of wood resource depletion through time. This may be due in part to the small sample size for each time period as well as to the smaller number of taxa available for exploitation.

At canyon sites, on the other hand, *Populus* makes a sudden appearance in Period 5. Both the direction and

Table 4.22 – Ubiquity of selected woody taxa in postholes containing identified wood, by modeling period*

Taxon	Sites in uplands												Sites in or near canyon												Total	
	Period 1 (T=8)		Period 2 (T=18)		Period 3 (T=11)		Period 4 (T=10)		Period 5 (T=1)		Periods 1-5 (T=48)		Period 2 (T=5)		Period 3 (T=25)		Period 4 (T=35)		Period 5 (T=100)		Period 6 (T=6)		Periods 2-6 (T=171)		Periods 1-6 (T=219)	
	N	U(%)	N	U(%)	N	U(%)	N	U(%)	N	U(%)	N	U(%)	N	U%	N	U(%)	N	U(%)	N	U(%)	N	U(%)	N	U(%)	N	U(%)
Gymnospermae			3	16.7	1	9.1	5	50.0	1	100.0	10	20.8			9	36.0	9	25.7	8	8.0	3	50.0	29	17.0	39	17.8
Juniperus	3	37.5	12	66.7	3	27.3					18	37.5	2	40.0	15	60.0	11	31.4	39	39.0	1	16.7	68	39.8	86	39.3
Pinus	5	62.5	5	27.8	6	54.6	5	50.0			21	43.8			8	32.0	8	22.9	16	16.0			32	18.7	53	24.2
Pinus edulis							2	20.0			†2	4.2	2	40.0	1	4.0			8	8.0			†11	6.4	13	5.9
Pinus ponderosa					1	9.1					§1	2.1			1	4.0	10	28.6	23	23.0	2	33.3	§36	21.1	37	16.9
Populus											**						††		††10	10.0			**10	5.9	10	4.6
Pseudotsuga menziesii													1	20.0			1	2.9					2	1.2	2	0.9

* Listed in this table are wood remains that weighed more than 1 g and that were recovered from fill interpreted to have been associated with the original use of the post-hole; charred and uncharred remains included. Period 6 and 7 excluded from uplands category, and Period 7 excluded from canyons category, due to small sample sizes. Period 1: A.D. 600-720; Period 2: A.D. 720-800; Period 3: A.D. 800-840; Period 4: A.D. 840-880; Period 5: A.D. 880-920; and Period 6: A.D. 920-980.

† The 95 percent confidence intervals (Snedecor and Cochran 1967:table 1.4.1) for identified *Pinus edulis* wood for upland versus canyon sites overlap (0-14 versus 6-18).

§ The 95 percent confidence intervals for identified *Pinus ponderosa* wood for upland versus canyon sites do not overlap (0-11 versus 28-44). A 2×2 chi-square test adjusted to allow for continuity for small cell values (a cell with contents less than 5; Blalock 1979:285-287) shows that the adjusted chi-square value is significant at the 0.01 level $\chi^2=8.676$; probability $>\chi^2<0.0032$).

** The 95 percent confidence intervals for identified *Populus* wood for upland versus canyon sites overlap (0-7 versus 6-16).

†† The 95 percent confidence intervals for identified *Populus* wood for Period 4 versus Period 5 canyon sites overlap (0-11 versus 4-16).

The sum of the taxa per modeling period may be larger than the T value because more than one taxon may have been identified from a single posthole.

N – Number of postholes with specific taxon of wood.

T – Number of postholes with identified wood that weighed more than 1 g and that was recovered from fill associated with the original use of the posthole.

U – Ubiquity index, or N/T, expressed as a percent.

magnitude of change through time can be taken as reinforcing the suggestion by Kohler et al. (1984) that wood resource depletion was occurring and that the Anasazi were having to increase use of the less desirable *Populus* wood for construction. However, the 95 percent confidence intervals for Period 4 and Period 5 overlaps, which indicates that the difference is not significant at the 0.05 level.

The slight increase between Periods 3 and 4 in the use of ponderosa pine in canyon sites and the slight decrease in the importance of juniper between Periods 3 and 4 are reminiscent of trends discussed by Kohler et al. (1984), but the differences are not significant at the 0.05 level. No *Pseudotsuga menziesii* was recovered from upland sites. However, only 2 postholes from canyon sites contained any. In short, the pattern detected by Kohler et al. (1984) for wood resource utilization for Grass Mesa seems also to be reflected in general by the larger subset of canyon sites.

Summary

Change in Anasazi botanical resource use in the Dolores area has been discussed in this section using a model of agricultural intensification presented by Orcutt (1984b, 1985c). Corn and plant pioneer resources appear to be the best indicators of change in resource use in the DAP macrobotanical assemblage. However, additional research on wild plants and on woody resources, both of which are believed to have the potential for illustrating change in procurement patterns and resource use strategies, is required.

In this summary of the DAP macrobotanical data, various expectations have been investigated using the entire data base, which in many ways has had a homogenizing effect on the data. The Dolores area is characterized by microclimatic variations that possibly would have required different responses in different portions of the project area. Localized variation in response, which has been detected in other data bases (chaps. 12 and 13), has been lost by not segregating the macrobotanical assemblage by project subareas; differences in the level of botanical retrieval from different areas prohibited such a detailed examination.

The evidence for intensification is strongest for Period 5, although the indications of intensification begin in Period 4, or possibly at the end of Period 3. The stronger evidence for intensification in Period 5 may be the result of the large data base accumulated for this period, although sample size is not the only factor. Intensification and its effect on the different macrobotanical categories may be strongest in Period 5 for several reasons. First, the population level, although lower than during Period 4, was still higher than during the time periods previous to Period 4 (chap. 8), which implies a continued high impact on the environment. Second, climatic stress during Period 5 may have initiated a response of increased storage, as suggested by Orcutt (1985a, 1985c) and Minnis (1981b). Although there is not an increase in the number of storage units built during this period (chap. 13), the number of potential storage units remaining from Period 4 would provide a large storage capacity for the Period 5 occupants. Third, large village structure continues during Period 5, with some adjustments in village composition (Kohler 1985). Although no substantiating evidence is present, it is assumed that sustaining large villages in the face of increasing production stress would require intensification or at least maintenance of production levels from Period 4. This would include diversification of procurement strategies as well as intensification of crop and pioneer plant production. Fourth, the archaeological record may lag behind the actual cultural events (cf. Cordell 1982), and some phenomena that appear to be associated with Period 5 may have their origins in, or be related to, Period 4; thus, Periods 4 and 5 should be considered together when evaluating changing resource use through time.

SECTION SUMMARY

The prehistoric botanical resource base used by the Dolores Anasazi has been presented in this section. Two problem domains of the DAP general research design – Economy and Adaptation, and Cultural Process – were addressed using the macrobotanical data base, which is considered adequate for such study despite some comparability problems related to differences in sample size and collection technique. Based on the modern vegetation reconnaissance, the range of available botanical resources was outlined. Evidence for the botanical resources actually used came from macrobotanical remains recovered from excavated sites. The macrobotanical assemblage is not considered a complete record of the resources used because not all exploited plants would have been preserved, and therefore represented, in the archaeological record, nor would preserved remains necessarily have been recovered during excavation. However, if the macrobotanical assemblage is considered representative of the resource mix, then, of edible resources, corn dominates the mix, and pioneer plants appear to be more important than wild resources. This relationship between components of the assemblage basically remains the same through all time periods.

Change in resource mix and procurement strategies was investigated within each of the 4 categories of macrobotanical remains. Expectations were generated concerning how these categories would have been affected

by a strategy of agricultural intensification. Within the macrobotanical assemblage, change was most apparent in corn and pioneer plants. Since the procurement strategies for these 2 types of resources are interrelated, change in agricultural practices was expected to effect change in pioneer plant procurement. Although change in procurement of wild resources was also suggested by the macrobotanical data, the evidence was not strong. Also, the data for wood resources suggest that wood resource depletion might have been a variable in procurement strategies after Period 3.

This summary has required a cursory and often homogenizing treatment of the data. More analysis is required, and more rigorous tests of the data should be conducted. Furthermore, this data base needs to be used in concert with other DAP data bases and compared with macrobotanical assemblages collected by other archaeological projects.

Section 3

TEMPORAL PATTERNS IN RESOURCE USE

Kenneth Lee Petersen

Pollen samples were collected at various sites in the Dolores Project area to obtain information on the prehistoric environment and to identify economic resources that could have been used by the Dolores Anasazi. The majority of the pollen samples were processed and analyzed by Linda Scott of Palynological Analysts (Golden, Colorado), who was contracted as a consultant to the DAP.

POLLEN ANALYSIS AND SOUTHWESTERN ARCHAEOLOGY

In contrast to analysts studying Quaternary pollen in the Eastern United States, palynologists in the arid West have been closely allied with archaeologists engaged in studies of archaeological and alluvial sites. The recent surge in pollen studies in the Southwest can be traced to the early work of Paul Shultz Martin (University of Arizona) and his students.

In 1957, Martin (1963) began palynological investigations in the desert grassland of southeastern Arizona. He critically examined the possibilities and limitations of pollen analysis in an area largely devoid of lakes and bogs, the traditional sites for obtaining pollen records. Martin sought other potential contexts for preserved fossil pollen and, with the development of appropriate extraction techniques (e.g., Gray 1965; Mehringer 1967:136-137), a variety of contexts have proven productive. These have included alluvium, playa-lake clays, eolian spring-mound deposits, buried organic mats, dunes, cave fill, coprolites, sediment adhering to artifact surfaces, and cultural surfaces and fills of archaeological sites. Even so, pollen in these contexts, if found at all, is often fragile due to its susceptibility to oxidation and microbial destruction.

Pollen analysis frequently has been applied to specific archaeological problems. These have included intrasite dating, determination of Pueblo room function, and identification of differential use of metates (e.g., corn versus cactus) (Hill and Hevly 1968; Hevly 1981); aboriginal diet as reflected in coprolites (Martin and Sharrock 1964; Williams-Dean and Bryant 1975; Kelso 1976; Scott 1979); and the presence and location of prehistoric agricultural fields (Martin and Schoenwetter 1960; Martin and Byers 1965:127-129; Woosley 1977; Berlin et al. 1977).

Most palynologists studying archaeological sites in the Southwest have concentrated on analysis of sediment from structure floors and features. Because of their archaeological associations, these sediments potentially are datable to within approximately 25 years of the actual date of deposition. When archaeological pollen samples are arranged chronologically, past regional patterns can be seen. Mehringer (1967); Schoenwetter (1970); Hevly (1981); and Bohrer (1981) provide more comprehensive discussions on the use of pollen analysis in archaeology.

THE DOLORES ARCHAEOLOGICAL PROGRAM POLLEN DATA BASE

From 1978 through 1984, 4324 pollen samples were collected by the DAP; of these, 775 were selected for processing. Roughly 76 percent of the processed samples (594) yielded sufficient pollen for analysis. Table 4.23 is an inventory of DAP pollen samples by site. Although budgetary constraints severely limited the number of samples that could be processed, the unprocessed samples provide a curated resource that may be tapped in future studies.

Sample Selection

A pollen sampling plan comparable to that used for collection of bulk soil (flotation) samples was implemented early in the project (Kane and Robinson 1984). Since relatively few samples could be examined, the first step in sample processing consisted of choosing which samples were likely to yield adequate information on the prehistoric environment and on the economic resources that might have been used by the

Table 4.23 – Dolores Archaeological Program pollen sample inventory

Site No.	No. of samples collected	No. of samples processed	No. of processed samples with sufficient pollen*	References for analyzed pollen samples†
5DL444	3	0		
5MT23	527	117	87	Scott (1982a, 1983a, 1985a)
5MT2151	50	20	16	Scott (1982a, 1983a, 1983b)
5MT2161	83	20	9	Scott (1983c)
5MT2181	8	4	4	Scott (1983d)
5MT2182	369	8	5	Scott (1985b)
5MT2191	37	11	6	Scott (1982a, 1983e)
5MT2192	44	10	9	Scott (1982a, 1982b, 1983a)
5MT2193	46	21	17	Scott (1982c, 1983a)
5MT2194	25	9	3	Scott (1982d)
5MT2198	32	11	8	Scott (1982a, 1983a, 1983f)
5MT2203	16	4	3	Scott (1982a)
5MT2205	1	0		
5MT2215	41	0		
5MT2226	20	0		
5MT2235	70	18	17	Scott (1982a, 1982e, 1983a)
5MT2241	23	10	9	Scott (1983g)
5MT2242	6	0		
5MT2320	23	5	4	Scott (1984a); Petersen and Scott (1985)
5MT2336	41	0		
5MT2378	26	0		
5MT2729	9	0		
5MT2731	5	0		
5MT2854	104	14	9	Scott (1983a, 1983h)
5MT2858	39	11	2	Scott (1982f)
5MT4447	1	0		
5MT4448	1	0		
5MT4449	1	0		
5MT4450	1	0		
5MT4475	663	48	40	Scott (1982a, 1983a, 1984b) Petersen and Scott (1985)
5MT4476	1	0		
5MT4477	455	41	37	Scott (1984b)
5MT4478	1	0		
5MT4479	309	32	31	Scott (1984b)
5MT4480	32	0		
5MT4482	1	0		
5MT4501	1	0		
5MT4502	1	0		
5MT4503	1	0		
5MT4509	1	0		
5MT4510	1	0		
5MT4512	36	3	3	Scott (1982a, 1982g)
5MT4518	2	0		
5MT4519	1	0		
5MT4520	1	0		
5MT4521	1	1	1	Petersen and Scott (1985)
5MT4522	1	0		
5MT4523	1	0		
5MT4526	2	0		
5MT4527	1	0		
5MT4529	1	0		
5MT4540	2	0		
5MT4545	11	7	6	Scott (1981, 1982a, 1983a)
5MT4548	1	0		
5MT4549	1	0		
5MT4550	1	0		
5MT4551	1	0		
5MT4552	1	0		
5MT4553	1	0		
5MT4554	1	0		
5MT4555	1	0		
5MT4556	2	0		
5MT4557	1	0		
5MT4559	1	0		
5MT4594	1	0		
5MT4596	1	0		
5MT4597	2	0		
5MT4598	1	0		
5MT4599	1	0		
5MT4600	1	0		
5MT4601	1	0		
5MT4602	1	0		
5MT4603	1	0		
5MT4604	1	0		
5MT4605	1	0		
5MT4606	1	0		
5MT4607	1	0		
5MT4608	1	0		
5MT4609	1	0		
5MT4610	1	0		
5MT4611	1	0		
5MT4612	1	0		
5MT4613	5	0		

Table 4.23 – Dolores Archaeological Program pollen sample inventory – Continued

Site No.	No. of samples collected	No. of samples processed	No. of processed samples with sufficient pollen*	References for analyzed pollen samples†
5MT4614	18	6	5	Scott (1982h)
5MT4615	1	0		
5MT4616	1	0		
5MT4617	1	0		
5MT4618	1	0		
5MT4619	1	0		
5MT4620	1	0		
5MT4621	1	0		
5MT4622	1	0		
5MT4623	1	0		
5MT4624	1	0		
5MT4625	1	0		
5MT4626	1	0		
5MT4627	2	0		
5MT4628	1	1	1	Petersen and Scott (1985)
5MT4629	1	0		
5MT4630	1	0		
5MT4631	1	0		
5MT4632	1	0		
5MT4633	1	0		
5MT4634	1	0		
5MT4635	1	0		
5MT4636	1	0		
5MT4637	1	0		
5MT4639	1	0		
5MT4640	1	0		
5MT4641	1	0		
5MT4642	1	0		
5MT4643	1	0		
5MT4644	257	156	86	Scott (1983a, 1984c)
5MT4645	1	0		
5MT4646	1	0		
5MT4647	1	0		
5MT4648	1	1	1	Petersen and Scott (1985)
5MT4649	1	0		
5MT4650	39	1	1	Petersen and Scott (1985)
5MT4651	1	0		
5MT4652	1	0		
5MT4654	17	4	4	Scott (1984d); Petersen (1985a); Petersen and Scott (1985)
5MT4655	1	1	1	Petersen and Scott (1985)
5MT4656	1	0		
5MT4657	1	0		
5MT4658	1	0		
5MT4659	1	0		
5MT4660	1	0		
5MT4661	1	0		
5MT4663	1	0		
5MT4664	1	0		
5MT4665	1	0		
5MT4667	1	0		
5MT4668	2	0		
5MT4669	1	0		
5MT4671	215	36	35	Petersen and Scott (1985); Scott (1983i)
5MT4672	1	1	1	Petersen and Scott (1985)
5MT4673	1	0		
5MT4674	1	1	1	Petersen and Scott (1985)
5MT4675	1	0		
5MT4678	1	1	1	Petersen and Scott (1985)
5MT4681	12	0		
5MT4683	127	43	40	Scott (1985c); Petersen and Scott (1985)
5MT4684	172	22	20	Scott (1983a, 1983j)
5MT4789	3	0		
5MT5104	8	0		
5MT5106	48	15	11	Scott (1984b)
5MT5107	61	26	25	Scott (1984b)
5MT5108	31	10	10	Scott (1984b)
5MT5361	3	0		
5MT5380	1	0		
5MT5399	4	0		
5MT5863	8	0		
G-4§	5	0		
G-5§	25	25	25	Petersen (1985b); Petersen Scott (1985)
Total	4324	775	594	

* The minimum number of pollen grains generally considered sufficient for analysis was 100; however, in seven instances, 50 grains was used as the minimum acceptable quantity. The 7 samples are PN 174 and PN 218 from Site 5MT4475, PN 167 and PN 221 from Site 5MT23, PN 71 from Site 5MT2161, PN 69 from Site 5MT4644, and PN 41 from Site 5MT4684.

† In addition to documents listed in this column, Benz (1984:table 45) provides a list of pollen types and their percentages for several DAP archaeological sites.

§ G-4 and G-5 are the lower moden garden and Sagehen Marsh, respectively.

Dolores Anasazi. Of all the contexts sampled, pitstructures yielded the best preserved pollen; the poorest preservation was noted in samples from surface rooms. This circumstance most likely was due to the high precipitation (45 cm/year) in the project area, which increases the rates of oxidation and microbial activity near modern ground surface. Rapid burial helps prevent pollen destruction, and the deep pitstructures seem to have provided contexts conducive to pollen preservation.

Selection of samples for processing was made by crew chiefs, in consultation with ESG or EAG personnel, after site excavation was completed. After 1982, these decisions were based largely on guidelines established to maximize information retrieval from the relatively few samples processed during the remainder of the project (Petersen 1982). These guidelines were intended to direct subsequent sampling decisions in the field, as well as to assist in the selection process in the laboratory.

To insure comparability between sites, pollen samples were selected for processing if they had been collected from similar areas within similar structures. It was hoped that this measure would provide a basis for intrasite comparison. Because samples collected from various surfaces (including pot, mano, and metate surfaces; the bottoms and sides of cists; pitstructure floors near the hearth; and pitstructures floors at the juncture between the wingwall and the main wall in the main chamber) usually provided the best information on economic pollen types, such samples tended to be selected over those not collected from these proveniences.

As a corrollary to this guideline, crew chiefs were encouraged to collect samples from proveniences known to provide good results. Although control samples from above and below cultural surfaces were collected routinely, only 1 control sample per structure was required for analysis. This control sample had to have been collected from some provenience other than roof fall, because the pollen contents of roof fall samples frequently are very similar to the pollen contents of floor samples. When selecting fill samples for processing, samples from hearths and middens were included only if sample locations had been mapped in cross section to aid in evaluating analysis results. Selection of other fill samples, unless directly related to the use of a feature, was discouraged. Also, sand fills usually proved to be poor media for containing pollen, because pollen typically is a silt-sized particle. Therefore, pollen samples from sandy fills usually were not selected for processing. Floor transect samples, if collected, sometimes were selected to serve as controls for feature samples. Pollen samples from burials in trash were avoided due to potential problems of interpretation, but samples associated with burials in other contexts sometimes were processed.

Selection of pollen samples in the manner described could potentially introduce bias in the data base. The most serious bias may result from the small number of samples selected to represent a feature or floor. If only 1 sample of many collected is selected for processing, a question always remains as to how representative that sample may be. Therefore, the patterns and trends described throughout this section could at least partly be artifacts of sampling and selection procedures. This topic is addressed in more detail later, in the discussion of pollen analysis results from an intensively sampled pitstructure.

Another source of bias stems from the limitations of pollen analysis itself. Pollen rarely can be identified to the species level, and so it provides only a very generalized picture of the resources potentially available to and used by the Dolores Anasazi. Also, the way that pollen is dispersed and subsequently deposited affects its utility as an indicator of actual resource use. Refer to Bohrer (1981) for a more thorough discussion of these potential biases.

Sample Processing and Analysis

After samples were selected for processing, they were subject to specific extraction and analysis procedures. Pollen samples submitted to Palynological Analysts in Golden, Colorado, were processed using a chemical flotation technique documented in Scott (1982a:8-9). The processed samples were examined with a light microscope, generally at a magnification of 430X. When possible, 200 pollen grains were counted per sample. Fewer than 100 grains generally was considered to be insufficient for analysis, although in 7 instances, samples that yielded only 50 grains were included (table 4.23). A tally also was kept of poorly preserved grains (Scott 1982a:8-9).

Twenty-five samples collected from Sagehen Flats Marsh were processed in addition to the samples collected from archaeological sites. Fourteen of the samples were processed by Palynological Analysts. To each of the 0.5-tsp samples were added 6 tablets of commercially prepared *Eucalyptus* pollen (batch 903722), each containing 16 180 ± 1 460 *Eucalyptus* pollen grains to act as exotic tracers. After the samples were processed, they were returned to the DAP facility for analysis by the author. The author also extracted and analyzed the remaining samples from the marsh. The extraction technique used for these samples generally followed Mehringer's (1967:136-137) chemical digestion method and included acetolysis. The first step in

the extraction process involved the addition of 8 commercially prepared *Lycopodium* tablets (batch 212761) to each 0.5-tsp sample; each tablet contained 12 500 ± 500 *Lycopodium* spores (Stockmarr 1971, 1973) and weak hydrochloric acid. This permitted calculation of the number of pollen grains per cubic centimeter of sediment. The extracted samples were mounted in silicone oil (2000 cSt) on glass microscope slides and were examined at 425X magnification. A minimum of 180 *Lycopodium* spores and 300 pollen grains (excluding aquatic types) was tallied per sample (Petersen 1985b).

DOLORES ARCHAEOLOGICAL PROGRAM POLLEN DATA AND THE GENERAL RESEARCH DESIGN

The results of DAP pollen analysis have little to contribute to studies of paleodemography, social organization, and extraregional relationships (Problem Domains 2, 3, and 4). In the area of extraregional relationships, pollen from plants not found in the project area today could be interpreted as evidence of human transport into the project area. However, because some pollen is subject to widespread dispersal by the wind, the presence of such types (e.g., *Picea*) does not necessarily denote human transport of the plants into the project area, unless pollen frequencies can be shown to be unusually high.

Dolores pollen data are more suited to addressing Problem Domains 1 and 5: Economy and Adaptation, and Cultural Process. In the following discussions, selected pollen data are used to answer questions regarding resource availability and use, change in resource use through time, and climatic reconstruction.

Problem Domain 1: Economy and Adaptation

Studies of prehistoric economy and adaptation require that the resources available to and used by the Dolores Anasazi be identified (Kane et al. 1983:42-43). Reconstruction of the paleoenvironment and of the Anasazi subsistence system is essential to addressing these topics.

Resource Availability and Use

Table 4.24 lists the pollen taxa or types identified in DAP pollen samples. Pollen types marked with an asterisk in the table are types that potentially could have been economically important as food. However, pollen usually can be identified only above the species level, which may not be sufficient to clearly identify potential resources. Evidence from macrobotanical remains provides complementary and more specific evidence for

Table. 4.24 – Pollen types identified in Dolores Archaeological Program pollen samples

Scientific name
Abies
Acer
Acer negundo
*Allium**
Alnus
Amelanchier-type*
*Arctostaphylos**
Artemisia
Betula
Betulaceae
Bistorta bistortoides-type
Cactaceae*
Campanula
Campanulaceae
Caprifoliaceae
Caryophyllaceae
*Ceanothus**
*Celtis**
Cercocarpus-type
Cheno-am*
Cirsium-type
*Cleome**
Collomia
Compositae-high spine*
Compositae-low spine
Compositae-Liguliflorae*
Cruciferae*
*Cucurbita**
Cylindopuntia-type*
Cyperaceae
Delphinium-type
Dodecatheon-type
Elaeagnaceae
Elaeagnus
Ephedra
Ephedra nevadensis-type*
Ephedra torreyana-type*
*Eriogonum**
Fendlera
Fraxinus
Geranium
Gramineae*
Gutierrezia-type
Helianthus-type*
Heliotropium
Heuchera
Juglans
*Juniperus**
Labiatae
Larrea
Leguminosae*
cf. *Lepidium**
Liliaceae*
Linaceae
Linum
*Lotus**
*Lycium**
Malvaceae*
Medicago-type
Mitella

Table 4.24 – Pollen types identified in Dolores Archaeological Program pollen samples – Continued

Scientific name
*Nicotiana**
Nymphaceae
Onagraceae*
*Opuntia**
Oryzopsis-type*
Ostrya-type
Phlox
*Physalis**
Picea
*Pinus**
*Plantago**
Platyopuntia-type*
Polemoniaceae
Polemonium
Polygonum
Polygonum convolvulus-type
Polygonum sawatchense-type*
cf. *Populus*
*Portulaca**
Potamogeton
Primulaceae
Prunus-type*
Pseudotsuga
*Quercus**
Ranunculaceae
Rhamnus
*Rhus**
*Ribes**
Rosaceae
Rumex
Rumex densiflorus-type
Ruppia
Sagittaria
Salix
*Sambucus**
Sarcobatus
Saxifragaceae
*Shepherdia**
Solanaceae
*Solanum**
*Sparganium/Typha**
Sphaeralcea-type*
Spiraea
Symphoricarpos-type
Tamarix
Thalictrum
Triticum-type
Tsuga
*Typha**
Typha angustifolia
*Typha latifolia**
Ulmaceae
Ulmus
Umbelliferae*
*Vaccinium**
Valeriana
Viola
Violaceae
*Yucca**
*Zea**

* Denotes a potential economic type.

what was actually used by the Anasazi (sect. 2). Ethnographic uses of economic plants identified in DAP pollen samples are outlined in Scott (1984b, 1985a).

Temporal Patterns

Two DAP pollen studies have potential for addressing the issue of which resources were used at different points in time. One study documents the pollen contents of 4 coprolites from Site 5MT4683 (Singing Shelter)(Scott 1985c); the other study reports the results of analysis of pollen samples collected from Site 5MT4644 (Windy Wheat Pueblo)(Scott 1983a, 1984c).

Coprolite study: Site 5MT4683. – Four human coprolites from Site 5MT4683 were examined for pollen content; samples from only 3 yielded sufficient pollen for analysis. The pollen results (Scott 1985c) complemented the macrobotanical analysis of the coprolites (Jones 1983), but added little information about additional dietary components. However, based on the pollen, at least 1 coprolite reflects a meal consumed in the fall, and another reflects a meal consumed in the summer.

Intensive pollen sampling study: Site 5MT4644. – In 1979, 2 pitstructures at Site 5MT4644 were sampled intensively to gather information about pollen distribution in such structures. Bulk soil samples were collected in addition to pollen samples. It was hoped that the results of this study would aid in pollen sample selection in future DAP studies.

The study of pollen from floor and above-floor sediments (the latter believed to be roof fall) in Pitstructure 1 at Site 5MT4644 is believed to be one of the major contributions to Southwestern palynology in recent years because of the large number of pollen samples collected from a single structure floor (Scott 1983a, 1984c). Pitstructure 1 is assigned to the Sagehen Phase, Dos Casas Subphase (A.D. 760-850), when pitstructures were still being used primarily as domiciles. Pollen samples were collected to see if any patterns in pollen distribution could be detected. Maps of the pollen frequencies in Pitstructure 1 (Scott 1983a, 1984c) reveal definite patterns of pollen distribution on the floor. Macrobotanical remains from the same sampling grid were examined by Matthews (1984b). Both analyses provide a detailed record of plant resources used in the structure.

Of the 120 samples collected from the floor of Pitstructure 1, 95 were processed, and 44 yielded sufficient pollen for analysis. All 28 samples that were collected from sediment 0 to 5 cm above the floor of this same structure were processed, and 18 had sufficient pollen. Intensive sampling in Pitstructure 2 was limited to the

floor, from which 23 samples were collected; 15 of these samples were processed, and 14 yielded sufficient pollen for analysis. Table 4.25 lists pollen types identified in the Pitstructure 1 and 2 samples believed to have been economically important to the Anasazi. Assessment of these types as economic is supported by the patterning in their distributions and by some corroborative evidence from macrobotanical remains (Scott 1983a, 1984c; Matthews 1984b). The ubiquity of a specific pollen type is expressed in this table as the percentage of samples containing that pollen type.

Except for *Zea, Cleome,* Umbelliferae, *Ephedra,* and *Nicotiana,* most of the pollen types occur in only a few of the processed samples that contained sufficient pollen for analysis. Table 4.25 demonstrates that fortuitous sampling may be the reason a particular pollen type is tallied. It follows that much can be said if an economic type is encountered (especially in large frequencies), but its failure to be tallied may only be a function of limited sampling. Table 4.25 suggests that the greater the number of samples collected, the greater the probability of detecting rarer types such as *Cucurbita* or *Portulaca.*

Table 4.25 shows that *Zea, Cleome,* and Umbelliferae pollen are among the most ubiquitous pollen types, as measured by their presence or absence in the pollen samples analyzed at Site 5MT4644. Because of the limited dispersal of corn pollen in modern corn fields and the large size of the *Zea* pollen grain, there is little question among pollen analysts that the presence of *Zea* pollen in a structure means that corn was used in the structure (Martin 1963:50).

As for *Cleome* pollen, Martin and Byers (1965) argue that its rarity in natural pollen rain and its abundance in archaeological samples suggest that *Cleome* was used by the Anasazi. No *Cleome* pollen was found in the modern DAP surface samples (Petersen and Scott 1985). The ubiquity of *Cleome* pollen in Pitstructures 1 and 2 at Site 5MT4644 suggests that *Cleome* was mostly in flower when it was collected and brought into the structures. Ethnographic sources (e.g., Stevenson 1915:69, 82) suggest that *Cleome* often was hung from rafters to dry. This could explain why the pollen was so widespread within the pitstructures.

Scott (1984c) notes that because Umbelliferae pollen is also ubiquitous, it may have been brought into the pitstructures while in flower, and possibly dried in the rafters similar to the manner in which *Cleome* may have been dried. Petersen and Scott (1985) recorded only 1 Umbelliferae pollen grain during analysis of 13 samples collected during modern surface transect sampling.

Zea and Cleome representation, by subphase. – As demonstrated by the Site 5MT4644 pollen analysis results, the total number of economic pollen types (richness) at a particular site may simply be a function of the number of samples analyzed. Therefore, only *Zea* and *Cleome,* 2 clearly identifiable and ubiquitous pollen types, will be examined in detail here.

Table 4.26 groups the individual sites with pollen results into subphases and indicates the number of samples at each site that contained *Zea* and *Cleome* pollen; again, ubiquity is expressed as the percentage of samples containing a particular pollen type. *Zea* occurs in 45.1 percent of 501 pollen samples examined, while *Cleome* occurs in 84.0 percent.

The Sagehill (A.D.700-780) and Marshview (A.D. 1050-1200) Subphases (table 4.26) have slightly lower *Cleome* percentages than do the other subphases. A 2×2 chi-square test for *Cleome* shows that, at the 0.05 level, only the Cline (A.D. 900-975) and Marshview Subphases (the highest and lowest in terms of ubiquity) differ significantly ($\chi^2=3.943$; probability $>\chi^2<0.047$). This suggests that, except for the reduction during the Marshview Subphase, the use of *Cleome* did not change significantly over time.

Zea, on the other hand, occurs in fewer Cline Subphase samples (36.4 percent) than Periman (A.D. 850-900) or Grass Mesa (A.D. 880-925) Subphase samples (40.9 and 50.0 percent, respectively). Because the ubiquity of *Cleome* does not concomitantly decline in the Cline Subphase, but actually is highest during this subphase, the low *Zea* frequency probably is not due simply to sampling bias. *Zea* may have been less ubiquitous or less important during the Cline Subphase. This seems to support Petersen's argument that the climate during the Cline Subphase was less favorable for growing corn (section 6, this chapter). However, since a 2×2 chi-square test indicates that the differences are not significant (the contrast between the Grass Mesa and Cline Subphases approaches the 0.05 level of significance but does not reach it:$\chi^2=3.112$; probability$>\chi^2<0.078$), they could be explained by chance alone. Scott (1984b), using a smaller sample size, found a significant contrast in the ubiquity of Zea in sediments assigned to the Cline Subphase as compared with *Zea* ubiquity in sediments assigned to the Periman Subphase. *Zea* also occurs in significantly fewer Marshview Subphase samples than in Tres Bobos Subphase samples. However, because a simultaneous reduction in *Cleome* occurs in Marshview samples, sampling bias may be partly responsible for the observed trend.

In short, one of the greatest decreases in the ubiquity of *Zea* pollen between consecutive subphases is that noted between the Grass Mesa and Cline Subphases;

Table 4.25 – Ubiquity of economic pollen types in pollen samples from intensively sampled pitstructures at Site 5MT4644*

Taxon	Pitstructure 1				Pitstructure 2	
	Floor (N = 44)		Upper† (N = 18)		Floor (N = 14)	
	No. with specific pollen type	Ubiquity (%)	No. with specific pollen type	Ubiquity (%)	No. with specific pollen type	Ubiquity (%)
Cleome	40	90.9	17	94.4	11	78.6
Zea	31	70.5	11	61.1	6	42.9
Cucurbita	3	6.8	3	16.7		
Portulaca	4	9.1				
Typha	4	9.1				
Opuntia	8	18.2	2	11.1	3	21.4
Allium	1	2.3				
Sphaeralcea	3	6.8	2	11.1	1	7.1
Nicotiana	20	45.5				
Umbelliferae	30	68.2	5	27.8	10	71.4
Ephedra§	21	47.7	10	55.6	5	35.7
Cheno-am**	1	2.3				
Shepherdia			2	11.1		
Compositae**	1	2.3				
Onagraceae	3	6.8			1	7.1

* Only those economic types that occurred in frequencies high enough to show patterning are included in this table.

† Upper: 0 to 5 cm above the floor; believed to be roof fall.

§ Combines grains identified as *nevadensis* and *torreyana*.

** Recorded only where greater than 30 percent of grains observed.

N is the number of samples that had sufficient pollen for analysis. "Ubiquity" refers to the percentage of these samples that contained pollen of a specific type.

the significance of the observed *Zea* decrease is enhanced by the fact that the ubiquity of *Cleome* simultaneously increases. Between the earliest and the latest subphases, a significant difference occurs in the ubiquity of *Zea* pollen. But there is also a reduction in the ubiquity of *Cleome* (although not significant at the 0.05 level), so that sampling error alone could explain the contrast in *Zea* ubiquity.

Problem Domain 5: Cultural Process

The goal of Problem Domain 5 research is to identify factors that contributed to cultural change and stability through time in the Dolores area (Kane et al. 1983:56). The pollen data base can be used to study one facet of this broad topic: the environmental factors that might have been involved in population movement, growth, and decline in the Escalante Sector.

The relationship between the environment and cultural process can be explored only if past climatic conditions are reconstructed. In reconstructing past climate, most Southwestern palynologists have concentrated on analysis of sediments from cultural surfaces and features of archaeological sites. Because of their archaeological associations, these sediments are potentially datable to within 25 years of the use of the context. However, pollen spectra from archaeological sites may have been affected by such cultural activities as tree clearance, local disturbance of native vegetation, and the intentional or incidental introduction of pollen into various contexts. Thus, these spectra may not represent the natural pollen rain. To overcome these biases, researchers have used several techniques for recognizing vegetation units: standard and adjusted pollen sums; ratios of arboreal to nonarboreal pollen, pine to juniper pollen, and large to small pine pollen; and multivariate statistical techniques (Euler et al. 1979; Fall et al. 1981; Hevly 1981; Schoenwetter 1970). Climatic reconstruction is accomplished by comparing and contrasting the prehistoric pollen spectra or ratios to modern pollen spectra from an elevational transect through different vegetation units and their associated climates.

Table 4.26 – Ubiquity of *Zea* and *Cleome* pollen in samples with sufficient pollen for analysis, by subphase

Subphase Site number	Pollen samples				
	No. with sufficient pollen	No. with *Zea*	Ubiquity (%)	No.with *Cleome*	Ubiquity (%)
Tres Bobos (A.D. 600-700)					
5MT4545	6	5	83.3	6	100.0
5MT4683	7	4	57.1	3	42.9
5MT4684	20	11	55.0	19	95.0
Subphase totals	33	20	60.6	28	84.8
Sagehill (A.D. 700-780)					
5MT23	3	1	33.3	2	66.7
5MT2151	3	3	100.0	2	66.7
5MT2194	1	0	0.0	1	100.0
5MT2198	8	2	25.0	5	62.5
5MT2854	9	5	55.6	8	88.9
5MT2858	2	0	0.0	1	50.0
5MT4614	5	0	0.0	4	80.0
5MT4644	2	1	50.0	2	100.0
5MT4683	3	3	100.0	2	66.7
Subphase totals	36	15	41.7	27	75.0
Dos Casas (A.D. 760-850)					
5MT23	11	10	90.9	9	81.8
5MT2151	8	4	50.0	7	87.5
5MT2181	4	2	50.0	4	100.0
5MT2192	6	2	33.3	5	83.3
5MT2193	17	7	41.2	15	88.2
5MT2194	2	0	0.0	1	50.0
5MT4644	84	53	63.1	74	88.1
5MT4671	32	6	18.8	25	78.1
5MT4683	10	4	40.0	7	70.0
Subphase totals	174	88	50.6	147	84.5
Periman (A.D. 850-900)					
5MT23	38	21	55.3	36	94.7
5MT2151	2	1	50.0	1	50.0
5MT2161	9	4	44.4	8	88.9
5MT2182	5	4	80.0	4	80.0
5MT2191	5	1	20.0	2	40.0
5MT2320	3	0	0.0	2	66.7
5MT4475	20	11	55.0	19	95.0
5MT4477	33	14	42.4	33	100.0
5MT4479	31	10	32.3	26	83.9

Table 4.26 – Ubiquity of *Zea* and *Cleome* pollen in samples with sufficient pollen for analysis, by subphase – Continued

Subphase Site number	Pollen samples				
	No. with sufficient pollen	No. with *Zea*	Ubiquity (%)	No. with *Cleome*	Ubiquity (%)
Periman (A.D. 850-900) (cont.)					
5MT4671	2	1	50.0	2	100.0
5MT4683	3	1	33.0	0	0.0
5MT5106	8	2	25.0	5	62.5
5MT5107	12	2	16.7	11	91.7
5MT5108	10	2	20.0	9	90.0
Subphase totals	181	74	40.9	158	87.3
Grass Mesa (A.D. 880-925)					
5MT23	23	11	47.8	19	82.6
5MT2151	1	1	100.0	1	100.0
Subphase totals	24	12	50.0	20	83.3
Cline (A.D. 900-975)					
5MT2203	3	0	0.0	3	100.0
5MT4475	16	6	37.5	16	100.0
5MT4477	3	2	66.7	1	33.3
Subphase totals	22	8	36.4	20	90.9
Marshview (A.D. 1050-1200)					
5MT2151	2	1	50.0	2	100.0
5MT2235	17	6	35.3	15	88.2
5MT2241	7	0	0.0	2	28.6
5MT4683	2	1	50.0	0	0.0
5MT5106	3	1	33.3	2	66.7
Subphase totals	31	9	29.0	21	67.7
Total	501	226	45.1	421	84.0

* "Ubiquity" refers to the percentage of samples that contained pollen of a specific type.

A Test of Dolores Project Area Climatic Reconstruction

A slightly different approach has been taken in reconstructing the climate of the project area. A continuous and well-dated pollen record from the La Plata Mountains (approximately 30 km east of the Dolores Project area), independent of the DAP's archaeological pollen record, was used, This reconstruction is outlined in detail by Petersen in section 6, this chapter.

An early test of Petersen's climatic reconstruction for the project area was provided by a few pollen samples from Site 5MT4654 (Beaver Trap Shelter) (Petersen 1985a). Next, it was hoped that a more detailed test might be provided by the analysis of pollen samples from Site 5MT4683 (Singing Shelter) (Scott 1985c). Three factors, however, complicated evaluation of the Site 5MT4683 samples in light of Petersen'c climatic reconstruction: (1) the site is located in a narrow canyon and is surrounded by vegetation that differs from that on surrounding sites located away from canyons (refer to Petersen and Scott 1985, for a discussion of this factor); (2) age assignments for the samples were too broad; and (3) deposition rates in caves and rockshelters vary widely. The last factor is serious, because a sample could represent pollen rain for as short a time as 1 rainstorm, or for as long a time as a portion of a year or, even more likely, many years. Comparing samples that represent very short time periods with samples that represent long time periods is difficult. These factors may partly explain why Scott (1985c) had difficulty in finding a satisfactory correlation between the Site

5MT4683 pollen analysis results and Petersen's (1985a) climatic reconstruction for the project area. However, during her analysis of 10 DAP sites, Scott (1982a) did detect relatively less sagebrush during the Sagehen Phase, relatively more sagebrush during the McPhee Phase, and relatively less sagebrush again during the Sundial Phase. This sequence is similar to that identified in the test of Petersen's climatic reconstruction presented here.

For this test, dating of contexts in the Dolores Project area has been described and standardized through the use of modeling period assignments (chap. 1). Figure 4.3 shows the date range of DAP pollen samples. If more than 1 set of samples is available for each site, the date range of each subset (indicated by a decimal number, with the smallest number being the oldest) is shown. Two date range assignments are possible for several sample sets: 5MT2192.2, 5MT4614.1, 5MT4683.1, 5MT4683.4, and 5MT5106.2.

The modern surface pollen study (Petersen and Scott 1985) demonstrated that pollen from sites located within canyons is not strictly comparable to pollen from sites located away from canyons, because of the different vegetation surrounding or near the respective sites. The sites located in canyons are shown by shading in figure 4.3. Other sites are simply called "upland sites" to distinguish them from the canyon sites. (The criteria used to distinquish upland and canyon sites based on pollen rain are different than those used to distinguish upland and canyon sites in the wood resource study presented in section 2 of this chapter: in section 2, sites located in or within approximately 1 km of the Dolores River Canyon are classified as "canyon sites"; in the present study, a site must be located in any canyon to be included in this group.) Because the canyon sites do not encompass quite as long a time span as do the upland sites, the upland sites will be the only ones used in this test of the LaPlata Mountains reconstruction.

As discussed in section 6, the climate in the project area during the Anasazi occupation is reconstructed as being either similar to or relatively drier than the present. When the climate is drier, an increase in sagebrush (relative to the present) is expected (Petersen 1985a; Petersen and Scott 1985). In figure 4.4, times believed to have been drier than the present are indicated by shading. Plotted on the same time scale are the date ranges of pollen samples from selected upland sites believed to provide a test of Petersen's reconstruction. Sites were selected on the basis of date range and whether or not they had yielded "paired" sample sets: sites that dated to periods encompassed by the reconstruction were used to "piece together" the total sequence; and sites that yielded paired samples were favored because they provided the basis for examining changing vegetation proportions through time in a single location. More reliance is placed on the direction of change of paired samples from a single site location than on the relative contrast between modern and archaeological samples from different locations, because the vegetation mosaic surrounding different sites may differ enough to make strict comparisons difficult. Figure 4.5 shows the location of the sites used to test the climatic reconstruction.

Also plotted in figure 4.4 is a series of pollen spectra that shows the proportion of sage pollen to juniper, pine, and oak pollen. By limiting the pollen to these 4 types, a spectrum that faithfully reflects the natural pollen rain of the major cover plants can be produced and possibly avoids the bias inherent in archaeological pollen samples. The pollen spectra are oriented such that the sagebrush wedge is always centered at the bottom and the other 3 wedges are plotted in relation to it. This plotting method gives a visual impression of the amount of sagebrush pollen versus the amount of the 3 woodland pollen types. To aid in comparison, modern pollen spectra (5MT4475.5 and 5MT4512) are also shown. If an archaeological sample contains more sagebrush than do the modern samples, it is interpreted as indicating drier conditions. If it has less sagebrush, it is interpreted as indicating wetter condition.

To overcome possible biases from location within an archaeological site, the 4 major pollen types from all pollen samples assigned to the same modeling period were averaged together. Table 4.27 lists the sites, the modeling period and subperiod assignments, and the pollen samples that were averaged together. Two pollen samples considered too aberrant to be included in this averaging process were excluded. They were PN (pollen sample number) 466 from Site 5MT4475 and PN 22 from Site 5MT2241.

In this test of the climatic reconstruction, the emphasis is on comparison of pollen spectra with the present and on the direction, rather than on the absolute magnitude, of changes through time within a single site. The 2 modern samples in figure 4.4 illustrate the range the modern pollen spectra from upland sites can have, and Petersen and Scott (1985) provide additional examples of variation.

Except for a dry period between about A.D. 650 and 675, the period from A.D. 600 to about A.D. 740 is reconstructed as being similar to the present (sect. 6). The Site 5MT4545 sample spectrum for the early A.D. 600's is very similar to the present Site 5MT4512 spectrum, and the site 5MT4684 spectrum is consistent with Petersen's reconstruction for drier conditions in the middle A.D. 600's (i.e., increased sagebrush).

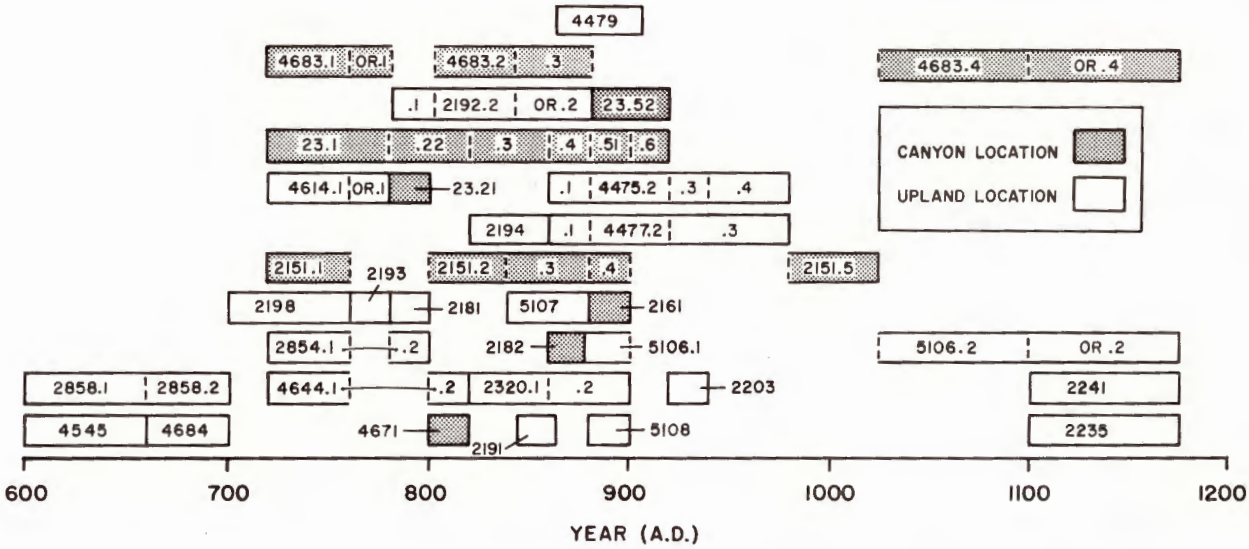

Figure 4.3 – Dating of Dolores Archaeological Program archaeological contexts containing pollen samples, based on modeling period assignment. Broken lines distinguish different sample sets from the same site or 2 possible date assignments for the same sample set. Similarly, a decimal point followed by a number indicates multiple samples for the same site or multiple date range interpretations for the same site (the smallest number indicates the oldest date range). For example, 2 samples are shown for Site 5MT2192: 2192.1 is the oldest, 2192.2 is the youngest. Two date ranges are possible for the latter: A.D. 800-840 and A.D. 840-880.

Petersen reconstructs the A.D. 800 to 1000 period as being drier than the present, which should be reflected by higher sagebrush proportions than at present. The driest conditions are centered on A.D. 900, with conditions being progressively less dry on either side. The paired samples from Site 5MT2320 show an increase in the proportion of sagebrush in the manner predicted by Petersen for the A.D. 800's (fig. 4.4). The paired samples from Site 5MT2192 are very similar, which might suggest they are quite close to each other in age. The slightly smaller proportion of sagebrush in the 5MT2192.2 sample may be related to the short period of relatively wetter conditions centered on A.D 800.

The series of pollen samples from Site 5MT4475 (fig. 4.4) provides the longest continuous test of the direction of vegetation change after A.D. 900. From shortly before A.D. 900 up to shortly before A.D. 1000, the pollen spectra show a reduction of sagebrush from a proportion greater than at present to one much less than at present.

The climatic reconstruction also suggests that, because of the relatively greater summer and winter precipitation during the A.D. 1000-1110 period, the dry-farming belt at that time was wider than at present. Based on the results from Site 5MT4475, sagebrush also might have been less extensive in the project area from A.D. 1000 to 1110. One other site (Site 5MT5106) shows the same trend, but its later pollen spectrum (5MT5106.2) is very similar to that of the modern Site 5MT4512. However, the date assignment for 5MT5106.2 is not secure.

The A.D. 1110-1325 period is reconstructed as having been drier than the present, and Site 5MT2241, which dates to the A.D. 1100's, has larger proportions of sagebrush than either of the modern samples. It is similar to other pollen spectra believed to represent time periods when the project area was drier than at present.

Discussion

The analysis reported here provides both greater dating control and greater detail than the other tests. All in all, the results of the pollen analysis of upland archaeological sites in the project area support Petersen's (1985a) general climatic reconstruction for the project area, which is based on a pollen record from the La Plata Mountains. This climatic reconstruction serves as a basis for arguments linking environmental change and cultural process.

Refer to section 6, this chapter, for a complete discussion of other regional climatic studies. In brief, the sequence outlined is in general agreement with that presented by Schoenwetter (1966, 1967, 1970); Schoenwetter and Eddy (1964); Euler et al. (1979); and Dean et al. (1985).

The palynological record at Hovenweep National Monument has provided the only study in southwestern Colorado that shows an increase in arboreal pollen frequencies over nonarboreal pollen frequencies during the A.D. 700-900 period (Weir 1976, 1977). Hovenweep National Monument is located below the elevational

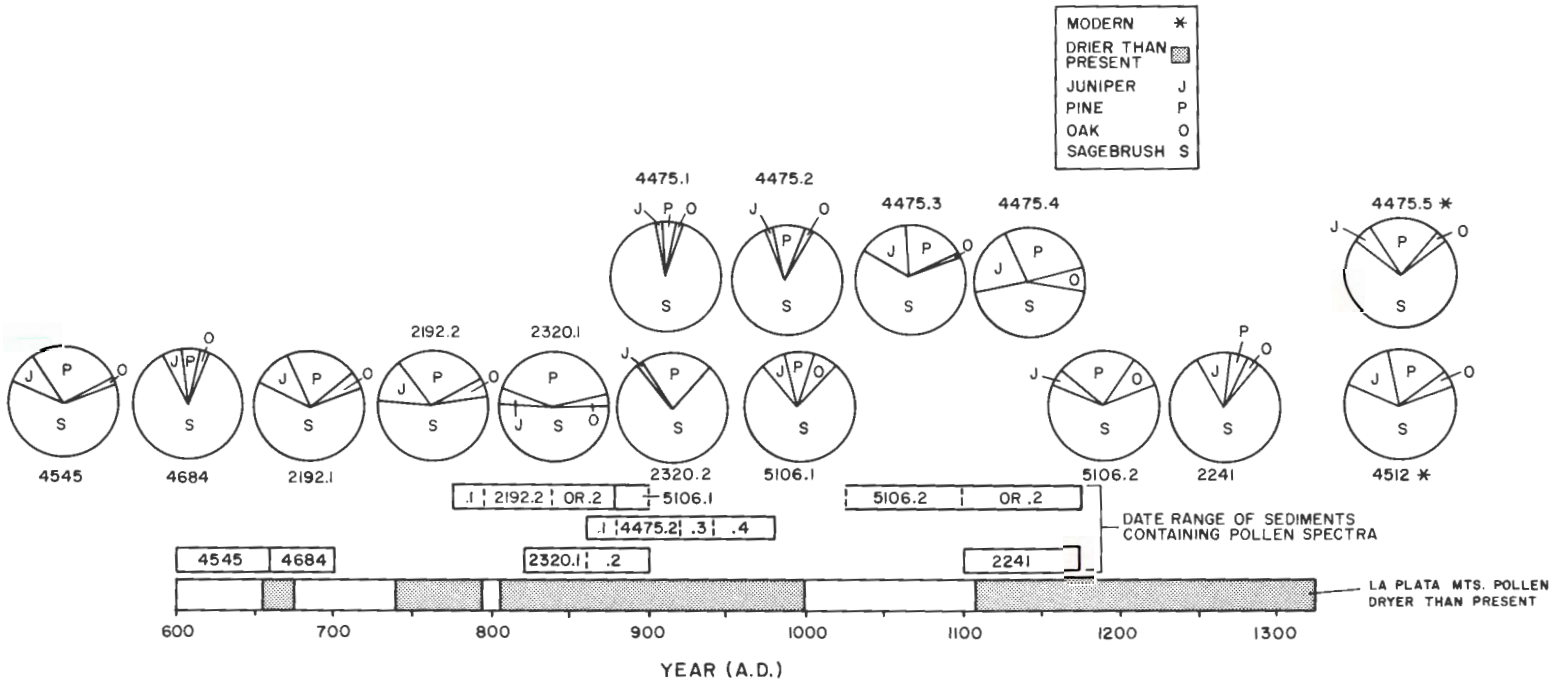

Figure 4.4 – Pollen spectra from Dolores Archaeological Program archaeological sites compared with the La Plata Mountains pollen reconstruction of climate. Broken lines distinguish different sample sets from the same site or 2 possible date assignments for the same sample set. Similarly, a decimal point followed by a number indicates multiple samples for the same site or multiple date range interpretations for the same site (the smallest number indicates the oldest date range). For example, 2 samples are shown for Site 5MT2192: 2192.1 is the oldest, 2192.2 is the youngest. Two date ranges are possible for the latter: A.D. 800-840 and A.D. 840-880.

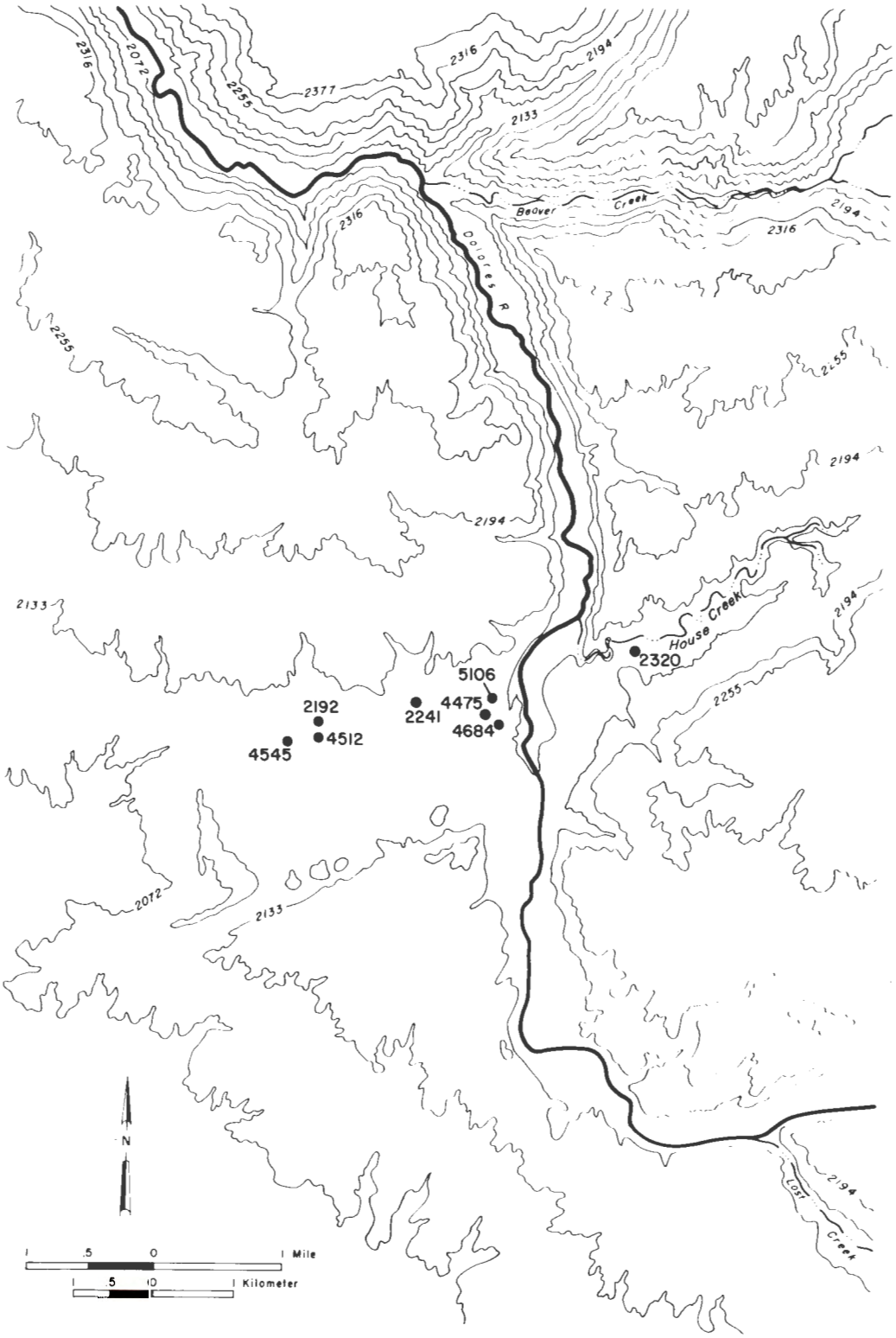

Figure 4.5 – Locations of sites used in test of climatic reconstruction: 5MT2192, 5MT2241, 5MT2320, 5MT4475, 5MT4512, 5MT4545, 5MT4684, and 5MT5106.

Table 4.27 – Dates for selected pollen samples whose pollen counts were averaged together to produce pollen spectra shown in figure 4.4.

Site number MP, SP	Date range (A.D.)	PN Number
5MT2192.1		
MP 2, SP3	780-800	26, 29, 31, 32, 36, 38
5MT2192.2		
MP 3 or MP 4	800-840 or 840-880	21, 24
5MT2241		
MP 7, SP3	1100-1175	1, 2, 3, 4, 9, 10, 23, 24
5MT2320.1		
MP 3, SP2 through MP 4, SP1	820-860	21
5MT2320.2		
MP 4, SP2 through MP 5, SP1	860-900	4, 7
5MT4475.1		
MP 5, SP2	860-880	447, 448, 449
5MT4475.2		
MP 4, SP1 through SP2	880-920	133, 160, 174, 175, 177, 178, 198, 200, 213, 214, 215, 216, 217, 218, 465, 467, 469
5MT4475.3		
MP 6, SP1	920-940	459, 463
5MT4475.4		
MP 6, SP2	940-980	9, 37, 40, 45, 85
5MT4475.5		
Modern surface		8001
5MT4512		
Modern surface		2, 5, 8
5MT4545		
MP 1, SP1	600-660	5, 6, 7, 8, 9, 11
5MT4684		
MP 1, SP2	660-700	17, 26, 34, 39, 41, 45, 47, 49, 52, 54, 96, 100, 104
5MT5106.1		
MP 5, SP1	880-900	22, 23, 24, 28, 29, 30, 32, 39
5MT5106.2		
MP 7, SP2 or SP3	1025-1100 or 1100-1175	15, 17, 21

MP – Modeling period.
SP – Modeling subperiod.
PN – Pollen sample.

range of pinyon (Petersen 1984a). If this increase in arboreal pollen was primarily due to an increase in pinyon trees, then it could be interpreted as being in agreement with the La Plata Mountain record, because pinyon is believed to have increased during the A.D. 750-900 period, due to increased summer rainfall and decreased winter precipitation. Only a site located well away from ponderosa pine and oak, such as Hovenweep National Monument, might be expected to be especially sensitive to an increase in an arboreal pollen component primarily made up of pinyon.

The pollen record from DAP archaeological samples verifies the climatic reconstruction presented in section 6. Drier conditions are believed to have resulted in a narrower dry-farming belt than exists at present. In terms of Problem Domain 5, which examines population growth, movement, and decline during relatively

drier periods, the project area is expected to have become more attractive to Anasazi populations living at the lower elevational limit of a shrinking dry-farming belt. Refer to section 6 for other climatic conditions that must be considered before a full evaluation can be made of the influence of climate on the Dolores Anasazi.

SUMMARY

The problem domains in the general research design (Kane et al. 1983) provide a useful framework for discussing the results of DAP pollen studies. Analysis results are applicable primarily to Problem Domain 1 (Economy and Adaptation) and Problem Domain 5 (Cultural Process).

In answering questions pertaining to Dolores Anasazi economy and adaptations, the results of pollen analysis give some insight into the potential resources available. Modern vegetation in the project area is characterized by a mosaic of sagebrush, juniper, pinyon, and oak. This same mosaic, and the associated plants that potentially are of economic importance, were present throughout the entire Anasazi occupation, although their respective proportions may have fluctuated.

The number of pollen types identified for the project area is relatively large; these types provide an inventory of plant taxa present. When used in conjunction with the results of the packrat midden analysis (Van Devender 1985) and the macrobotanical analysis of bulk soil samples from the archaeological sites (sect. 2), an extensive inventory is obtained.

Results of the intensive pollen sampling at Site 5MT4644 (Scott 1983a, 1984c), when combined with the results of the bulk soil sampling (Matthews 1984b), provide an outstanding case study of resource use and patterning. The results also allow the specification of a pollen sampling plan for Pueblo I pitstructures that maximizes information return for the number of samples analyzed.

A clear picture of past climatic conditions is necessary to address questions concerning cultural process. Petersen (sect. 6) suggests a climatic deterioration was detrimental to corn farming during the late A.D. 800's and the early A.D. 900's, just prior to the Cline Subphase; corn farming during the Cline Subphase (the A.D. 900's) would have been more risky as well. A measure was made of the ubiquity of *Zea* and *Cleome* pollen in the samples that had sufficient pollen for analysis during each subphase. During the Cline Subphase, ubiquity of *Zea* pollen was reduced at the same time that the ubiquity of *Cleome* pollen slightly increased, although neither the decrease nor the increase are significant at the 0.05 level. These results seem to confirm Petersen's contention that the increased risk of corn farming during the A.D. 900's may have resulted in less dependence on corn, and possibly in a concomitant shift to a greater reliance on native resources.

Support for Petersen's climatic reconstruction for the remainder of the Anasazi occupation of the project area can be found in dated pollen spectra from upland archaeological sites. Petersen reconstructs the climate for the A.D. 800's, when population reached its height, as being drier than that of the present. Pollen spectra representing that time period indicate more extensive sagebrush, at the expense of woodland, than at present. The direction of vegetation change predicted by Petersen's overall chronology is largely supported by results of the pollen analysis in the project area, even including the detection of a short dry period in the middle to late A.D. 600's.

Section 4

THE DOLORES ARCHAEOLOGICAL PROGRAM FAUNAL DATA BASE: RESOURCE AVAILABILITY AND RESOURCE MIX

Sarah W. Neusius

The primary goal of the DAP Faunal Studies Section has been the creation of a faunal data base suitable for reconstruction of Dolores area prehistory and useful to studies of Dolores Anasazi adaptive strategies. Problem Domain 1 of the general research design (Kane et al. 1983) focuses on study of prehistoric economy and adaptation, and the economic system is a crucial component in the DAP model of Dolores Anasazi adaptations (Lipe 1984; part 4, this volume). In keeping with the general project focus, the Faunal Studies Section has compiled faunal data on resource availability and resource mix for the Dolores Anasazi. Four subsections address these concerns.

First, the DAP faunal data base is outlined. The types of data available, the procedures used in gathering and analyzing data, and the effects of postdepositional processes on the faunal assemblage are briefly discussed. Data quality, which is a basic consideration in all faunal analyses, is evaluated in this sub-section. Despite the major effort put into faunal analysis by the DAP, the end product has been shaped by excavation and analysis priorities, personnel changes, and shifting theoretical emphases during the course of the program's history. Although the DAP faunal data is believed to be of high quality, a thorough taphonomic study has not been

completed, nor have the effects of excavation and analysis procedures been fully researched. The first subsection acquaints potential researchers with the general characteristics of the evidence amassed and with the concerns to be addressed in using these data.

Second, prehistoric resource availability is examined. A preliminary report on findings was presented in Neusius (1985a). This report contained raw data on probable resource availability and distribution. It did not consider which resources might have been preferred, nor how availability and preference may have changed through time. Since these topics are of major concern in DAP synthetic studies, some attention has been given them here.

The third sub-section presents the evidence for resource mix. A list of taxa recognized in the DAP faunal assemblage is presented in annotated form, and preliminary comments on relative abundance are offered. Analysis of the composition of the DAP faunal assemblage has not progressed beyond the most basic stage, except in the case of particular sites or communities (e.g., Neusius 1985b; Neusius and Gould 1985), nor has temporal variability been studied. The discussion in this sub-section is supplemented by tabular presentation of data on taxonomic composition. Both NISP (number of individual specimens) and MNI (minimum number of individuals) calculations are given.

Finally, the significance of the data for studying game procurement and processing strategies is briefly discussed. Because time and budget constraints precluded detailed analysis, this sub-section remains largely descriptive, although some of the ideas presented may serve to guide future research. That much more analysis could be conducted is a reflection of the DAP's thoroughness in developing a usable data base, for without a sound data base, there would be much less to be studied in the future.

THE DOLORES ARCHAEOLOGICAL PROGRAM FAUNAL DATA BASE

Background Studies

Zooarchaeological analysis involves more than the identification and study of faunal remains recovered from archaeological sites. Faunal assemblages must be placed in perspective with respect to environmental reconstructions, resource availability, ethnohistoric and ethnographic records of subsistence practices, and the archaeological record from relevant locales, time periods, and cultural groups. Although the need for background information on these topics was recognized by the DAP, collection of such data was limited by the more compelling necessity of recording and describing the archaeologically recovered faunal remains.

As a result, the only background studies undertaken consisted of research on faunal resource availability and on known uses of faunal resources by Southwestern groups. Summaries of the information collected in each case have been presented in Neusius (1985a, 1985c). In these documents, faunal species possibly found in the project area prehistorically have been listed. The habitats in which each animal may be found and the relative abundance of each species also have been indicated. In addition, uses of taxa by various ethnographically known groups have been tabulated according to three general use categories: food, raw materials, and medicinal or ceremonial uses. Neusius (1985a, 1985c) should be consulted for more detailed information.

Archaeological Data

The archaeological faunal remains collected by the DAP can be subdivided into 3 categories: macrofaunal remains, microfaunal remains, and miscellaneous faunal remains. The different assemblages in each of these categories can be kept separate and considered as different indicators of the Dolores Anasazi's use of animal resources. Noncultural assemblages of bone can be deleted from such considerations.

The macrofaunal assemblage consists of nonhuman bones collected during the course of routine excavation. Most of the faunal remains from DAP sites (76 224 fragments) are included in this assemblage. The majority of the bones were collected during the course of shoveling, troweling, and screening of site deposits. No special sampling strategies were employed in the recovery of these bones, although, as discussed below, collection mode did vary and was used to subsample assemblages in the faunal laboratory when required. Included in the macrofaunal assemblage are some nonhuman bones collected from packrat middens at Site 5MT4654 (Emslie 1985; Van Devender 1985).

The smallest pieces of bone, including those from very small animals, usually were not recovered during the course of routine excavation. The microfaunal assemblage consists of 5723 bones collected by methods designed to recover very small items. A very small percentage of these materials was collected by dry-screening sediment through mesh measuring 1/16-inch or less. A larger, but still small, percentage of the microfaunal assemblage was recovered during water-screening through similar-sized mesh. While the former recovery method was employed in an unsystematic manner at the discretion of field crew chiefs, the latter method was routinely applied to hearth fills at several

sites. Because the water-screening of hearth fills resulted in the recovery of very large quantities of bones, only a small number of these bones were actually identified by the Faunal Studies Section.

Most of the microfaunal remains came from bulk soil (flotation) samples. The DAP bulk soil sampling program was aimed primarily at recovery of botanical remains (Litzinger 1979, 1980). Nevertheless, many of the sampled contexts (e.g., hearths, middens) also were of interest with respect to faunal remains. Thus, these samples were further subsampled by the Faunal Studies Section as a check on results obtained from the macrofaunal assemblage.

Initially, the heavy fractions of all bulk soil samples were "picked" for bone. These bones and any located by the Botanical Studies Section during their examination of light and heavy fractions were scanned for diagnostic elements. Such scanning procedures are one means of dealing with vast quantities of small-scale remains (Neusius 1978), but they cannot be relied on to provide a representative list of taxa or skeletal elements.

In 1981, a new approach to the study of bulk soil remains was initiated. The goal of this new approach was to check the taxonomic composiiton of the DAP faunal assemblage. Two groups of animals, fish and very small mammals such as shrews, mice, and voles, could have been under-represented among the macrofaunal remains. While fish generally have been considered to have been unimportant in Anasazi economics, recovery procedures usually have not been good enough to unequivocally demonstrate that such was the case. Furthermore, the Dolores Anasazi inhabited a comparatively well watered environment in which some fish would have been available. For these reasons, it was important to establish that use of fish was as minor as suggested by the macrofaunal assemblage.

With respect to small mammals, the primary concern was not dietary or economic reconstruction, but the possibility that key environmental indicators had been overlooked. Many small mammals are excellent indicators of environmental change because they are particularly sensitive to such change. Even though the analysis of this type of material could not have been performed at the Dolores faunal laboratory, consultation with specialists would have been warranted if the bulk soil samples had been rich in this type of material.

Given these research goals, the nonhuman bone recovered from bulk soil samples had to be examined in a more detailed manner than it had been previously. All midden samples and a 5-percent random sample of all other bulk soil samples from cultural contexts were selected for study, and each bone fragment was to be studied and coded in the same way as the macrofaunal remains (Neusius and Canaday 1985). Thus, subsampling was done at the sample level rather than at the level of individual bones. Due to time and personnel constraints, only materials from the midden samples were identified.

As a result of these changing approaches, the microfaunal assemblage is not as representative as the macrofaunal assemblage. However, 5723 fragments of bone have been examined. This assemblage is not without implications for resource mix.

The miscellaneous category of faunal remains from the DAP includes 3 small assemblages of bone. None of these are considered in this chapter, but the reader should be advised of their existence. The first of these consists of nonhuman bone recovered from coprolite samples. These bones have been listed in Jones (1983). Although these remains may be of dietary significance, the sample is too minuscule to be interpretable. The second assemblage consists of the bones of an extinct musk ox (*Symbos* sp.) recovered from eolian deposits beneath the Grass Mesa Village site (site 5MT23). These remains, which apparently are not associated with the human habitation of the Dolores area, have been described in detail in Clay, Canaday, and Neusius (1985) and in McDonald et al. (1985). Finally, some nonhuman bone was collected from packrat middens at Site 5MT4654 (Emslie 1985; Van Devender 1985). These materials were not studied further, but they are available for analysis and may be of environmental significance.

Procedures

Field and laboratory procedures have had both positive and negative effects on the DAP faunal data base. Neusius (1985b) and Neusius and Gould (1985) have considered some possible effects; however, judgments concerning the quality of the DAP faunal data base remain largely subjective. The following review of the procedures employed by the DAP highlights areas in which recovery and analytical procedures may have had an effect on the faunal assemblage. Further study would be required to arrive at an objective assessment of the influence of archaeological procedures.

Two general methods of sampling were employed at DAP sites. The probability sampling program described by Kohler and Gross (1984) has provided useful estimates of artifact and structure populations (Kohler 1985). A less formal judgmental approach to sampling also was employed by the DAP. Two differences between probability and judgmental sampling pertain to the amount of screening (more in probability sampling than in judgmental sampling) and the emphasis on structural contexts (less in probability sampling than in

judgmental sampling). However, preliminary comparison of the faunal assemblages from these 2 types of samples indicates only minor differences (Neusius 1985b; Neusius and Gould 1985).

Nevertheless, the faunal remains recovered from different context types do appear to vary (Neusius and Gould 1985). Therefore, the types of contexts sampled may affect the composition of the DAP faunal assemblage. Table 4.28 provides a list of context types represented in the DAP faunal assemblage. This table provides only the most general means of assessing the representativeness of the assemblage, because the obvious emphasis on pitstructures may reflect selection of more of these contexts for excavation, more thorough excavation of these contexts, better preservation within these contexts, disposal of refuse in abandoned structures, or catastrophic abandonment of pitstructures. No attempt is made in this section to attribute the amount or the type of faunal remains from various contexts to one or more factors. However, this topic should not be wholly ignored and the assemblages from individual time periods should be evaluated with respect to context.

As for the types of activities represented by these remains, a breakdown of use area types for the assemblage indicates that much of the material comes from contexts classified as "unknown" in terms of use area type (table 4.29). Otherwise, the bone usually comes from contexts interpreted to be general-purpose use areas. Relatively little faunal material is clearly assignable at the activity area level.

Several recovery methods were employed in the collection of this data base (table 4.30). Variability in collection procedures is a necessity for large mitigation projects such as the DAP, because some sites are excavated quickly, while others are intensively excavated. However, different procedures result in faunal assemblages that differ in representativeness and that may not be comparable.

Kane and Robinson (1984) sought to deal with the problem of representativeness and comparability by defining assemblage and nonassemblage mode techniques on the basis of how representative the recovery was likely to be. They then provided guidelines for the use of these 2 techniques during excavation. Neusius (1985b) and Neusius and Gould (1985) have examined differences in the taxonomic and element composition of faunal assemblages according to collection mode. In general, these studies suggest only weak correlations between collection mode and assemblage composition. However, troweling may be a less reliable method of obtaining a representative faunal sample than assumed by Kane and Robinson (refer to Neusius and Gould [1985]).

Figure 4.6 provides a quick assessment of relative representativeness if one accepts Payne's (1975) suggestion that percent identifiable is inversely related to sample representativeness. Low percentages of identifiable remains are believed by Payne to indicate more representative assemblages. As shown in figure 4.6, the percent identifiable varies from 6.1 to 42.1 percent, with screening resulting in the lowest percentages, and shoveling and heavy equipment producing the highest. Surface collection and other methods produce unexpectedly low percentages (less than 30 percent). The low percentage of identifiable remains in surface collections can perhaps be explained by the more extensive weathering and breakage of bones from such contexts and by the collecting and processing procedures used for surface materials. These figures generally support Kane and Robinson's (1984) grouping of assemblage and nonassemblage mode techniques, although troweling, with 34.9 percent identifiable, clearly is not an assemblage mode technique.

Identification procedures for DAP faunal remains have been discussed in detail in Neusius and Canaday (1985). Identifications were made by comparisons to modern reference skeletons in the Anasazi Heritage Center collection or on loan to the Faunal Studies Section. Prior to 1981, the collections of the Center for Western Studies (Flagstaff, Arizona) also were consulted (Emslie 1982). When comparative material was lacking, or when metric analysis was too time consuming, identifications were made only to higher taxonomic levels. The "compares favorably" designation (c.f.) also was used to indicate identifications made with less reliability.

A detailed computer coding format was employed for all specimens. Record was made of provenience, human and nonhuman modification, taxon, element side, element type, element portion, number of items, age of breakage, cut marks, and burning. Additional information also was recorded less formally with a code in the computer file. Neusius and Canaday (1985) provide detailed coding instructions.

Several secondary intensive studies that provide important supplementary data also were undertaken by the Faunal Studies Section. These studies include indentification of cottontail mandibles and use of this information to test a hypothesis of localized procurement (Flint and Neusius 1985; Neusius and Flint 1985), detailed measurement and analysis of canid remains from DAP sites (Clark et al. 1985), and development of a computer program for the calculation of MNI's (Udick and Gross 1985). All of these studies have been

Table 4.28 – Context types represented in the Dolores Archaeological Program faunal assemblage

	Not features		Benches		Wall features		Artifact features		Burial features		Fire-related features		Storage features		Ritual features		Other features		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Surface structures																				
Associated with surfaces	2 619	3.2	X		53	0.1	36	0.0	123	0.2	2345	2.9	689	0.8	X		751	0.9	6 616	8.1
Not associated with surfaces	6 837	8.3	X		X		0	0.0	4	0.0	1	0.0	655	0.8	X		2	0.0	7 499	9.2
Total	9 456	11.5	X		53	0.1	36	0.0	127	0.2	2346	2.9	1344	1.6	X		753	0.9	14 115	17.2
Pitstructures																				
Associated with surfaces	5 208	6.4	575	0.7	2562	3.1	30	0.0	284	0.3	3787	4.6	2915	3.6	265	0.3	3502	4.3	19 128	23.3
Not associated with surfaces	17 357	21.2	X		X		374	0.5	114	0.1	41	0.1	8	0.0	X		175	0.2	18 069	22.0
Total	22 565	27.5	575	0.7	2562	3.1	404	0.5	398	0.5	3828	4.7	2923	3.6	265	0.3	3677	4.5	37 197	45.4
Miscellaneous structures																				
Associated with surfaces	0	0.0	172	0.2	0	0.0	0	0.0	0	0.0	56	0.1	39	0.0	0	0.0	0	0.0	267	0.3
Not associated with surfaces	173	0.2	X		X		0	0.0	0	0.0	0	0.0	0	0.0	X		0	0.0	173	0.2
Total	173	0.2	172	0.2	0	0.0	0	0.0	0	0.0	56	0.1	39	0.0	0	0.0	0	0.0	440	0.5
Nonstructural units																				
Associated with surfaces	1 067	1.3	X		X		28	0.0	105	0.1	650	0.8	100	0.1	X		2190	2.7	4 140	5.1
Not associated with surfaces	10 289	12.6	X		X		0	0.0	224	0.3	0	0.0	0	0.0	X		8	0.0	10 521	12.8
Total	11 356	13.9	X		X		28	0.0	329	0.4	650	0.8	100	0.1	X		2198	2.7	14 661	17.9
Excavation units																				
Total	2 792	3.4	X		X		0	0.0	0	0.0	0	0.0	43	0.1	X		4	0.0	2 839	3.5
RDA's																				
Total	1 625	2.0	X		X		0	0.0	0	0.0	0	0.0	0	0.0	X		0	0.0	1 625	2.0
Grid squares																				
Total	9 884	12.1	X		X		3	0.0	36	0.0	85	0.1	17	0.0	X		517	0.6	10 542	12.9
Other Proveniences																				
Total	341	0.4	X		X		0	0.0	1	0.0	49	0.1	0	0.0	X		137	0.2	528	0.6
Total	58 192	71.0	747	0.9	2615	3.2	471	0.6	891	1.1	7014	8.6	4466	5.4	265	0.3	7286	8.9	81 947	

An "X" in the N column indicates that a particular provenience-feature combination is not possible; for example, benches do not occur in surface structures.

Table 4.29 – Use area types represented in the Dolores Archaeological Program faunal assemblage

Use area type	No. of bones	% of total
Intrahousehold or household		
Economic	7 269	8.9
Domestic	7 275	8.9
Multipurpose	12	0.0
nfs	2 469	3.0
Interhousehold		
Economic	4 026	4.9
Multipurpose	15 989	19.5
nfs	34	0.0
Roomblock		
Economic	2 070	2.5
Integrative	990	1.2
Multipurpose	474	0.6
Community cluster		
Integrative	100	0.1
nfs	64	0.1
No group assigned	9 472	11.6
Unknown	31 703	38.7
Total	81 947	100.0

nfs – Not further specified.

documented elsewhere and are not discussed further in this report.

The Effects of Postdepositional Processes

Due to practical considerations, relatively little attention could be paid to the issue of postdepositional transformation of the Dolores faunal assemblage. Except for a study of pitstructure filling (Petersen et al. 1985), analyses of site formation processes have not been carried out by the DAP. Chemical analysis of sediments at DAP sites also has been limited (Clay, Petersen, and Decker [1985]). Further work is required to understand the possible effects of postdepositional processes; however, both the condition of the faunal remains and the good contextual control achieved during excavation allow some degree of confidence about this data base.

Alteration of DAP faunal remains by carnivores and rodents has been recorded when observed. The incidence of both types of gnawing is low. Bones from rodent burrows have been deleted from the assemblage. However, examination of the other types of contexts containing gnawed bone might prove informative.

Similarly, most of the DAP faunal remains are well preserved and nonfriable, and they exhibit very little checking or exfoliation. Again, study of the contexts from which weathered bone was recovered might be informative.

Finally, detailed provenience information is available for all the DAP faunal remains. For analytic purposes, bone from contexts identified as recently disturbed has not been included in the analyses. In general, such areas were not excavated, and the materials were not collected. Nevertheless, a review of this information might provide some insights into postdepositional processes.

RESOURCE AVAILABILITY

Abundant information on this topic has been compiled by the DAP; the "raw data" are presented in Neusius (1985a). Although these data require critical evaluation, they do represent a comprehensive list of the species probably available, and they give some information on the types of habitats in which each species might have been found. However, all of the animals listed would not have been important Anasazi resources. Also, resource distribution, abundance, and preference may have changed through time. Even if the time frame is restricted to the period between A.D. 600 and 950, during which the principal Anasazi occupation occurred, possible changes in resources availability should be considered.

Thus, the concern in the following discussion is the transformation of the data presented in Neusius (1985a) into a more usable form. The first problem considered is which resources might have been preferred by the Dolores Anasazi. A wide variety of resources would have been available, but not all of these would have been good sources of food and raw materials and easily procured. Which species were most likely to have been exploited? The second problem is whether significant variation in faunal resource supply occurred prehistorically. Two possible sources of change in availability are considered here. These are climatic change and the impact of humans.

Preferred Resources

Because description of the archaeological faunal remains was the first priority, and because time, personnel, and library access was limited, the issue of preference has not been completely explored. However, despite the fact that a thorough investigation of this problem was beyond the scope of this chapter, a simplified approach was developed and applied to the

Table 4.30 – Collection mode used in the recovery of the Dolores Archaeological Program faunal assemblage*

Collection mode	Identifiable NHB†		Indeterminate NHB		Total NHB	
	No. of bones	% of total	No. of bones	% of total	No. of bones	% of total
One-sixteenth-inch screen, wet and dry	263	0.3	4 035	4.9	4 298	5.2
One-eighth-inch screen, wet and dry	1 013	1.2	4 273	5.2	5 286	6.5
One-quarter-inch screen, wet and dry	9 345	11.4	25 532	31.2	34 877	42.6
Other screen methods	455	0.6	6 197	7.6	6 652	8.1
Trowel	5 021	6.1	9 371	11.4	14 392	17.6
Mixed methods	4 939	6.0	7 029	8.6	11 968	14.6
Shovel	557	0.7	765	0.9	1 322	1.6
Heavy equipment	636	0.8	881	1.1	1 517	1.9
Surface collection	220	0.3	690	0.8	910	1.1
Other methods	199	0.2	526	0.6	725	0.9
Total	22 648	27.6	59 299	72.4	81 947	100.0

* Only the collection mode used for most of a context was recorded. Thus, bulk soil sampling does not appear here, and bones from bulk soil samples are grouped according to the method of collection generally used for that provenience.
† Identifiable at least to order.
NHB – Nonhuman bone.

mammalian species listed by Neusius (1985a). The following discussion describes the method used and proposes several lists of mammalian resources against which the archaeological data can be evaluated. The reader is referred to recent sources that use optimal foraging theory and linear programming to model resource use among hunter-gatherers (Winterhalder and Smith 1981; Reidhead 1976; Keene 1981) and to Hastorf's (1980) work with the prehistoric agriculturalists of the Mimbres Valley for examples of in-depth resource studies.

It is assumed relative biomass can be used to assess the probability of inclusions in the Dolores Anasazi diet. Those species with the highest relative biomass were most likely to have been exploited, and the probability of inclusion in the diet decreased along with decreasing biomass. It is not assumed that natural biomass can be used to predict either the proportion of a species in the diet or the number of species (diet breadth). Thus, only a generalized understanding of those animals most likely to be part of the resource mix can be gained from biomass estimates.

In the strictest sense, this assumption is naive. Inclusion in the diet certainly is a function of a complex set of factors of which natural biomass is only one (Earle 1980). Nevertheless, this approach provides a starting point. Perhaps more importantly, with only a small amount of additional information, the data given by Neusius (1985a) can be transformed into relative biomass estimates, and a clearer picture of the implications of resource availability can be gained.

Biomass estimates usually are derived by multiplying the average density of a species by the average weight per individual of that species. Average weights can be obtained easily from many sources that provide descriptions of taxa (e.g., Nowak and Paradiso 1983; Lechleitner 1969). However, the use of averages for species that display sexual dimorphism or extreme variation in size could be questioned.

Density figures are more of a problem. These are scattered throughout the ecological, wildlife management, and zoological literature. Accurate figures for specific regions are difficult to obtain. However, Neusius (1985a) included the qualitative abundance estimates from the Colorado latilong studies (Bissell 1978; Bissell and Dillon 1982; Hammerson and Langlois 1981; Chase et al. 1982; Kingery and Graul 1978). Following Yesner (1981), these estimates can be transformed into numerical figures, as shown in table 4.31, and used to provide biomass rankings. It must be stressed that these rankings do not provide real estimates of density or

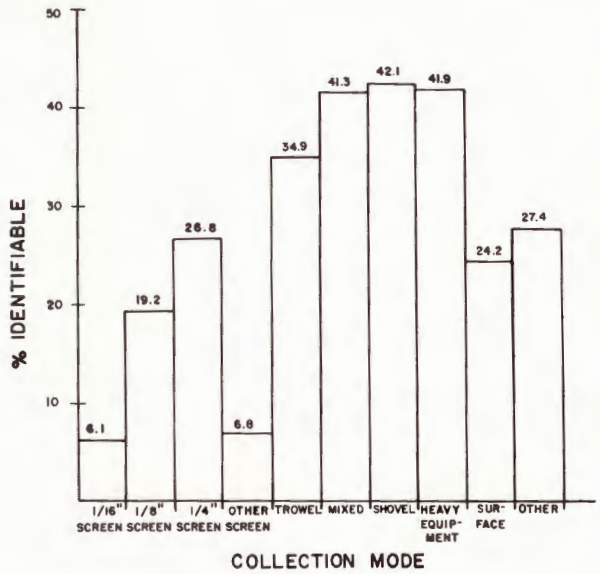

Figure 4.6 – Percent identifiable in the faunal assemblage for each collection mode. Percent based on total number of bones within each collection mode category.

Table 4.31 – Transformation of qualitative abundance estimates

Qualitative abundance	Rank	Relative order of magnitude
Abundant	1	10^2
Common	2	10^1
Fairly common	3	10^0
Unusual	4	10^{-1}
Rare	5	10^{-2}
Undetermined	3	10^0

biomass, but relative ones, which it is hoped are reasonably accurate. The use of powers of 10 is arbitrary; it follows Yesner (1981:appendix 2) and, to some extent, Fay and Cade (1959:83-87). The author finds the use of powers of 10 preferable to the use of the constants 1 through 5, because, with the former, density is weighted fairly equally with average meat weight as a result. Otherwise, density tends to be insignificant in comparison to meat weight.

Table 4.32 contains the calculation of biomass ranks for the mammals listed by Neusius. A general rank is calculated first, and then adjustments are made for seasonal availability, following the discussion in Neusius (1985a). Species not available for the entire year are assigned lower biomass figures by this adjustment. It is probably not accurate to assume that a species either was or was not present during a given season. Instead, relative abundance should be adjusted for each season and an average calculated; as done by Yesner (1981). However, qualitative abundance estimates were not available by season, so only presence/absence could be estimated.

A second difficulty is in assessing the influence of hibernation or winter dormancy. In some instances, hibernation may simply make an animal's location more predictable rather than make the animal unavailable. Thus, 2 rankings adjusted for season were calculated (table 4.32). In the first, hibernation was assumed to remove the species from the group of available resources. In the second, shown in parentheses, these species were assumed to remain available.

No adjustment has been made in table 4.32 for the habitat distributions of these species, although these distributions certainly affect the biomass available. Although information on the areal extent for each habitat type was not available to the author when this section was being prepared, such information can be obtained in other DAP reports (Petersen 1985c; Orcutt 1984b). Correction for the extent of the Escalante Sector or of an individual site catchment would result in refined predictions of resource preference.

Tables 4.33, 4.34, and 4.35 present several rankings of mammalian resources. In table 4.33, general preference lists for mammals are given. These lists, which are reordering a species listed in table 4.32 according to rank rather than taxonomy, include an unadjusted ranking and 2 variants of a ranking adjusted for season. These rankings might be compared with the total DAP faunal assemblage to obtain a general understanding of whether biomass might have influenced resource selection.

Table 4.34 presents a similar set of rankings, except that species considered unavailable within each season are deleted. This list might be useful in considering season of occupation for particular sites. For example, the faunal assemblage from all field houses might be compared to the summer preference list.

Table 4.35 presents habitat-specific rankings. These might be used to assess habitat utilization by the inhabitants of various sites. For example, Neusius (1983a, 1983b) suggested the use of the riparian habitat by the inhabitants of LeMoc Shelter (Site 5MT2151) and Prince Hamlet (Site 5MT2161) seemed lower than one would expect based on the proximity of these sites to this vegetation zone. These preference rankings could be used to more closely examine habitat utilization at such sites.

The rankings in these tables serve 2 purposes. First, they demonstrate the issue of resource preference can be addressed using Neusius' (1985a:table 13) data and a small amount of additional information. The actual

Table 4.32 – Calculation of relative biomass estimates and ranks for mammalian species probably present in the Escalante Sector prehistorically

Scientific name*	Common name*	Qualitative abundance assessment†	Relative abundance estimate§	Average adult weight** (kg)	Percent edible	Edible meat weight (kg)	Relative biomass estimate†† (kg)	Rank within class	No. of seasons present§§ ***	Adjusted relative biomass***	Rank adjusted for season availability***
Sorex vagrans	Wandering shrew	Common	10^1	0.010	50	0.005	0.050	50	4	0.050	50 (51)
Sorex nanus	Dwarf shrew	Undetermined	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Sorex palustris	Water shrew	Fairly common	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Sorex merriami	Merrian's shrew	Undetermined	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Microsorex hoyi	Pygmy shrew	Undetermined	10^0	.004	50	.002	.002	56	4	.002	59 (60)
Myotis lucifugus	Little brown bat	Common	10^1	.010	50	.005	.050	50	4	.050	50 (57)
Myotis yumenensis	Yuma myotis	Fairly common	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Myotis evotis	Long-eared myotis	Undetermined	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Myotis thysanodes	Fringed myotis	Rare	10^{-2}	.010	50	.005	.000	57	4	.000	61 (62)
Myotis californicus	California myotis	Undetermined	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Myotis leibii	Small-footed myotis	Fairly common	10^0	.010	50	.005	.005	55	4	.005	57 (58)
Myotis volans	Long-legged myotis	Common	10^1	.010	50	.005	.050	50	4	.050	50 (51)
Lasionycteris noctivagans	Silver-haired bat	Undetermined	10^0	.010	50	.005	.005	55	3	.004	58 (59)
Pipistrellus hesperus	Western pipistrelle	Common	10^1	.012	50	.006	.060	48	4	.060	48 (49)
Eptesicus fuscus	Big brown bat	Common	10^1	.022	50	.011	.110	44	4	.110	44 (44)
Lasiurus cinereus	Hoary bat	Common	10^1	.018	50	.009	.090	45	3	.068	47 (48)
Plecotus townsendii	Townsend's big eared bat	Common	10^1	.013	50	.007	.070	47	4	.070	46 (47)
Antrozous pallidus	Pallid bat	Fairly common	10^0	.023	50	.012	.012	53	4	.072	53 (54)
Tadarida brasiliensis	Brazilian free-tailed bat	Rare	10^{-2}	.013	50	.007	.000	57	3	.000	61 (62)
Sylvilagus nuttallii	Nuttall's cottontail	Common	10^1	1.473	50	.737	7.370	24	4	7.370	24 (24)
Sylvilagus audubonii	Desert cottontail	Abundant	10^2	1.473	50	.737	73.700	8	4	73.700	8 (8)
Lepus americanus	Snowshoe hare	Common	10^1	1.703	50	.852	8.520	23	4	8.520	22 (23)
Lepus townsendii	White-tailed jackrabbit	Common	10^1	3.819	50	1.910	19.100	20	4	19.100	20 (20)
Lepus californicus	Black-tailed jackrabbit	Abundant	10^2	3.274	50	1.637	163.70	6	4	163.700	5 (5)
Eutamias minimus	Least chipmunk	Common	10^1	.064	50	.032	.320	38	3 (4)	.240 (.320)	40 (38)
Eutamias quadrivittatus	Colorado chipmunk	Common	10^1	.064	50	.032	.320	38	3 (4)	.240 (.320)	40 (38)
Marmota flaviventris	Yellow-bellied marmot	Common	10^1	5.120	50	2.560	25.600	16	3 (4)	19.200 (25.600)	19 (16)
Amnospermophilus leucurus	White-tailed antelope squirrel	Undetermined	10^0	.114	50	.057	.057	49	4	.057	49 (50)
Spermophilus spilosome	Spotted ground squirrel	Fairly common	10^0	.113	50	.057	.057	49	4	.057	49 (50)
Spermophilus lateralis	Golden-mantled ground squirrel	Abundant	10^2	.235	50	.118	11.800	21	3 (4)	8.850 (11.800)	21 (21)
Spermophilus variegatus	Rock squirrel	Common	10^1	.838	50	.419	4.190	28	4	4.190	26 (28)
Cynomys gunnisoni	Gunnison's prairie dog	Common	10^1	.925	50	.463	4.630	26	3 (4)	3.463 (4.630)	28 (26)
Sciurus aberti	Abert's squirrel	Fairly common	10^0	.600	50	.300	.300	39	4	.300	38 (39)
Tamiasciurus hudsonicus	Chickaree	Common	10^1	.227	50	.114	1.140	33	4	1.140	33 (33)
Thomomys bottae	Valley pocket gopher	Common	10^1	.340	50	.170	1.700	32	4	1.700	32 (32)
Thomomys talpoides	Northern pocket gopher	Common	10^1	.340	50	.170	1.700	32	4	1.700	32 (32)
Perognathus flavus	Silky pocket mouse	Common	10^1	.027	50	.014	.140	43	4	.140	43 (43)
Perognathus apache	Apache pocket mouse	Undetermined	10^0	.027	50	.014	.014	52	4	.014	52 (53)
Dipodomys ordii	Ord's kangaroo rat	Abundant	10^2	.108	50	.054	5.400	25	3 (4)	4.050 (5.400)	27 (25)
Castor canadensis	Beaver	Common	10^1	17.190	70	12.033	120.330	7	4	120.330	6 (6)
Reithrodontomys megalotis	Western harvest mouse	Abundant	10^2	.013	50	.007	.700	35	4	.700	35 (35)
Peromyscus maniculatus	Deer mouse	Abundant	10^2	.039	50	.020	2.000	31	4	2.000	31 (31)

Table 4.32 – Calculation of relative biomass estimates and ranks for mammalian species probably present in the Escalante Sector prehistorically – Continued

Scientific name*	Common name*	Qualitative abundance assessment†	Relative abundance estimate§	Average adult weight** (kg)	Percent edible	Edible meat weight (kg)	Relative biomass estimate†† (kg)	Rank within class	No. of seasons present§§ ***	Adjusted relative biomass***	Rank adjusted for seasonal availability***
Peromyscus boylii	Brush mouse	Undetermined	10^0	0.039	50	0.020	0.020	51	4	0.020	51 (52)
Peromyscus truei	Pinyon mouse	Common	10^1	.039	50	.020	.200	42	4	.200	42 (42)
Peromyscus crinitus	Canyon mouse	Common	10^1	.039	50	.020	.200	42	4	.200	42 (42)
Onychomys leucogaster	Northern grasshopper mouse	Common	10^1	.042	50	.021	.210	41	4	.210	41 (41)
Neotoma cinerea	Bushy-tailed wood rat	Common	10^1	.227	50	.114	1.140	33	4	1.140	33 (33)
Neotoma mexicana	Mexican wood rat	Common	10^1	.227	50	.114	1.140	33	4	1.140	33 (33)
Neotoma albigula	White-throated wood rat	Common	10^1	.227	50	.114	1.140	33	4	1.140	33 (33)
Microtus montanus	Montane vole	Abundant	10^2	.049	50	.205	2.500	30	4	2.500	29 (30)
Microtus longicaudus	Long-tailed vole	Common	10^1	.049	50	.025	.250	40	4	.250	39 (40)
Microtus mexicanus	Mexican vole	Rare	10^{-2}	.049	50	.025	.000	57	4	.000	61 (62)
Microtus pennsylvenicus	Meadow vole	Common	10^1	.049	50	.025	.250	40	4	.250	39 (40)
Ondatra zibethicus	Muskrat	Abundant	10^2	1.249	50	.625	62.500	10	4	62.500	10 (10)
Zapus princeps	Western jumping mouse	Common	10^1	.017	50	.009	.090	45	3 (4)	.068 (.090)	47 (45)
Erethizon dorsatum	Porcupine	Common	10^1	7.518	50	3.759	37.590	13	4	37.590	13 (13)
Canis latrans	Coyote	Common	10^1	12.900	50	6.450	64.500	9	4	64.500	9 (9)
Canis lupus	Gray wolf	Undetermined	10^0	47.229	50	23.615	23.615	18	4	23.615	17 (18)
Vulpes vulpes	Red fox	Common	10^1	4.653	50	2.327	23.270	19	4	23.270	18 (19)
Vulpes macrotis	Kit fox	Rare	10^{-2}	2.050	50	1.025	.000	54	4	.000	55 (56)
Urocyon cinereoargenteus	Gray fox	Common	10^1	4.750	50	2.375	23.750	17	4	23.750	16 (17)
Ursus americanus	Black bear	Common	10^1	144.564	50	72.28	722.820	2	3 (4)	542.120 (722.820)	1 (1)
Bassariscus astutus	Ringtail	Fairly common	10^0	1.081	50	.541	.541	37	4	.541	37 (37)
Procyon lotor	Raccoon	Common	10^1	7.000	50	3.500	35.000	14	3 (4)	26.250 (35.000)	15 (14)
Martes americana	Marten	Common	10^1	.886	50	.443	4.430	27	4	4.430	25 (27)
Mustela erminea	Ermine	Fairly common	10^0	.150	50	.075	.075	46	4	.075	45 (46)
Mustela vison	Mink	Fairly common	10^0	1.153	50	.577	.577	36	4	.577	36 (36)
Mustela frenata	Long-tailed weasel	Common	10^1	.224	50	.112	1.120	34	4	1.120	34 (34)
Taxidea taxus	Badger	Common	10^1	8.354	50	5.848	58.480	11	4	58.480	11 (11)
Spilogale putorius	Spotted skunk	Common	10^1	.567	50	.284	2.840	29	3 (4)	2.130 (2.840)	30 (29)
Mephitis mephitis	Striped skunk	Common	10^1	2.117	50	1.058	10.580	22	3 (4)	7.935 (10.580)	23 (22)
Lynx rufus	Bobcat	Common	10^1	9.593	50	4.797	47.970	12	4	47.970	12 (12)
Felis concolor	Mountain lion	Fairly common	10^0	66.500	50	33.250	33.250	15	4	33.250	14 (18)
Cervus elaphus	American elk	Common	10^1	210.531	58.7	123.582	1235.820	1	1	308.955	3 (3)
Odocoileus hemionus	Mule deer	Common	10^1	100.567	50	50.284	502.840	3	3	377.130	2 (2)
Antilocapra americana	Pronghorn	Common	10^1	51.638	50	25.819	258.190	5	3	193.643	4 (4)
Ovis canadensis	Bighorn	Common	10^1	76.304	50	38.152	381.520	4	1	95.380	7 (7)

* Species list obtained from Neusius (1985a:table 13), excluding species known only from habitats other than those reconstructed for the Escalante Sector or from adjacent latilongs, unless these species are present archaeologically.

† Abundance compiled from Bissell and Dillon (1982); Chase et al. (1982); and Hammerson and Langlois (1981).

§ Following Yesner (1981); refer to text and table 4.31.

** Compiled from Nowak and Paradiso (1983).

†† Relative abundance estimate times edible meat weight.

§§ From Neusius (1985a).

*** Numbers in parentheses indicate number of seasons or rank if hibernation is considered to have no effect on species availability.

rankings might need additional adjustments to better approximate actual preference patterns. For example, large carnivores such as bears and mountain lions tend to rank high on these lists; yet these animals would have been difficult and dangerous to catch. Biomass alone would not likely have dictated the exploitation of these species. However, that this questions arises indicates the utility of this approach rather than its inadequacy. This approach, though overly simplistic, provides a better understanding of preferences in resource selection than no attempt at all.

Second, this attempt to rank mammals according to the biomass they provide sheds light on some aspects of

Table 4.33 – The 25 mammals most likely to have been exploited based on general and seasonally adjusted biomass rankings

General		Adjusted for season 1*		Adjusted for season 2*	
Cervus elaphus	American elk	*Ursus americanus*	black bear	*Ursus americanus*	black bear
Ursus americanus	black bear	*Odocoileus hemionus*	mule deer	*Odocoileus hemionus*	mule deer
Odocoileus hemionus	mule deer	*Cervus elaphus*	American elk	*Cervus elaphus*	American elk
Ovis canadensis	bighorn	*Antilocapra americana*	pronghorn	*Anitlocapra american*	proghorn
Antilocapra americana	pronghorn	*Lepus californicus*	black-tailed jackrabbit	*Lepus californicus*	black-tailed jackrabbit
Lepus californicus	black-tailed jackrabbit	*Castor canadensis*	beaver	*Castor canadensis*	beaver
Castor canadensis	beaver	*Ovis canadensis*	bighorn	*Ovis canadensis*	bighorn
Sylvilagus audubonii	desert cottontail	*Sylvilagus audubonii*	desert cottontail	*Sylvilagus audubonii*	desert cottontail
Canis latrans	coyote	*Canis latrans*	coyote	*Canis latrans*	coyote
Ondatra ziebethicus	muskrat	*Ondatra zibethicus*	muskrat	*Ondatra zibethicus*	muskrat
Taxidea taxus	badger	*Taxidea taxus*	badger	*Taxidea taxus*	badger
Lynx rufus	bobcat	*Lynx rufus*	bobcat	*Lynx rufus*	bobcat
Erethizon dorsatum	porcupine	*Erethizon dorsatum*	porcupine	*Erethizon dorsatum*	porcupine
Procyon lotor	raccoon	*Felis concolor*	mountain lion	*Procyon lotor*	raccoon
Fells concolor	mountain lion	*Procyon lotor*	raccoon	*Felis concolor*	mountain lion
Marmota flaviventris	yellow-bellied marmot	*Urocyon cinereoargenteus*	gray fox	*Marmota flaviventris*	yellow-bellied marmot
Urocyon cinereoargenteus	gray fox	*Canis lupus*	gray wolf	*Urocyon cinereoargenteus*	gray fox
Canis lupus	gray wolf	*Vulpes vulpes*	red fox	*Canis lupus*	gray wolf
Vulpes vulpes	red fox	*Marmota flaviventris*	yellow-bellied marmot	*Vulpes vulpes*	red fox
Lepus townsendii	white-tailed jackrabbit	*Lepus townsendii*	white-tailed jackrabbit	*Lepus townsendii*	white tailed jackrabbit
Spermophilus lateralis	golden-mantled ground squirrel	*Spermophilus lateralis*	golden-mantled ground squirrel	*Spermophilus lateralis*	golden-mantled ground squirrel
Mephitis mephitis	striped skunk	*Lepus americanus*	snowshoe hare	*Mephitis mephitis*	striped skunk
Lepus americanus	snowshoe hare	*Mephitis mephitis*	striped skunk	*Lepus americanus*	snowshoe hare
Sylvilagus nuttallii	Nuttall's cottontail	*Sylvilagus nuttallii*	Nuttall's cottontail	*Sylvilagus nuttallii*	Nuttall's cottontail
Dipodomys ordii	Ord's kangaroo rat	*Martes americana*	marten	*Dipodomys ordii*	Ord's kangaroo rat

* Hibernation assumed to remove some species from group of available resources.
† Hibernation assumed to have no effect on species availability.

Table 4.34 – Mammals most likely to have been exploited during each season

Winter 1*		Winter 2†		Spring		Summer		Fall	
Cervus elaphus	American elk	*Cervus elaphus*	American elk	*Ursus americanus*	black bear	*Ursus americanus*	black bear	*Ursus americanus*	black bear
Odocoileus hemionus	mule deer	*Ursus americanus*	black bear	*Odocoileus hemionus*	mule deer	*Antilocapra americana*	pronghorn	*Odocoileus hemionus*	mule deer
Ovis canadensis	bighorn	*Odocoileus hemionus*	mule deer	*Antilocapra americana*	pronghorn	*Lepus californicus*	black-tailed jackrabbit	*Antilocapra americana*	pronghorn
Lepus californicus	black-tailed jackrabbit	*Ovis canadensis*	bighorn	*Lepus californicus*	black-tailed jackrabbit	*Castor canadensis*	beaver	*Lepus californicus*	black-tailed jackrabbit
Castor canadensis	beaver	*Lepus californicus*	black-tailed jackrabbit	*Castor canadensis*	beaver	*Sylvigus audubonii*	desert cottontail	*Castor canadensis*	beaver
Sylvilagus audubonii	desert cottontail	*Castor canadensis*	beaver	*Sylvilagus audubonii*	desert cottontail	*Canis latrans*	coyote	*Sylvilagus audubonii*	desert cottontail
Canis latrans	coyote	*Sylvilagus audubonii*	desert cottontail	*Canis latrans*	coyote	*Ondatra zibethicus*	muskrat	*Canis latrans*	coyote
Ondatra zibethicus	muskrat	*Canis latrans*	coyote	*Ondatra zibethicus*	muskrat	*Taxidea taxus*	badger	*Ondatra zibethicus*	muskrat
Taxidea taxus	badger	*Ondatra zibethicus*	muskrat	*Taxidea taxus*	badger	*Lynx rufus*	bobcat	*Taxidea taxus*	badger
Lynx rufus	bobcat	*Taxidea taxus*	badger	*Lynx rufus*	bobcat	*Erethizon dorsatum*	porcupine	*Lynx rufus*	bobcat
Erethizon dorsatum	porcupine	*Lynx rufus*	bobcat	*Erethizon dorsatum*	porcupine	*Procyon lotor*	raccoon	*Erethizon dorsatum*	porcupine
Felis concolor	mountain lion	*Erethizon dorsatum*	porcupine	*Procyon lotor*	raccoon	*Felis concolor*	mountain lion	*Procyon lotor*	raccoon
Urocyon cinereoargenteus	gray fox	*Procyon lotor*	raccoon	*Felis concolor*	mountain lion	*Marmota flaviventris*	yellow-bellied marmot	*Felis concolor*	mountain lion
Canis lupus	gray wolf	*Felis concolor*	mountain lion	*Marmota flaviventris*	yellow-bellied marmot	*Urocyon cinereoargenteus*	gray fox	*Marmota flaviventris*	yellow-bellied marmot
Vulpes vulpes	red fox	*Marmota vlaviventris*	yellow-bellied marmot	*Urocyon cinereoargenteus*	gray fox	*Canis lupus*	gray wolf	*Urocyon cinereoargenteus*	gray fox
Lepus townsendii	white-tailed jackrabbit	*Urocyon cinereoargenteus*	gray fox	*Canis lupus*	gray wolf	*Vulpes vulpes*	red fox	*Canis lupus*	gray wolf
Lepus americanus	snowshoe hare	*Canis lupus*	gray wolf	*Vulpes vulpes*	red fox	*Lepus townsendii*	white-tailed jackrabbit	*Vulpes vulpes*	red fox
Sylvilagus nuttallii	Nuttall's cottontail	*Vulpes vulpes*	red fox	*Lepus townsendii*	white-tailed jackrabbit	*Spermophilus lateralis*	golden-mantled ground squirrel	*Lepus townsendii*	white-tailed jackrabbit
Martes americana	marten	*Lepus townsendii*	white-tailed jackrabbit	*Spermophilus lateralis*	golden-mantled ground squirrel	*Mephitis mephitis*	striped skunk	*Spermophilus lateralis*	golden-mantled ground squirrel
Spermophilus variegatus	rock squirrel	*Spermophilus lateralis*	golden-mantled ground squirrel	*Mephitis mephitis*	striped skunk	*Lepus americanus*	snowshoe hare	*Mephitis mephitis*	striped skunk
Spilogale putorius	spotted skunk	*Mephitis mephitis*	striped skunk	*Lepus americanus*	snowshoe hare	*Sylvilagus nuttallii*	Nuttall's cottontail	*Lepus americanus*	snowshoe hare
Microtus montanus	montane vole	*Lepus americanus*	snowshoe hare	*Sylvilagus nuttallii*	Nuttall's cottontail	*Dipodomys ordii*	Ord's kangaroo rat	*Sylvilagus nuttallii*	Nuttall's cottontail
Peromyscus maniculatus	deer mouse	*Sylvilagus nuttallii*	Nuttall's cottontail	*Dipodomys ordii*	Ord's kangaroo rat	*Cynomys gunnisoni*	Gunnison's prairie dog	*Dipodomys ordii*	Ord's kangaroo rat
Thomomys bottae	valley pocket gopher	*Dipodomys ordii*	Ord's kangaroo rat	*Cynomys gunnisoni*	Gunnison's prairie dog	*Martes americana*	marten	*Cynomys gunnisoni*	Gunnison's prairie dog
Tamiasciurus hudsonicus	chickaree	*Cynomys gunnisoni*	Gunnison's prairie dog	*Martes americana*	marten	*Spermophilus variegatus*	rock squirrel	*Martes americana*	marten

* Hibernation assumed to remove some species from group of available resources.
† Hibernation assumed to have no effect on species availability.

Table 4.35 – Mammals most likely to have been exploited within each habitat type*

Riparian transition	Aspen	Pinyon-juniper	Ponderosa pine	Douglas-fir	Scrub oak (mountail brush)	Sagebrush	Mountain meadow or parkland	Aquatic
Ursus americanus	*Cervus elaphus*	*Odocoileus hemionus*	*Cervus elaphus*	*Cervus elaphus*	*Cervus elaphus*	*Odocoileus hemionus*	*Cervus elaphus*	*Castor canadensis*
Odocoileus hemionus	*Castor canadensis*	*Lepus californicus*	*Canis latrans*	*Ursus americanus*	*Odocoileus hemionus*	*Ovis canadensis*	*Canis latrans*	*Canis latrans*
Castor canadensis	*Canis latrans*	*Canis latrans*	*Lynx rufus*	*Odocoileus hemionus*	*Ovis canadensis*	*Canis latrans*	*Taxidea taxus*	*Ondatra zibethicus*
Sylvilagus audubonii	*Erethizon dorsatum*	*Taxidea taxus*	*Erethizon dorsatum*	*Canis latrans*	*Lepus californicus*	*Taxidea taxus*	*Vulpes vulpes*	*Lynx rufus*
Canis latrans	*Marmota flaviventris*	*Erethizon dorsatum*	*Felis concolor*	*Lynx refus*	*Sylvilagus audubonii*	*Lynx rufus*	*Lepus townsendii*	*Procyon lotor*
Lynx rufus	*Vulpes vulpes*	*Marmota vlaviventris*	*Urocyon cinereoargenteus*	*Mephitis mephitis*	*Canis latrans*	*Urocyon cinereoargenteus*	*Mephitis mephitis*	*Vulpes vulpes*
Erethizon dorsatum	*Spermophilus lateralis*	*Urocyon cinereoargenteus*	*Lepus townsendii*	*Martes americana*	*Lynx rufus*	*Lepus townsendii*	*Sylvilagus nuttallii*	*Mephitis mephitis*
Procyon lotor	*Mephitis mephitis*	*Lepus townsendii*	*Mephitis mephitis*	*Peromyscus maniculatus*	*Erethizon dorsatum*	*Mephitis mephitis*	*Cynomys gunnisoni*	*Microtus montanus*
Felis concolor	*Lepus americanus*	*Spermophilus lateralis*	*Martes americana*	*Mustela frenata*	*Marmota flaviventris*	*Dipodomys ordii*	*Spermophilus variegatus*	*Peromyscus maniculatus*
Marmota flaviventris	*Peromyscus maniculatus*	*Mephitis mephitis*	*Spermophilus variegatus*	*Sorex vagrans*	*Urocyon cinereoargenteus*	*Spilogale putorius*	*Peromyscus maniculatus*	*Mustela frenata*
Urocyon cinereoargenteus	*Thomomys talpoides*	*Sylvilagus nuttallii*	*Peromyscus maniculatus*	*Sorex nanus*	*Lepus townsendii*	*Peromyscus maniculatus*	*Thomomys bottae*	*Reithrodontomys megalotis*
Vulpes vulpes	*Tamiasciurus hudsonicus*	*Spermophilus variegatus*	*Neotome mexicana*	*Sorex palustris*	*Mephitis mephitis*	*Thomomys talpoides*	*Thomomys talpoides*	*Microtus longicaudus*
Mephitis mephitis	*Neotoma cinerea*	*Spilogale putorius*	*Mustela frenata*		*Lepus americanus*	*Neotoma cinerea*	*Mustela frenata*	*Microtus pennsylvanicus*
Lepus americanus	*Mustela frenata*	*Peromyscus maniculatus*	*Eutamias minimus*		*Sylvilagus nuttallii*	*Mustela frenata*	*Eutamias minimus*	*Sorex vagrans*
Sylvilagus nuttallii	*Eutamias minimus*	*Neotoma cinerea*	*Eutamias quadrivittatus*		*Spermophilus variegatus*	*Reithrodontomys megalotis*	*Microtus pennsylvanicus*	*Sorex palustris*
Spermophilus variegatus	*Microtus longicaudus*	*Neotoma mexicana*	*Sciurus aberti*		*Microtus montanus*	*Microtus longicaudus*	*Mustela erminea*	
Spilogale putorius	*Zapus princeps*	*Neotoma albigula*	*Eptesicus fuscus*		*Peromyscus maniculatus*	*Onochomys leucogaster*	*Sorex vagrans*	
Microtus montanus	*Sorex vagrans*	*Mustela frenata*	*Zapus princeps*		*Thomomys talpoides*	*Peromyscus truel*	*Myotis leibii*	
Peromyscus maniculatus	*Peromyscus boylii*	*Bassariscus astutus*	*Lasiurus cinereus*		*Neotoma mexicana*	*Sorex merriami*		
Thomomys talpoides	*Sorex palustris*	*Eutamias minimus*	*Plecotus townsendii*		*Neotoma albigula*	*Myotis thysanodes*		
Tamiasciurus hudsonicus	*Myotis yumanensis*	*Eutamias quadrivittatus*	*Sorex vagrans*		*Mustela frenata*			
Neotoma cinerea	*Microsorex hoyl*	*Peromyscus truel*	*Sorex nanus*		*Bassariscus astutus*			
Mustela frenata		*Peromyscus crinitus*	*Myotis evotis*		*Eutamias minimus*			
Mustela vison		*Eptesicus fuscus*	*Lasionycteris noctivagans*		*Eutamias quadrivittatus*			
Eutamias minimus		*Lasiurus cinereus*	*Myotis thysanodes*		*Microtus longicaudus*			

* *Only naturally occurring habitats included.*

the environment of the Dolores area. With respect to mammals, seasonal variation appears to be less important than habitat distribution. Some habitats were noticeably less productive in terms of mammals than others (e.g., aquatic habitats, Douglas-fir forest). Fewer than 25 mammal species are listed for several of the habitat types, including sagebrush. Because sagebrush probably covered much of the Escalante Sector prehistorically (Petersen 1985c), the availability of mammalian fauna in the Dolores area may be more depauperate than it at first appears.

Temporal Variability

In the preceding discussion, resource availability and preference was treated as a constant throughout prehistory. This obviously is a fallacy. Two factors, climatic change and land clearing by the Anasazi, are believed to have affected the availability and distribution of resources during the peak period of occupation of the Dolores area (ca. A.D. 600 through 950).

For the A.D. 600-740 period, Petersen (1985a) reconstructs the environment of the Dolores area as being similar to that of today; however, during the A.D. 740-1000 period, he believes a shift upslope of the major vegetation zones could have occurred. (This shift is illustrated in figures 4.15 and 4.17 in section 6 of this chapter). During this time, an expansion of the portion of the Escalante Sector covered by both pinyon-juniper woodland and sagebrush is seen. During the A.D. 800-980 period, oakbrush or mountain brush also covers much of the area formerly supporting ponderosa pine, aspen, and Douglas-fir.

The impacts of this change on resource supply should have been subtle. Sagebrush is a less productive habitat than pinyon-juniper wood land, but oak/mountain brush is a more productive habitat than ponderosa pine, aspen, and Douglas-fir woodlands. Thus, the overall affects in biomass may have balanced out. A change in proportions of xeric Sonoran fauna may have occurred. The more interesting question pertains to changes in the habitats around individual sites. Figures 4.15 and 4.17 show significant changes may have occurred at the site catchment level. To look at the effects on supply and preference for each site, a catchment approach must be used and the figures in table 4.32 adjusted, tasks beyond the scope of this volume.

The timing of habitat change due to land clearing is less firm. It is assumed the Anasazi settlers of the Dolores area either cleared land for fields or removed trees for fuel and construction. Through time, a progressively larger part of the Escalante Sector was either under cultivation or was in the early stages of succession as population grew. With the population decline after A.D. 900, this trend should have reversed itself.

It also is assumed that land clearing had a generally positive effect on animal biomass because it would have increased the area of edge and the availability of food (greens, seeds, insects). Certain species are more likely to have been attracted to fields, their margins, fallow fields, or disturbed areas than others. Rabbits often prefer edges (e.g., Armstrong 1972:82, 85), and both cottontails (Bissell and Dillon 1982:7) and jackrabbits (Lechleitner 1969:73) are known to damage crops. Some species of ground squirrel and prairie dog damage crops (Lechleitner 1969:92, 98). Rock squirrels have been found in croplands (Bissell and Dillon 1982:9) and pocket gophers commonly are found in agricultural areas (Lechleitner 1969:109; Bissell and Dillon 1982:10). Various mice and vole species are obvious candidates for garden hunting species (Armstrong 1972; Lechleitner 1969).

Predators also would have been found in gardens and fields. These include: (1) coyotes, which are attracted to edges because of prey abundance (Armstrong 1972:255); (2) foxes, because they prey on rabbits, pocket gophers, and other rodents (Lechleitner 1969:111, 126); (3) raccoons, which are known to favor gardens and fields (Armstrong 1972:267; Lechleitner 1969:1984; Bissell and Dillon 1982:18); and (4) skunks, which also favor agricultural areas (Armstong 1972:286; Lechleitner 1969:201; Bissell and Dillon 1982:19).

Deer are attracted to fields and gardens; however, relatively few deer would have remained at the elevation of Dolores Anasazi fields during the summer. Birds also are attracted. Avian taxa that should be common have been specified by Emslie (1981:318-320). These include some species of waterfowl, hawks and falcons, turkey, sandhill crane, doves, owls, horned lark, nighthawks, swallows, robin, bluebirds, blackbirds, and meadowlarks.

Biomass estimates for areas under cultivation or in fallow could be generated for comparison with the estimates for other habitat types outlined above. This could be done on either an individual site basis or for the Escalante Sector as a whole, taking into account information on population density to achieve temporal variation. In future studies of Dolores area faunal resource availability, it would be important to include this habitat type. Certainly, the composition of Dolores faunal assemblages should be compared to the list of taxa available in and around fields and gardens, because garden hunting may have been an important game procurement strategy among the Dolores Anasazi (Emslie 1981; Linares 1976; Neusius 1984; Neusius and Phagan 1983).

RESOURCE MIX

Less justice has been done to the topic of resource mix than to resource availability. The primary reason for this is that the study of resource mix, except on a site-specific basis (e.g., Neusius 1983a, 1983b, 1985b, 1985d; Neusius and Gould 1985), was not possible until identifications were completed. Neusius (1985d) presented a basic list of taxa identified prior to the fall of 1984 and offered some comments on specific taxa that deserved further examination. Because the scope of the present study is limited, this section contains an annotated list of taxa and some comments on using the raw data on relative abundance. Anyone who hopes to use the data presented in tabular form is strongly advised to consult the following text, as it is intended to alert those not familiar with this data base to potential problems. Additional discussion of resource mix can be found in chapter 7 of this volume.

Annotated List of Taxa

The faunal remains recovered by the DAP have been assigned to a variety of mammalian, avian, reptilian, amphibian, and piscine taxa, as well as to an indeterminate vertebrate category (tables 4.36, 4.37, 4.38, and 4.39). However, the overwhelming majority of the bones (90.6 percent of the macrofaunal remains and 84.9 percent of the microfaunal remains) apparently represent mammals (tables 4.36 and 4.37). Reptile, amphibian, and piscine remains occur very rarely among both the macrofaunal and microfaunal remains. Twenty-one orders, 42 families, 77 genera, and 92 species are represented by the taxa that make up the identifiable assemblages (the assemblages of remains identified at least to order). The most basic level at which taxonomic composition can be considered is presence versus absence. At this level, note is made of the animals represented and of the types of habitats preferred by each. An annotated list of taxa at or below the level of order follows. Tables 4.38 and 4.39 should be consulted for additional detail.

Insectivora, Soricidae, *Microsorex hoyi* – Insectivores, Shrews, Pygmy Shrew

Because the only insectivores known from southwestern Colorado are shrews (Soricidae) (Armstrong 1972:41; Bissell and Dillon 1982), the designation insectivore can be considered synonymous with Soricidae. As indicated in Neusius (1985a:table 13), 7 types of shrews may have occurred in the immediate Dolores area prehistorically (refer also to Bissel and Dillon [1982]). In general, the Anasazi Heritage Center collection was inadequate for the identification of Soricidae skeletal material beyond the level of family. The identification of 8 fragments as pygmy shrew (*Microsorex hoyi*) was made prior to the formation of the EAG.[4] As noted previously (Neusius 1985d), this identification should be checked further because most authorities (Burt and Grossenheider 1976:13; Armstrong 1972:51; Bissell 1978:2) have indicated a range well removed from the Dolores area. However, recent note of this species by Bissel and Dillon (1982:2) in the Montrose latilong, adjacent to the Cortex latilong (in which the Escalante Sector is situated), suggests this species may have a less restricted range than previously believed.

Shrews are known to frequent virtually all the habitats believed to have existed in the Escalante Sector prehistorically, with the exception of the garden habitat created by Anasazi land clearing, cultivation, and fallowing (Neusius 1985a: table 13). However, the pygmy shrew is commonly found in mountain meadows and in aspen and coniferous forests (Armstrong 1972:51), and probably would have been confined to the highest elevations in the Escalante Sector. Further identification of the shrew remains in the Dolores faunal assemblage might provide some insights concerning past environments, because each species is environmentally sensitive. The small number of bones assigned to this order did not warrant further work in the initial phase of identification.

Lagomorpha, Leporidae – Pikas, Rabbits and Hares

The most commonly occurring order in Dolores faunal assemblages is Lagomorpha. Almost without exception, these bones are from cottontails or jackrabbits (Leporidae). In some instances, due to poor preservation or fragmentation, specimens could not be identified beyond order or family.

Ochotona princeps – Pika

Only 1 bone is assigned to this species (table 4.38). Such rarity might be expected, given this species' preference for alpine and subalpine habitat types which are not likely to have occurred within the Escalante Sector prehistorically. According to Armstrong (1972:76) and Bissell and Dillon (1982:7), this species inhabits talus slopes near and above timberline and is seldom found below 2590 m (8500 ft). The occurrence of pika might be an indication of the mobility of Dolores populations after the majority of Dolores Anasazi sites had been abandoned, since the context from which this bone was recovered has been dated to Modeling Period 7 (A.D. 980-1250).

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[4]Identifications made by Steven D. Emslie, consultant, Center for Western Studies, Flagstaff.

Table 4.36 – NISP in the total macrofaunal assemblage

	Modeling Period 1									Modeling Period 2								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	1	0.0	0.0	26	3.4	3.2	27	1.2	1.2	3	0.0	0.0	58	2.1	2.0	61	0.8	0.8
Small	242	17.0	16.8	368	48.2	46.6	610	27.9	27.4	2745	63.7	61.6	2059	77.4	73.8	4804	68.9	66.3
Medium	522	36.8	36.3	72	9.4	9.1	594	27.2	26.7	744	17.2	16.7	129	4.8	4.6	873	12.5	12.0
Medium or large	13	0.9	0.9				13	0.5	0.5	40	0.9	0.8				40	0.5	0.5
Large	638	45.0	44.4	297	38.9	37.6	935	42.9	42.0	775	17.9	17.4	412	15.5	14.7	1187	17.0	16.3
Total Mammalia	1416	100.0	98.6	763	100.0	96.7	2179	100.0	97.9	4307	100.0	96.7	2658	100.0	95.3	6965	100.0	96.1
Mammalia or Aves	6	100.0	0.4				6	100.0	0.2	35	100.0	0.7				35	100.0	0.4
Aves:																		
Indeterminate	9	69.2	0.6				35	89.7	1.5	87	88.7	1.9				218	95.1	3.0
Small	0	0.0	0.0				0	0.0	0.0	2	2.0	0.0				2	0.8	0.0
Medium	2	15.3	0.1				2	5.1	0.0	4	4.0	0.0				4	1.7	0.0
Large	2	15.3	0.1				2	5.1	0.0	5	5.1	0.1				5	2.1	0.0
Total Aves	13	100.0	0.9	26	100.0	3.2	39	100.0	1.7	98	100.0	2.2	131	100.0	4.6	229	100.0	3.1
Osteichthyes	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Reptilia	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	100.0	0.0	0	0.0	0.0	4	100.0	0.0
Amphibia	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Vertebrata, indeterminate	0	0.0	0.0				0	0.0	0.0	8	100.0	0.1				8	100.0	0.1
Total assemblage	1435		100.0	789		100.0	2224		100.0	4452		100.0	2789		100.0	7241		100.0

A blank indicates that the number and percentages for the corresponding category were not calculated.
NISP– Number of individual specimens.

Table 4.36 – NISP in the total macrofaunal assemblage – Continued

	Modeling Period 3									Modeling Period 4								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	128	2.9	2.8	107	4.2	4.0	235	3.4	3.3	98	2.5	2.3	71	4.6	4.4	169	3.1	2.8
Small	1937	45.3	43.7	1562	62.3	59.4	3499	51.6	49.5	950	24.6	22.3	846	55.2	52.8	1796	33.3	30.7
Medium	834	19.5	18.8	275	10.9	10.4	1109	16.3	15.7	484	12.5	11.4	95	6.2	5.9	579	10.7	9.9
Medium or large	111	2.6	2.5				111	1.6	1.5	460	11.9	10.8				460	8.5	7.8
Large	1257	29.4	28.3	562	22.4	21.3	1819	26.8	25.7	1860	48.2	43.8	519	33.8	32.4	2379	44.1	40.7
Total Mammalia	4267	100.0	96.2	2506	100.0	95.3	6773	100.0	95.9	3852	100.0	90.7	1531	100.0	95.6	5383	100.0	92.1
Mammalia or Aves	93	100.0	2.0				93	100.0	1.3	170	100.0	4.0				170	100.0	2.9
Aves:																		
Indeterminate	50	75.7	1.1				169	91.3	2.3	37	29.1	0.8				105	53.8	1.7
Small	6	9.0	0.1				6	3.2	0.0	37	29.1	0.8				37	18.9	0.6
Medium	3	4.5	0.0				3	1.6	0.0	21	16.5	0.4				21	10.7	0.3
Large	7	10.6	0.1				7	3.7	0.0	32	25.1	0.7				32	16.4	0.5
Total Aves	66	100.0	1.4	119	100.0	4.5	185	100.0	2.6	127	100.0	2.9	68	100.0	4.2	195	100.0	3.3
Osteichthyes	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	35	100.0	0.8	0	0.0	0.0	35	100.0	0.5
Reptilia	1	100.0	0.0	0	0.0	0.0	1	100.0	0.0	1	100.0	0.0	2	100.0	0.1	3	100.0	0.0
Amphibia	0	0.0	0.0	4	100.0	0.1	4	100.0	0.0	21	100.0	0.4	0	0.0	0.0	21	100.0	0.3
Vertebrata, indeterminate	4	100.0	0.0				4	100.0	0.0	37	100.0	0.8				37	100.0	0.6
Total assemblage	4431		100.0	2629		100.0	7060		100.0	4243		100.0	1601		100.0	5844		100.0

Table 4.36 – NISP in the total macrofaunal assemblage – Continued

	Modeling Period 5									Modeling Period 6								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	931	9.8	7.4	249	6.3	5.8	1 180	8.7	7.0	5	0.0	0.0	86	3.4	3.2	91	1.1	1.1
Small	2 506	26.4	20.1	2215	56.2	52.2	4 721	35.1	28.2	1244	23.7	23.0	1433	58.2	54.3	2677	34.7	33.2
Medium	1 429	15.0	11.4	210	5.3	4.9	1 639	12.2	9.8	942	17.9	17.4	204	8.2	7.7	1146	14.8	14.2
Medium or large	1 255	13.2	10.0				1 255	9.3	7.5	85	1.6	1.5				85	1.1	1.0
Large	3 359	35.4	26.9	1267	32.1	29.8	4 626	34.4	27.6	2959	56.5	54.7	738	29.9	27.9	3697	48.0	45.9
Total Mammalia	9 480	100.0	76.0	3941	100.0	92.9	13 421	100.0	80.3	5235	100.0	96.8	2461	100.0	93.2	7696	100.0	95.6
Mammalia or Aves	727	100.0	5.8				727	100.0	4.3	48	100.0	0.8				48	100.0	0.5
Aves:																		
Indeterminate	142	57.2	1.1				439	80.5	2.6	50	74.6	0.9				228	93.0	2.8
Small	23	9.2	0.1				23	4.2	0.1	4	5.9	0.0				4	1.6	0.0
Medium	29	11.6	0.2				29	5.3	0.1	5	7.4	0.0				5	2.0	0.0
Large	54	21.7	0.4				54	9.9	0.3	8	11.9	0.1				8	3.2	0.0
Total Aves	248	100.0	1.9	297	100.0	7.0	545	100.0	3.2	67	100.0	1.2	178	100.0	6.7	245	100.0	3.0
Osteichthyes	28	100.0	0.2	0	0.0	0.0	28	100.0	0.1	39	100.0	0.7	0	0.0	0.0	39	100.0	0.4
Reptilia	0	0.0	0.0	1	100.0	0.0	1	100.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Amphibia	3	100.0	0.0	2	100.0	0.0	5	100.0	0.0	5	100.0	0.0	0	0.0	0.0	5	100.0	0.0
Vertebrata, indeterminate	1 981	100.0	15.8				1 981	100.0	11.8	11	100.0	0.2				11	100.0	0.1
Total assemblage	12 467		100.0	4241		100.0	16 708		100.0	5405		100.0	2639		100.0	8044		100.0

Table 4.36 – NISP in the total macrofaunal assemblage – Continued

	Modeling Period 7									Other†								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	370	17.1	11.6	62	7.9	7.2	432	14.6	10.6	275	1.5	1.4	321	5.0	4.7	596	2.5	2.3
Small	634	29.3	19.8	553	70.6	64.6	1187	40.3	29.3	4 931	28.4	26.8	3833	60.4	57.0	8 764	37.0	34.9
Medium	378	17.4	11.8	41	5.2	4.7	419	14.2	10.3	2 601	15.0	14.1	387	6.1	5.7	2 988	12.6	11.9
Medium or large	113	5.2	3.5				113	3.8	2.7	1 694	9.7	9.2				1 694	7.1	6.7
Large	666	30.8	20.9	127	16.2	14.8	793	26.9	19.6	7 839	45.2	42.7	1795	28.3	26.7	9 634	40.6	38.4
Total Mammalia	2161	100.0	67.8	783	100.0	91.5	2944	100.0	72.8	17 340	100.0	94.5	6334	100.0	94.2	23 676	100.0	94.4
Mammalia or Aves	750	100.0	23.5				750	100.0	18.5	422	100.0	2.3				422	100.0	1.6
Aves:																		
Indeterminate	21	67.7	0.6				85	89.4	2.1	112	23.7	0.6				466	56.4	1.8
Small	3	9.6	0.0				3	3.1	0.0	40	8.4	0.2				40	4.8	0.1
Medium	0	0.0	0.0				0	0.0	0.0	94	19.9	0.5				94	11.3	0.3
Large	7	22.5	0.2				7	7.3	0.1	225	47.7	1.2				225	27.2	0.8
Total Aves	31	100.0	0.9	64	100.0	7.4	95	100.0	2.3	471	100.0	2.5	354	100.0	5.2	825	100.0	3.2
Osteichthyes	8	100.0	0.2	6	100.0	0.7	14	100.0	0.3	27	100.0	0.1	4	100.0	0.0	31	100.0	0.1
Reptilia	1	100.0	0.0	2	100.0	0.2	3	100.0	0.0	3	100.0	0.0	11	100.0	0.1	14	100.0	0.0
Amphibia	4	100.0	0.1	0	0.0	0.0	4	100.0	0.0	6	100.0	0.0	17	100.0	0.2	23	100.0	0.0
Vertebrata, indeterminate	231	100.0	7.2				231	100.0	5.7	71	100.0	0.3				71	100.0	0.2
Total assemblage	3186		100.0	855		100.0	4041		100.0	18 340		100.0	6722		100.0	25 062		100.0

† Other – Not assigned to period.

Table 4.36 – NISP in the total macrofaunal assemblage – Continued

	Total								
	Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:									
Indeterminate	1 811	3.7	3.3	980	4.6	4.4	2 791	4.0	3.6
Small	15 189	31.6	28.1	12 869	61.3	57.7	28 058	40.6	36.8
Medium	7 934	16.5	14.7	1 413	6.7	6.3	9 347	13.5	12.2
Medium or large	3 771	7.8	6.9				3 771	5.4	4.9
Large	19 353	40.2	35.8	5 717	27.2	25.6	25 070	36.3	32.8
Total Mammalia	48 058	100.0	89.0	20 979	100.0	94.2	69 037	100.0	90.5
Mammalia or Aves	2 251	100.0	4.1				2 251	100.0	2.9
Aves:									
Indeterminate	508	45.3	0.9				1 745	74.0	2.2
Small	115	10.2	0.2				115	4.8	0.1
Medium	158	14.0	0.2				158	6.7	0.2
Large	340	30.3	0.6				340	14.4	0.4
Total Aves	1 121	100.0	2.0	1 237	100.0	5.5	2 358	100.0	3.0
Osteichthyes	137	100.0	0.2	10	100.0	0.0	147	100.0	0.1
Reptilia	10	100.0	0.0	16	100.0	0.0	26	100.0	0.0
Amphibia	39	100.0	0.0	23	100.0	0.1	62	100.0	0.0
Vertebrata, indeterminate	2 343	100.0	4.3				2 343	100.0	3.0
Total assemblage	53 959		100.0	22 265		100.0	76 224		100.0

* Identifiable at least to order.

***Sylvilagus* spp., *Sylvilagus nuttalli*, *Sylvilagus audubonii* – Cottontails, Nuttall's cottontail, Desert Cottontail**

Cottontails are the most common taxa in the Dolores faunal assemblages. Although both Nuttall's and desert cottontails were present in the Dolores area, most cottontail remains cannot be separated on the basis of osteological characteristics. Relatively complete mandibles from adult cottontails apparently can be separated on the basis of the ratio of depth to length (Findley et al. 1975:83-86). Measurements of such mandibles in the Dolores faunal assemblage have been made (Flint and Neusius 1985; Neusius and Flint 1985), and identifications based on these are indicated in tables 4.38 and 4.39. However, Neusius and Flint (1985) also found that the separation based on these characteristics is incomplete, and they have suggested that additional characteristics and specimens be studied.

The Nuttall's cottontail is also known as the mountain cottontail (in contrast to the desert cottontail) (Armstrong 1972:82). Flint and Neusius (1985) found a close correspondence between the amount of reconstructed sagebrush in a site catchment (Petersen 1985a; Orcutt 1984b, 1984c, 1985a, 1985c) and the proportion of desert cottontail mandibles among the total cottontail mandibles from that site. This seems to confirm the assumption that cottontails were procured in close proximity to habitations.

***Lepus* spp., *Lepus americanus*, *Lepus townsendii*, *Lepus californicus* – Jackrabbits, Snowshoe Hare, White-tailed Jackrabbit, Black-tailed Jackrabbit**

Remains of jackrabbits also are very common in Dolores faunal assemblages. The majority of these bones have been assigned only to *Lepus* spp., because thorough analysis was precluded by lack of comparative materials and time. Originally, most of these remains were believed to represent black-tailed jackrabbits, the species most common in the Southwest. However, careful comparison of a sample of *Lepus* remains with U.S.

Table 4.37 – NISP in the total microfaunal assemblage

	Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:									
Indeterminate	339	7.5	6.4	17	4.7	4.4	356	7.3	6.2
Small	3919	87.1	73.4	329	90.1	85.9	4248	87.4	74.2
Medium	9	0.2	0.2	9	2.5	2.4	18	0.4	0.3
Medium or large	133	3.0	2.5				133	2.7	2.3
Large	97	2.2	1.8	10	2.7	2.6	107	2.2	1.9
Total Mammalia	4497	100.0	84.3	365	100.0	95.3	4862	100.0	84.9
Mammalia or Aves	301	100.0	5.6				301	100.0	5.3
Aves:									
Indeterminate	16	64.0	0.3	15	100.0	3.9	31	77.5	0.5
Small	9	36.0	0.2				9	22.5	0.2
Total Aves	25	100.0	0.5	15	100.0	3.9	40	100.0	0.7
Osteichthyes	5	100.0	0.1				5	100.0	0.1
Reptilia	2	100.0	0.0	3	100.0	0.8	5	100.0	0.1
Amphibia	1	100.0	0.0				1	100.0	0.0
Vertebrata, indeterminate	509	100.0	9.5				509	100.0	8.9
Total assemblage	5340		100.0	383		100.0	5723		100.0

* Identifiable at least to order.
NISP – Number of individual specimens.

Fish and Wildlife Service collections in Fort Collins, Colorado, indicated a small proportion of the materials represented snowshoe hare, while both white-tailed and black-tailed jackrabbits were well represented. The identifications made in Fort Collins have been recorded and are reflected in tables 4.38 and 4.39. Identifications to jackrabbit species, which predate the author's tenure at the DAP, have been reviewed and in most cases changed to a genus or family designation, pending further analysis.

The most conservative approach to these identifications would be to equate all of the speciated remains with *Lepus* spp. However, there is reason to trust the snowshoe hare identification, because of the smaller size of this species. This animal usually is found between 2440 and 3350 m (8000 and 11 000 ft) and prefers brushy openings in mountain forests (Armstrong 1972:87-88). It is known to occur in southwestern Colorado (Bissell and Dillon 1982:7) and may even have been found in higher-altitude habitat types reconstructed for the Escalante Sector (Neusius 1985a:table 13). This species occurs throughout the temporal sequence in small numbers. Thus, accepting the argument that it is a marker for the expansion of boreal habitats due to climatic changes is difficult (Benz 1984:211).

The separation of the black-tailed and white-tailed jackrabbit is a more difficult issue. Osteological separation using mandibular characteristics and discriminant analysis has been undertaken for the Great Basin (Leonard 1980), but there is less reason to expect that postcranial remains can be separated.[5] The white-tailed jackrabbit tends to be larger in size, but this is difficult to assess, except relatively. Based on the Fort Collins collection, it appears some elements or parts of elements with distinct morphological attributes do occur. These elements are the innominate, the humerus, the distal femur, the proximal tibia, and probably the radius. However, the DAP has not been able to test the reliability of those observations on other materials. For this reason, it now seems most advisable to consider

[5]Robert D. Leonard, Black Mesa Archaeological Project, Center for Archaeological Investigations, Southern Illinois University, Carbondale, personal communication.

Table 4.38 – NISP in the identifiable macrofaunal assemblage

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mammalia:																		
Insectivora																		
insectivores																		
Soricidae																		
shrews							1	(1)	0.0	(0.0)	0.0	(0.0)						
Microsorex hoyi																		
pygmy shrew							7	(7)	0.2	(0.2)	0.2	(0.2)						
Lagomorpha																		
pikas, rabbits, and hares	1	(1)	0.1	(0.1)	0.1	(0.1)	1	(1)	0.0	(0.0)	0.0	(0.0)	7	(7)	0.2	(0.2)	0.2	(0.2)
Ochotona princeps																		
pika																		
Leporidae																		
rabbits and hares	6	(6)	0.8	(0.7)	0.7	(0.7)	24	(24)	0.9	(0.9)	0.8	(0.8)	12	(12)	0.4	(0.4)	0.4	(0.4)
Sylvilagus spp.																		
cottontails	128	(130)	17.1	(17.0)	16.6	(16.4)	997	(997)	38.1	(37.5)	36.4	(35.7)	565	(567)	23.1	(22.6)	22.2	(21.5)
Sylvilagus nuttallii																		
Nuttall's cottontail							5	(6)	0.1	(0.2)	0.1	(0.2)	16	(20)	0.6	(0.7)	0.6	(0.7)
Sylvilagus audubonii																		
desert cottontail	5	(5)	0.6	(0.6)	0.6	(0.6)	37	(37)	1.4	(1.3)	1.3	(1.3)	24	(24)	0.9	(0.9)	0.9	(0.9)
Lepus spp.																		
jackrabbits	65	(65)	8.6	(8.5)	8.4	(8.2)	387	(400)	14.7	(15.0)	14.1	(14.3)	302	(312)	12.3	(12.4)	11.8	(11.8)
Lepus americanus																		
snowshoe hare							9	(9)	0.3	(0.3)	0.3	(0.3)	1	(1)	0.0	(0.0)	0.0	(0.0)
Lepus townsendii																		
white-tailed jackrabbit	2	(4)	0.2	(0.5)	0.2	(0.5)	2	(5)	0.0	(0.1)	0.0	(0.1)	12	(18)	0.4	(0.7)	0.4	(0.6)
Lepus californicus																		
black-tailed jackrabbit	0	(1)	0.0	(0.1)	0.0	(0.1)							4	(6)	0.1	(0.2)	0.1	(0.2)
Rodentia																		
rodents	11	(11)	1.4	(1.4)	1.4	(1.3)	39	(39)	1.4	(1.4)	1.4	(1.3)	54	(54)	2.2	(2.1)	2.1	(2.0)
Sciuridae																		
squirrels	21	(21)	2.8	(2.7)	2.7	(2.6)	79	(79)	3.0	(2.9)	2.8	(2.8)	52	(52)	2.1	(2.0)	2.0	(1.9)
Eutamias spp.																		
chipmunks																		

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Marmota flaviventris yellow-bellied marmot	13	(14)	1.7	(1.8)	1.6	(1.7)	103	(103)	3.9	(3.8)	3.7	(3.6)	104	(110)	4.2	(4.3)	4.0	(4.1)
Amnospermophilus leucurus white-tailed antelope squirrel																		
Spermophilus spp. ground squirrels																		
Spermophilus spilosoma spotted ground squirrel	2	(2)	0.2	(0.2)	0.2	(0.2)	58	(59)	2.2	(2.2)	2.1	(2.1)						
Spermophilus lateralis golden-mantled ground squirrel							1	(2)	0.0	(0.0)	0.0	(0.0)	3	(4)	0.1	(0.1)	0.1	(0.1)
Spermophilus variegatus rock squirrel	3	(3)	0.4	(0.3)	0.3	(0.3)	18	(19)	0.6	(0.7)	0.6	(0.6)	34	(35)	1.3	(1.3)	1.3	(1.3)
Cynomys gunnisoni Gunnison's prairie dog	95	(95)	12.7	(12.4)	12.3	(12.0)	145	(147)	5.5	(5.5)	5.2	(5.2)	46	(46)	1.8	(1.8)	1.8	(1.7)
Geomyidae pocket gophers							1	(1)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Thomomys spp. pocket gophers	7	(7)	0.9	(0.9)	0.9	(0.8)	16	(16)	0.6	(0.6)	0.5	(0.5)	85	(86)	3.4	(3.4)	3.3	(3.2)
Thomomys bottae valley pocket gopher	9	(9)	1.2	(1.1)	1.1	(1.1)	14	(14)	0.5	(0.5)	0.5	(0.5)	24	(24)	0.9	(0.9)	0.9	(0.9)
Thomomys talpoides nothern pocket gopher																		
Heteromyidae pocket mice, kangaroo rats																		
Perognathus apache Apache pocket mouse																		
Dipodomys ordii Ord's kangaroo rat	0	(1)	0.0	(0.1)	0.0	(0.1)	0	(2)	0.0	(0.0)	0.0	(0.0)						
Castor canadensis beaver	9	(10)	1.2	(1.3)	1.1	(1.2)	11	(11)	0.4	(0.4)	0.4	(0.3)	16	(16)	0.6	(0.6)	0.6	(0.6)
Cricetidae New World rats and mice							12	(12)	0.4	(0.4)	0.4	(0.4)	30	(30)	1.2	(1.1)	1.1	(1.1)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Peromyscus spp.																		
white-footed mice							48	(48)	1.8	(1.8)	1.7	(1.7)	48	(48)	1.9	(1.9)	1.8	(1.8)
Peromyscus maniculatus																		
deer mouse																		
Peromyscus boylii or *truei*																		
brush or pinyon mouse							7	(7)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.0	(0.0)	0.0	(0.0)
Onochomys leucogaster																		
northern grasshopper mouse							3	(3)	0.1	(0.1)	0.1	(0.1)						
Neotoma spp.																		
wood rats	2	(2)	0.2	(0.2)	0.2	(0.2)	27	(27)	1.0	(1.0)	0.9	(0.9)	127	(127)	5.2	(5.0)	4.9	(4.8)
Neotoma cinerea																		
bushy-tailed wood rat							3	(4)	0.1	(0.1)	0.1	(0.1)	2	(3)	0.0	(0.1)	0.0	(0.1)
Neotoma mexicana																		
Mexican wood rat							2	(2)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Microtus spp.																		
voles	1	(2)	0.1	(0.2)	0.1	(0.2)	4	(4)	0.1	(0.1)	0.1	(0.1)	10	(10)	0.4	(0.3)	0.3	(0.3)
Microtus montanus																		
montane vole							18	(18)	0.6	(0.6)	0.6	(0.6)	1	(1)	0.0	(0.0)	0.0	(0.0)
Microtus longicaudus																		
long-tailed vole													1	(1)	0.0	(0.0)	0.0	(0.0)
Microtus mexicanus																		
Mexican vole													5	(5)	0.2	(0.1)	0.1	(0.1)
Microtus pennsylvanicus																		
meadow vole							0	(1)	0.0	(0.0)	0.0	(0.0)						
Ondatra zibethicus																		
muskrat							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Zapodidae																		
jumping mice																		
Erethizon dorsatum																		
porcupine	6	(6)	0.8	(0.7)	0.7	(0.7)	20	(20)	0.7	(0.7)	0.7	(0.7)	55	(58)	2.2	(2.3)	2.1	(2.2)
Carnivora																		
carnivores	8	(8)	1.0	(1.0)	1.0	(1.0)	2	(2)	0.0	(0.0)	0.0	(0.0)	9	(9)	0.3	(0.3)	0.3	(0.3)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Canidae																		
canids	2	(2)	0.2	(0.2)	0.2	(0.2)	5	(5)	0.1	(0.1)	0.1	(0.1)	4	(8)	0.1	(0.3)	0.1	(0.3)
Canis spp.																		
dog, coyote, or wolf	5	(5)	0.6	(0.6)	0.6	(0.6)	11	(12)	0.4	(0.4)	0.4	(0.4)	25	(36)	1.0	(1.4)	0.9	(1.3)
Canis familiaris																		
domestic dog	20	(20)	2.6	(2.6)	2.5	(2.5)	65	(65)	2.4	(2.4)	2.3	(2.3)	184	(184)	7.5	(7.3)	7.2	(6.9)
Canis familiaris or *latrans*																		
dog or coyote																		
Canis latrans																		
coyote	5	(5)	0.6	(0.6)	0.6	(0.6)	7	(7)	0.2	(0.2)	0.2	(0.2)	4	(4)	0.1	(0.1)	0.1	(0.1)
Canis lupus																		
gray wolf	2	(2)	0.2	(0.2)	0.2	(0.2)	0	(1)	0.0	(0.0)	0.0	(0.0)						
Vulpes spp.																		
red or kit foxes																		
Vulpes vulpes																		
red fox	23	(23)	3.0	(3.0)	2.9	(2.9)	11	(13)	0.4	(0.4)	0.4	(0.4)	3	(4)	0.1	(0.1)	0.1	(0.1)
Vulpes or *Urocyon* spp.																		
foxes																		
Urocyon cinereoargenteus																		
gray fox							1	(1)	0.0	(0.0)	0.0	(0.0)						
Ursus spp.																		
bears	3	(3)	0.4	(0.3)	0.3	(0.3)							2	(2)	0.0	(0.0)	0.0	(0.0)
Ursus americanus																		
black bear	0	(1)	0.0	(0.1)	0.0	(0.1)												
Bassariscus astutus																		
ringtail							1	(1)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Mustelidae																		
mustelids																		
Martes americana																		
marten													1	(1)	0.0	(0.0)	0.0	(0.0)
Mustela spp.																		
weasels																		

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustela vison mink																		
Mustela frenata long-tailed weasel							2	(2)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Gulo gulo wolverine																		
Taxidea taxus badger							7	(7)	0.2	(0.2)	0.2	(0.2)	1	(1)	0.0	(0.0)	0.0	(0.0)
Spilogale putorius spotted skunk																		
Mephitis mephitis striped skunk													1	(2)	0.0	(0.0)	0.0	(0.0)
Felidae cats																		
Lynx spp. bobcat or lynx													2	(2)	0.0	(0.0)	0.0	(0.0)
Lynx rufus bobcat	8	(8)	1.0	(1.0)	1.0	(1.0)	5	(5)	0.1	(0.1)	0.1	(0.1)	4	(4)	0.1	(0.1)	0.1	(0.1)
Felis concolor mountain lion																		
Equus spp. horses																		
Equus caballus horse																		
Artiodactyla artiodactyls	104	(104)	13.9	(13.6)	13.4	(13.1)	82	(89)	3.1	(3.3)	2.9	(3.1)	197	(198)	8.0	(7.9)	7.7	(7.5)
Cervidae deer	115	(115)	15.3	(15.0)	14.9	(14.5)	204	(204)	7.8	(7.6)	7.4	(7.3)	117	(118)	4.7	(4.7)	4.5	(4.4)
Cervus elaphus American elk	1	(2)	0.1	(0.2)	0.1	(0.2)	3	(4)	0.1	(0.1)	0.1	(0.1)	4	(6)	0.1	(0.2)	0.1	(0.2)
Odocoileus hemionus mule deer	36	(40)	4.8	(5.2)	4.6	(5.0)	94	(96)	3.5	(3.6)	3.4	(3.4)	205	(212)	8.3	(8.4)	8.0	(8.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Antilocapra americana pronghorn	15	(15)	2.0	(1.9)	1.9	(1.9)	9	(9)	0.3	(0.3)	0.3	(0.3)	7	(7)	0.2	(0.2)	0.2	(0.2)
Antilocapra or *Ovis* spp. pronghorn or sheep																		
Ovis spp. sheep																		
Ovis canadensis bighorn	14	(14)	1.8	(1.8)	1.8	(1.7)	7	(9)	0.2	(0.3)	0.2	(0.3)	7	(7)	0.2	(0.2)	0.2	(0.2)
Ovis aries domestic sheep	1	(1)	0.1	(0.1)	0.1	(0.1							1	(1)	0.0	(0.0)	0.0	(0.0)
Ovis or *Capra* spp. sheep or goat																		
Bos taurus domestic cow													11	(11)	0.4	(0.4)	0.4	(0.4)
Bos or *Bison* cow or bison																		
Total Mammalia	748	(763)	100.0	(100.0)	97.0	(96.7)	2615	(2658)	100.0	(100.0)	95.5	(95.3)	2441	(2506)	100.0	(100.0)	95.9	(95.3)
Aves:																		
Gaviiformes loons																		
Ciconiformes deep water waders																		
Anatidae geese and ducks													1	(1)	1.0	(0.8)	0.0	(0.0)
Anserinae geese													1	(1)	1.0	(0.8)	0.0	(0.0)
Branta canadensis Canada goose	1	(2)	4.3	(7.6)	0.1	(0.2)	2	(2)	1.6	(1.5)	0.0	(0.0)	1	(1)	1.0	(0.8)	0.0	(0.0)
Anas spp. surface-feeding ducks													1	(1)	1.0	(0.8)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Anas platyrhynchos mallard													0	(1)	0.0	(0.8)	0.0	(0.0)
Oxyura jamaicensis ruddy duck													5	(6)	5.0	(5.0)	0.1	(0.2)
Falconiformes vultures, hawks, and falcons							2	(2)	1.6	(1.5)	0.0	(0.0)	1	(1)	1.0	(0.8)	0.0	(0.0)
Cathartes aura turkey vulture							1	(5)	0.8	(3.8)	0.0	(0.1)						
Accipitridae hawks and eagles																		
Accipiter spp. hawks																		
Accipiter gentilis goshawk																		
Accipiter striatus sharp-shinned hawk																		
Accipiter cooperii Cooper's hawk																		
Buteo spp. buteos																		
Buteo jamaicensis red-tailed hawk													1	(1)	1.0	(0.8)	0.0	(0.0)
Buteo swainsoni Swainson's hawk																		
Aquila or *Haliaeetus* spp. eagles																		
Aquila chrysaetos golden eagle	2	(2)	8.6	(7.6)	0.2	(0.2)							2	(2)	2.0	(1.6)	0.0	(0.0)
Haliaeetus leucocephalus bald eagle																		
Faco mexicanus prairie falcon																		

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Falco sparverius																		
American kestrel							12	(12)	9.7	(9.1)	0.4	(0.4)	2	(2)	2.0	(1.6)	0.0	(0.0)
Galliformes																		
fowl-like birds							1	(1)	0.8	(0.7)	0.0	(0.0)						
Tetraonidae																		
grouse	11	(11)	47.8	(42.3)	1.4	(1.3)	27	(28)	21.9	(21.3)	0.9	(1.0)	43	(48)	43.4	(40.3)	1.6	(1.8)
Centrocercus urophasianus																		
sage grouse																		
Gallus domesticus																		
chicken																		
Meleagris gallopavo																		
turkey	4	(5)	17.3	(19.2)	0.5	(0.6)	39	(39)	31.7	(29.7)	1.4	(1.3)	17	(27)	17.1	(22.6)	0.6	(1.0)
Grus canadensis																		
sandhill crane							16	(17)	13.0	(12.9)	0.5	(0.6)	4	(7)	4.0	(5.8)	0.1	(0.2)
Tringa melanoleuca																		
greater yellowlegs																		
Zenaida macroura																		
mourning dove	0	(1)	0.0	(3.8)	0.0	(0.1)							1	(1)	1.0	(0.8)	0.0	(0.0)
Otus asio																		
screech owl																		
Bubo virginianus																		
great horned owl													2	(2)	2.0	(1.6)	0.0	(0.0)
Glaucidium gnoma																		
pygmy owl																		
Asio spp.																		
long- or short-eared owl													1	(1)	1.0	(0.8)	0.0	(0.0)
Asio otus																		
long-eared owl																		
Colaptes auratus																		
common flicker	2	(2)	8.6	(7.6)	0.2	(0.2)	3	(3)	2.4	(2.2)	0.1	(0.1)	1	(1)	1.0	(0.8)	0.0	(0.0)
Passeriformes																		
perching birds	1	(1)	4.3	(3.8)	0.1	(0.1)	12	(12)	9.7	(9.1)	0.4	(0.4)	2	(2)	2.0	(1.6)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Tyrannus verticalis																		
western kingbird																		
Corvidae																		
jays, crows, and magpies							2	(2)	1.6	(1.5)	0.0	(0.0)						
Corvus spp.																		
raven or crow																		
Corvus corax																		
common raven	1	(1)	4.3	(3.8)	0.1	(0.1)	2	(2)	1.6	(1.5)	0.0	(0.0)	1	(1)	1.0	(0.8)	0.0	(0.0)
Corvus brachyrhynchos																		
common crow													1	(1)	1.0	(0.8)	0.0	(0.0)
Cyanocitta stelleri																		
Steller's jay																		
Gymnorhinus cyanocephalus																		
pinyon jay																		
Aphelocoma coerulescens																		
scrub jay																		
Pica pica																		
black-billed magpie													3	(3)	3.0	(2.5)	0.1	(0.1)
Turdidae																		
thrushes and bluebirds																		
Sialia currucoides																		
mountain bluebird																		
Turdus migratorius																		
American robin							0	(1)	0.0	(0.7)	0.0	(0.0)						
Lanius excubitor																		
northern shrike																		
Sturnella spp.																		
meadowlarks							1	(1)	0.8	(0.7)	0.0	(0.0)						
Xanthocephalus																		
xanthocephalus																		
yellow-headed blackbird																		
Fringillidae																		
finch-like birds							1	(1)	0.8	(0.7)	0.0	(0.0)						

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Pipilo chlorura green-tailed towhee	1	(1)	4.3	(3.8)	0.1	(0.1)	2	(3)	1.6	(2.2)	0.0	(0.1)	8	(8)	8.0	(6.7)	0.3	(0.3)
Total Aves	23	(26)	100.0	(100.0)	2.9	(3.2)	123	(131)	100.0	(100.0)	4.4	(4.6)	99	(119)	100.0	(100.0)	3.8	(4.5)
Reptilia:																		
Squamata lizards and snakes																		
Sauria lizard																		
Sceloporus undulatus elongatus northern plateau lizard																		
Serpentes snakes																		
Crotalus viridis western rattlesnake																		
Total Reptilia																		
Amphibia:																		
Anura frogs and toads													4	(4)	100.0	(100.0	0.1	(0.1)
Bufo spp. true toads																		
Total Amphibia													4	(4)	100.0	(100.0)	0.1	(0.1)
Osteichthyes:																		
Cypriniformes cyprinids																		
Catostomidae suckers																		

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 1			Modeling Period 2			Modeling Period 3		
	N	% class	% total	N	% class	% total	N	% class	% total
Catostomus spp. flannelmouth or bluehead sucker									
Total Osteichthyes									
Total assemblage	771 (789)		100.0 (100.0)	2738 (2789)		100.0 (100.0	2544 (2629)		100.0 (100.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mammalia:																		
Insectivora																		
insectivores							0	(3)	0.0	(0.0)	0.0	(0.0)						
Soricidae																		
shrews																		
Microsorex hoyi																		
pygmy shrew							1	(1)	0.0	(0.0)	0.0	(0.0)						
Lagomorpha																		
pikas, rabbits, and hares							1	(1)	0.0	(0.0)	0.0	(0.0)						
Ochotona princeps																		
pika																		
Leporidae																		
rabbits and hares	28	(28)	1.9	(1.8)	1.8	(1.7)	72	(72)	1.9	(1.8)	1.8	(1.6)	2	(2)	0.0	(0.0)	0.0	(0.0)
Sylvilagus spp.																		
cottontails	284	(294)	19.6	(19.2)	18.9	(18.3)	538	(602)	16.0	(15.2)	14.9	(14.1)	686	(686)	28.5	(27.8)	26.9	(25.9)
Sylvilagus nuttallii																		
Nuttall's cottontail	5	(6)	0.3	(0.3)	0.3	(0.3)	9	(9)	0.2	(0.2)	0.2	(0.2)	4	(6)	0.1	(0.2)	0.1	(0.2)
Sylvilagus audubonii																		
desert cottontail	12	(12)	0.8	(0.7)	0.8	(0.7)	36	(37)	0.9	(0.9)	0.9	(0.8)	34	(36)	1.4	(1.4)	1.3	(1.3)
Lepus spp.																		
jackrabbits	175	(185)	12.1	(12.0)	11.6	(11.5)	787	(801)	21.4	(20.3)	20.0	(18.8)	258	(258)	10.7	(10.4)	10.1	(9.7)
Lepus americanus																		
snowshoe hare	1	(1)	0.0	(0.0)	0.0	(0.0)	3	(3)	0.0	(0.0)	0.0	(0.0)	5	(5)	0.2	(0.2)	0.1	(0.1)
Lepus townsendii																		
white-tailed jackrabbit	11	(18)	0.7	(1.1)	0.7	(1.1)	32	(69)	0.8	(1.7)	0.8	(1.6)	0	(2)	0.0	(0.0)	0.0	(0.0)
Lepus californicus																		
black-tailed jackrabbit	2	(6)	0.1	(0.3)	0.1	(0.3)	14	(42)	0.3	(1.0)	0.3	(0.9)	2	(3)	0.0	(0.1)	0.0	(0.1)
Rodentia																		
rodents	20	(20)	1.3	(1.3)	1.3	(1.2)	56	(56)	1.5	(1.4)	1.4	(1.3)	39	(39)	1.6	(1.5)	1.5	(1.4)
Sciuridae																		
squirrels	29	(29)	2.0	(1.8)	1.9	(1.8)	70	(73)	1.9	(1.8)	1.7	(1.7)	134	(135)	5.5	(5.4)	5.2	(5.1)
Eutamias spp.																		
chipmunks							1	(1)	0.0	(0.0)	0.0	(0.0)						

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Marmota flaviventris yellow-bellied marmot	38	(44)	2.6	(2.8)	2.5	(2.7)	55	(58)	1.5	(1.4)	1.3	(1.3)	24	(26)	1.0	(1.0)	0.9	(0.9)
Amnospermophilus leucurus white-tailed antelope squirrel																		
Spermophilus spp. ground squirrels	1	(1)	0.0	(0.0)	0.0	(0.0)												
Spermophilus spilosoma spotted ground squirrel													0	(1)	0.0	(0.0)	0.0	(0.0)
Spermophilus lateralis golden-mantled ground squirrel	12	(14)	0.8	(0.9)	0.8	(0.8)	10	(11)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.0	(0.0)	0.0	(0.0)
Spermophilus variegatus rock squirrel	15	(15)	1.0	(0.9)	1.0	(0.9)	43	(50)	1.1	(1.2)	1.0	(1.1)	31	(38)	1.2	(1.5)	1.2	(1.4)
Cynomys gunnisoni Gunnison's prairie dog	60	(67)	4.1	(4.3)	4.0	(4.1)	120	(135)	3.2	(3.4)	3.0	(3.1)	124	(125)	5.1	(5.0)	4.8	(4.7)
Geomyidae pocket gophers																		
Thomomys spp. pocket gophers	26	(28)	1.8	(1.8)	1.7	(1.7)	64	(68)	1.7	(1.7)	1.6	(1.6)	24	(26)	1.0	(1.0)	0.9	(0.9)
Thomomys bottae valley pocket gopher	7	(7)	0.4	(0.4)	0.4	(0.4)	18	(18)	0.4	(0.4)	0.4	(0.4)	5	(5)	0.2	(0.2)	0.1	(0.1)
Thomomys talpoides northern pocket gopher																		
Heteromyidae pocket mice, kangaroo rats							0	(8)	0.0	(0.2)	0.0	(0.1)						
Perognathus apache Apache pocket mouse							0	(3)	0.0	(0.0)	0.0	(0.0)	8	(8)	0.3	(0.3)	0.3	(0.3)
Dipodomys ordii Ord's kangaroo rat							0	(1)	0.0	(0.0)	0.0	(0.0)	0	(2)	0.0	(0.0)	0.0	(0.0)
Castor canadensis beaver	20	(22)	1.3	(1.4)	1.3	(1.3)	38	(41)	1.0	(1.0)	0.9	(0.9)	26	(27)	1.0	(1.0)	1.0	(1.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cricetidae																		
New World rats and mice	3	(3)	0.2	(0.1)	0.2	(0.1)	24	(24)	0.6	(0.6)	0.6	(0.5)	13	(13)	0.5	(0.5)	0.5	(0.4)
Peromyscus spp.																		
white-footed mice	42	(42)	2.9	(2.7)	2.8	(2.6)	70	(71)	1.9	(1.8)	1.7	(1.6)	1	(1)	0.0	(0.0)	0.0	(0.0)
Peromyscus maniculatus																		
deer mouse																		
Peromyscus boylii or *truei*																		
brush or pinyon mouse																		
Onochomys leucogaster																		
northern grasshopper mouse	0	(1)	0.0	(0.0)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)						
Neotoma spp.																		
wood rats	26	(29)	1.8	(1.8)	1.7	(1.8)	34	(38)	0.9	(0.9)	0.8	(0.8)	25	(26)	1.0	(1.0)	0.9	(0.9)
Neotoma cinerea																		
bushy-tailed wood rat	1	(1)	0.0	(0.0)	0.0	(0.0)												
Neotoma mexicana																		
Mexican wood rat	1	(1)	0.0	(0.0)	0.0	(0.0)							0	(1)	0.0	(0.0)	0.0	(0.0)
Microtus spp.																		
voles	9	(9)	0.6	(0.5)	0.6	(0.5)	8	(14)	0.2	(0.3)	0.2	(0.3)	1	(1)	0.0	(0.0)	0.0	(0.0)
Microtus montanus																		
montane vole																		
Microtus longicaudus																		
long-tailed vole													1	(5)	0.0	(0.2)	0.0	(0.1)
Microtus mexicanus																		
Mexican vole																		
Microtus pennsylvanicus																		
meadow vole																		
Ondatra zibethicus																		
muskrat	2	(2)	0.1	(0.1)	0.1	(0.1)							1	(1)	0.0	(0.0)	0.0	(0.0)
Zapodidae																		
jumping mice													1	(1)	0.0	(0.0)	0.0	(0.0)
Erethizon dorsatum																		
porcupine	21	(30)	1.4	(1.9)	1.4	(1.8)	38	(48)	1.0	(1.2)	0.9	(1.1)	64	(69)	2.6	(2.8)	2.5	(2.6)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cricetidae																		
New World rats and mice	3	(3)	0.2	(0.1)	0.2	(0.1)	24	(24)	0.6	(0.6)	0.6	(0.5)	13	(13)	0.5	(0.5)	0.5	(0.4)
Peromyscus spp.																		
white-footed mice	42	(42)	2.9	(2.7)	2.8	(2.6)	70	(71)	1.9	(1.8)	1.7	(1.6)	1	(1)	0.0	(0.0)	0.0	(0.0)
Peromyscus maniculatus																		
deer mouse																		
Peromyscus boylii or *truei*																		
brush or pinyon mouse																		
Onochomys leucogaster																		
northern grasshopper mouse	0	(1)	0.0	(0.0)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)						
Neotoma spp.																		
wood rats	26	(29)	1.8	(1.8)	1.7	(1.8)	34	(38)	0.9	(0.9)	0.8	(0.8)	25	(26)	1.0	(1.0)	0.9	(0.9)
Neotoma cinerea																		
bushy-tailed wood rat	1	(1)	0.0	(0.0)	0.0	(0.0)												
Neotoma mexicana																		
Mexican wood rat	1	(1)	0.0	(0.0)	0.0	(0.0)							0	(1)	0.0	(0.0)	0.0	(0.0)
Microtus spp.																		
voles	9	(9)	0.6	(0.5)	0.6	(0.5)	8	(14)	0.2	(0.3)	0.2	(0.3)	1	(1)	0.0	(0.0)	0.0	(0.0)
Microtus montanus																		
montane vole																		
Microtus longicaudus																		
long-tailed vole													1	(5)	0.0	(0.2)	0.0	(0.1)
Microtus mexicanus																		
Mexican vole																		
Microtus pennsylvanicus																		
meadow vole																		
Ondatra ziebethicus																		
muskrat	2	(2)	0.1	(0.1)	0.1	(0.1)							1	(1)	0.0	(0.0)	0.0	(0.0)
Zapodidae																		
jumping mice													1	(1)	0.0	(0.0)	0.0	(0.0)
Erethizon dorsatum																		
porcupine	21	(30)	1.4	(1.9)	1.4	(1.8)	38	(48)	1.0	(1.2)	0.9	(1.1)	64	(69)	2.6	(2.8)	2.5	(2.6)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Carnivora																		
carnivores	15	(15)	1.0	(0.9)	1.0	(0.9)	30	(31)	0.8	(0.7)	0.7	(0.7)	7	(7)	0.2	(0.2)	0.2	(0.2)
Canidae																		
canids	2	(2)	0.1	(0.1)	0.1	(0.1)	24	(28)	0.6	(0.7)	0.6	(0.6)	18	(19)	0.7	(0.7)	0.7	(0.7)
Canis spp.																		
dog, coyote, or wolf	32	(34)	2.2	(2.2)	2.1	(2.1)	115	(131)	3.1	(3.3)	2.9	(3.0)	16	(17)	0.6	(0.6)	0.6	(0.6)
Canis familiaris																		
domestic dog	29	(30)	2.0	(1.9)	1.9	(1.8)	67	(82)	1.8	(2.0)	1.7	(1.9)	25	(27)	1.0	(1.0)	0.9	(1.0)
Canis familiaris or *latrans*																		
dog or coyote							8	(8)	0.2	(0.2)	0.2	(0.1)	2	(2)	0.0	(0.0)	0.0	(0.0)
Canis latrans																		
coyote	5	(5)	0.3	(0.3)	0.3	(0.3)	11	(11)	0.3	(0.2)	0.2	(0.2)	23	(23)	0.9	(0.9)	0.9	(0.8)
Canis lupus																		
gray wolf	1	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Vulpes spp.																		
red or kit foxes							0	(1)	0.0	(0.0)	0.0	(0.0)						
Vulpes vulpes																		
red fox							2	(2)	0.0	(0.0)	0.0	(0.0)	24	(27)	1.0	(1.0)	0.9	(1.0)
Vulpes or *Urocyon* spp.																		
foxes													4	(4)	0.1	(0.1)	0.1	(0.1)
Urocyon cinereoargenteus																		
gray fox																		
Ursus spp.																		
bears	10	(13)	0.6	(0.8)	0.6	(0.8)	1	(1)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Ursus americanus																		
black bear							2	(2)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Bassariscus astutus																		
ringtail																		
Mustelidae																		
mustelids							1	(2)	0.0	(0.0)	0.0	(0.0)						
Martes americana																		
marten							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustela spp.																		
weasels	1	(1)	0.0	(0.0)	0.0	(0.0)							13	(13)	0.5	(0.5)	0.5	(0.4)
Mustela vison																		
mink																		
Mustela frenata																		
long-tailed weasel	1	(1)	0.0	(0.0)	0.0	(0.0)							3	(3)	0.1	(0.1)	0.1	(0.1)
Gulo gulo																		
wolverine							1	(1)	0.0	(0.0)	0.0	(0.0)						
Taxidea taxus																		
badger	1	(1)	0.0	(0.0)	0.0	(0.0)	3	(6)	0.0	(0.1)	0.0	(0.1)	3	(4)	0.1	(0.1)	0.1	(0.1)
Spilogale putorius																		
spotted skunk	1	(1)	0.0	(0.0)	0.0	(0.0)							1	(1)	0.0	(0.0)	0.0	(0.0)
Mephitis mephitis																		
striped skunk																		
Felidae																		
cats																		
Lynx spp.																		
bobcat or lynx	2	(3)	0.1	(0.1)	0.1	(0.1)	2	(2)	0.0	(0.0)	0.0	(0.0)						
Lynx rufus																		
bobcat	4	(4)	0.2	(0.2)	0.2	(0.2)	7	(9)	0.1	(0.2)	0.1	(0.2)	24	(25)	1.0	(1.0)	0.9	(0.9)
Felis concolor																		
mountain lion							1	(1)	0.0	(0.0)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)
Equus spp.																		
horses							3	(3)	0.0	(0.0)	0.0	(0.0)						
Equus caballus																		
horse							1	(1)	0.0	(0.0)	0.0	(0.0)						
Artiodactyla																		
artiodactyls	240	(242)	16.6	(15.8)	16.0	(15.1)	513	(515)	14.0	(13.0)	13.0	(12.1)	215	(221)	8.9	(8.9)	8.4	(8.3)
Cervidae																		
deer	67	(67)	4.6	(4.3)	4.4	(4.1)	224	(226)	6.1	(5.7)	5.6	(5.3)	118	(118)	4.9	(4.7)	4.6	(4.4)
Cervus elaphus																		
American elk	9	(12)	0.6	(0.7)	0.6	(0.7)	24	(37)	0.6	(0.9)	0.6	(0.8)	101	(101)	4.2	(4.1)	3.9	(3.8)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Odocoileus hemionus																		
mule deer	155	(162)	10.7	(10.5)	10.3	(10.1)	387	(429)	10.5	(10.8)	9.8	(10.1)	212	(218)	8.8	(8.8)	8.3	(8.2)
Antilocapra americana																		
pronghorn	6	(9)	0.4	(0.5)	0.4	(0.5)	21	(28)	0.5	(0.7)	0.5	(0.6)	30	(30)	1.2	(1.2)	1.1	(1.1)
Antilocapra or *Ovis* spp.																		
pronghorn or sheep	5	(5)	0.3	(0.3)	0.3	(0.3)	2	(2)	0.0	(0.0)	0.0	(0.0)						
Ovis spp.																		
sheep																		
Ovis canadensis																		
bighorn	7	(8)	0.4	(0.5)	0.4	(0.4)	18	(19)	0.4	(0.4)	0.4	(0.4)	40	(44)	1.6	(1.7)	1.5	(1.6)
Ovis aries																		
domestic sheep							1	(1)	0.0	(0.0)	0.0	(0.0)						
Ovis or *Capra* spp.																		
sheep or goat																		
Bos taurus																		
domestic cow																		
Bos or *Bison*																		
cow or bison																		
Total Mammalia	1444	(1531)	100.0	(100.0)	96.3	(95.6)	3662	(3941)	100.0	(100.0)	93.0	(92.9)	2400	(2461)	100.0	(100.0)	94.2	(93.2)
Aves:																		
Gaviiformes																		
loons																		
Ciconiformes																		
deep water waders																		
Anatidae																		
geese and ducks	1	(1)	1.8	(1.4)	0.0	(0.0)												
Anserinae																		
geese							5	(5)	1.8	(1.6)	0.1	(0.1)	4	(4)	2.7	(2.2)	0.1	(0.1)
Branta canadensis																		
Canada goose	1	(2)	1.8	(2.9)	0.0	(0.1)	3	(6)	1.1	(2.0)	0.0	(0.1)	2	(3)	1.3	(1.6)	0.0	(0.1)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Anas spp.																		
surface-feeding ducks							2	(3)	0.7	(1.0)	0.0	(0.0)	1	(1)	0.6	(0.5)	0.0	(0.0)
Anas platyrhynchos																		
mallard							1	(1)	0.3	(0.3)	0.0	(0.0)	2	(2)	1.3	(1.1)	0.0	(0.0)
Oxyura jamaicensis																		
ruddy duck																		
Falconiformes																		
vultures, hawks, and falcons	5	(5)	9.4	(7.3)	0.3	(0.3)	1	(2)	0.3	(0.6)	0.0	(0.0)						
Cathartes aura																		
turkey vulture													0	(1)	0.0	(0.5)	0.0	(0.0)
Accipitridae																		
hawks and eagles							4	(4)	1.4	(1.3)	0.1	(0.0)						
Accipiter spp.																		
hawks							0	(1)	0.0	(0.3)	0.0	(0.0)						
Accipiter gentilis																		
goshawk													1	(1)	0.6	(0.5)	0.0	(0.0)
Accipiter striatus																		
sharp-shinned hawk													2	(2)	1.3	(1.1)	0.0	(0.0)
Accipiter cooperii																		
Cooper's hawk							1	(1)	0.3	(0.3)	0.0	(0.0)	1	(1)	0.6	(0.5)	0.0	(0.0)
Buteo spp.																		
buteos	1	(1)	1.8	(1.4)	0.0	(0.0)	7	(7)	2.5	(2.3)	0.1	(0.1)	1	(1)	0.6	(0.5)	0.0	(0.0)
Buteo jamaicensis																		
red-tailed hawk							5	(6)	1.8	(2.0)	0.1	(0.1)	1	(1)	0.6	(0.5)	0.0	(0.0)
Buteo swainsoni																		
Swainson's hawk													1	(1)	0.6	(0.5)	0.0	(0.0)
Aquila or *Haliaeetus* spp.																		
eagles													1	(1)	0.6	(0.5)	0.0	(0.0)
Aquila chrysaetos																		
golden eagle	1	(1)	1.8	(1.4)	0.0	(0.0)	1	(1)	0.3	(0.3)	0.0	(0.0)	8	(8)	5.4	(4.4)	0.3	(0.3)
Haliaeetus leucocephalus																		
bald eagle													1	(1)	0.6	(0.5)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Falco mexicanus																		
prairie falcon							0	(1)	0.0	(0.3)	0.0	(0.0)						
Falco sparverius																		
American kestrel													2	(2)	1.3	(1.1)	0.0	(0.0)
Galliformes																		
fowl-like birds	4	(5)	7.5	(7.3)	0.2	(0.3)	1	(1)	0.3	(0.3)	0.0	(0.0)						
Tetraonidae																		
grouse	19	(19)	35.8	(27.9)	1.2	(1.11)	41	(45)	15.1	(15.1)	1.0	(1.0)	42	(49)	28.7	(27.5)	1.6	(1.8)
Centrocercus urophasianus																		
sage grouse	1	(1)	1.8	(1.4)	0.0	(0.0)	2	(2)	0.7	(0.6)	0.0	(0.0)	10	(10)	6.8	(5.6)	0.3	(0.3)
Gallus domesticus																		
chicken																		
Meleagris gallopavo																		
turkey	16	(28)	30.1	(41.1)	1.0	(1.7)	178	(189)	65.9	(63.6)	4.5	(4.4)	49	(69)	33.5	(38.7)	1.9	(2.6)
Grus canadensis																		
sandhill crane							2	(2)	0.7	(0.6)	0.0	(0.0)	1	(1)	0.6	(0.5)	0.0	(0.0)
Tringa melanoleuca																		
greater yellowlegs													0	(1)	0.0	(0.5)	0.0	(0.0)
Zenaida macroura																		
mourning dove							1	(1)	0.3	(0.3)	0.0	(0.0)	1	(1)	0.6	(0.5)	0.0	(0.0)
Otus asio																		
screech owl							1	(1)	0.3	(0.3)	0.0	(0.0)						
Bubo virginianus																		
great horned owl	0	(1)	0.0	(1.4)	0.0	(0.0)	4	(4)	1.4	(1.3)	0.1	(0.0)	6	(7)	4.1	(3.9)	0.2	(0.2)
Glaucidium gnoma																		
pygmy owl																		
Asio spp.																		
long- or short-eared owl																		
Asio otus																		
long-eared owl																		
Colaptes auratus																		
common flicker																		

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Passeriformes																		
perching birds	2	(2)	3.7	(2.9)	0.1	(0.1)	1	(2)	0.3	(0.6)	0.0	(0.0)	1	(1)	0.6	(0.5)	0.0	(0.0)
Tyrannus verticalis																		
western kingbird													1	(1)	0.6	(0.5)	0.0	(0.0)
Corvidae																		
jays, crows, and magpies							2	(2)	0.7	(0.6)	0.0	(0.0)						
Corvus spp.																		
raven or crow							0	(1)	0.0	(0.3)	0.0	(0.0)						
Corvus corax																		
common raven	1	(1)	1.8	(1.4)	0.0	(0.0)	6	(6)	2.2	(2.0)	0.1	(0.1)	3	(3)	2.0	(1.6)	0.1	(0.1)
Corvus brachyrhynchos																		
common crow	1	(1)	1.8	(1.4)	0.0	(0.0)	1	(2)	0.3	(0.6)	0.0	(0.0)						
Cyanocitta stelleri																		
Steller's jay																		
Cymnorhinus cyanocephalus																		
pinyon jay																		
Aphelocoma coerulescens																		
scrub jay																		
Pica pica																		
black-billed magpie													4	(4)	2.7	(2.2)	0.1	(0.1)
Turdidae																		
thrushes and bluebirds																		
Sialia currucoides																		
mountain bluebird																		
Turdus migratorius																		
American robin							0	(1)	0.0	(0.3)	0.0	(0.0)						
Lanius excubitor																		
northern shrike																		
Sturnella spp.																		
meadowlarks																		
Xanthocephalus xanthocephalus																		
yellow-headed blackbird													0	(1)	0.0	(0.5)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4					Modeling Period 5					Modeling Period 6				
	N		% class	% total		N		% class	% total		N		% class	% total	
Fringillidae															
finch-like birds															
Pipilo chlorura															
green-tailed towhee															
Total Aves	53	(68)	100.0	(100.0)	3.5 (4.2)	270	(297)	100.0	(100.0)	6.8 (7.0)	146	(178)	100.0	(100.0)	5.7 (6.7)
Reptilia:															
Squamata															
lizards and snakes															
Sauria															
lizard															
Sceloporus undulatus elongatus															
northern plateau lizard															
Serpentes															
snakes	2	(2)	100.0	(100.0)	0.1 (0.1)	1	(1)	100.0	(100.0)	0.0 (0.0)					
Crotaius viridis															
western rattlesnake															
Total Reptilia	2	(2)	100.0	(100.0)	0.1 (0.1)	1	(1)	100.0	(100.0)	0.0 (0.0)					
Amphibia:															
Anura															
frogs and toads															
Bufo spp.															
true toads						2	(2)	100.0	(100.0)	0.0 (0.0)					
Total Amphibia						2	(2)	100.0	(100.0)	0.0 (0.0)					
Osteichthyes:															
Cypriniformes															
cyprinids															

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 4			Modeling Period 5			Modeling Period 6		
	N	% class	% total	N	% class	% total	N	% class	% total
Catostomidae									
suckers									
Catostomus spp.									
flannelmouth or bluehead sucker									
Total Osteichthyes									
Total assemblage	1499 (1601)		100.0 (100.0)	3935 (4241)		100.0 (100.0)	2546 (2639)		100.0 (100.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mammalia:																		
Insectivora																		
insectivores													0	(3)	0.0	(0.0)	0.0	(0.0)
Soricidae																		
shrews							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)
Microsorex hoyi																		
pygmy shrew													8	(8)	0.0	(0.0)	0.0	(0.0)
Lagomorpha																		
pikas, rabbits, and hares	10	(10)	1.3	(1.2)	1.2	(1.1)	1	(1)	0.0	(0.0)	0.0	(0.0)	21	(21)	0.1	(0.1)	0.0	(0.0)
Ochotona princeps																		
pika	1	(1)	0.1	(0.1)	0.1	(0.1)							1	(1)	0.0	(0.0)	0.0	(0.0)
Leporidae																		
rabbits and hares	31	(33)	4.0	(4.2)	3.8	(3.8)	83	(83)	1.3	(1.3)	1.3	(1.2)	258	(260)	1.2	(1.2)	1.2	(1.1)
Sylvilagus spp.																		
cottontails	233	(235)	30.6	(30.0)	28.8	(27.4)	1407	(1437)	23.5	(22.6)	22.3	(21.3)	4888	(4948)	24.4	(23.5)	23.1	(22.2)
Sylvilagus nuttallii																		
Nuttall's cottontail	4	(6)	0.5	(0.7)	0.4	(0.7)	18	(23)	0.3	(0.3)	0.2	(0.3)	61	(76)	0.3	(0.3)	0.2	(0.3)
Sylvilagus audubonii																		
desert cottontail	14	(14)	1.8	(1.7)	1.7	(1.6)	46	(48)	0.7	(0.7)	0.7	(0.7)	208	(213)	1.0	(1.0)	0.9	(0.9)
Lepus spp.																		
jackrabbits	47	(48)	6.1	(6.1)	5.8	(5.6)	755	(784)	12.6	(12.3)	12.0	(11.6)	2776	(2853)	13.8	(13.5)	13.1	(12.8)
Lepus americanus																		
snowshoe hare							9	(10)	0.1	(0.1)	0.1	(0.1)	28	(29)	0.1	(0.1)	0.1	(0.1)
Lepus townsendii																		
white-tailed jackrabbit							62	(93)	1.0	(1.4)	0.9	(1.3)	121	(209)	0.6	(0.9)	0.5	(0.9)
Lepus californicus																		
black-tailed jackrabbit							15	(35)	0.2	(0.5)	0.2	(0.5)	37	(93)	0.1	(0.4)	0.1	(0.4)
Rodentia																		
rodents	56	(56)	7.3	(7.1)	6.9	(6.5)	137	(137)	2.2	(2.1)	2.1	(2.0)	412	(412)	2.0	(1.9)	1.9	(1.8)
Sciuridae																		
squirrels	18	(18)	2.3	(2.2)	2.2	(2.1)	135	(135)	2.2	(2.1)	2.1	(2.0)	538	(542)	2.6	(2.5)	2.5	(2.4)
Eutamias spp.																		
chipmunks							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Marmota flaviventris																		
yellow-bellied marmot	2	(2)	0.2	(0.2)	0.2	(0.2)	183	(208)	3.0	(3.2)	2.9	(3.0)	522	(565)	2.6	(2.6)	2.4	(2.5)
Amnospermophilus leucurus																		
white-tailed antelope squirrel							2	(2)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Spermophilus spp.																		
ground squirrels							1	(4)	0.0	(0.0)	0.0	(0.0)	3	(6)	0.0	(0.0)	0.0	(0.0)
Spermophilus spilosoma																		
spotted ground squirrel							41	(42)	0.6	(0.6)	0.6	(0.6)	101	(104)	0.5	(0.4)	0.4	(0.4)
Spermophilus lateralis																		
golden-mantled ground squirrel	2	(2)	0.2	(0.2)	0.2	(0.2)	9	(11)	0.1	(0.1)	0.1	(0.1)	39	(46)	0.1	(0.2)	0.1	(0.2)
Spermophilus variegatus																		
rock squirrel	8	(9)	1.0	(1.1)	0.9	(1.0)	127	(138)	2.1	(2.1)	2.0	(2.0)	279	(307)	1.3	(1.4)	1.3	(1.3)
Cynomys gunnisoni																		
Gunnison's prairie dog	60	(60)	7.9	(7.6)	7.4	(7.0)	165	(172)	2.7	(2.7)	2.6	(2.5)	815	(847)	4.0	(4.0)	3.8	(3.8)
Geomyidae																		
pocket gophers							1	(1)	0.0	(0.0)	0.0	(0.0)	4	(4)	0.0	(0.0)	0.0	(0.0)
Thomomys spp.																		
pocket gophers	9	(9)	1.1	(1.1)	1.1	(1.0)	151	(164)	2.5	(2.5)	2.4	(2.4)	382	(404)	1.9	(1.9)	1.8	(1.8)
Thomomys bottae																		
valley pocket gopher	11	(11)	1.4	(1.4)	1.3	(1.2)	11	(13)	0.1	(0.2)	0.1	(0.1)	99	(101)	0.4	(0.4)	0.4	(0.4)
Thomomys talpoides																		
northern pocket gopher	0	(1)	0.0	(0.1)	0.0	(0.1)	1	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)
Heteromyidae																		
pocket mice, kangaroo rat													0	(8)	0.0	(0.0)	0.0	(0.0)
Perognathus apache																		
Apache pocket mouse							0	(1)	0.0	(0.0)	0.0	(0.0)	8	(12)	0.0	(0.0)	0.0	(0.0)
Dipodomys ordii																		
Ord's kangaroo rat	0	(1)	0.0	(0.1)	0.0	(0.1)	0	(2)	0.0	(0.0)	0.0	(0.0)	0	(9)	0.0	(0.0)	0.0	(0.0)
Castor canadensis																		
beaver	17	(17)	2.2	(2.1)	2.1	(1.9)	74	(81)	1.2	(1.2)	1.1	(1.2)	211	(225)	1.0	(1.0)	0.9	(1.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cricetidae																		
New World rats and mice	11	(11)	1.4	(1.4)	1.3	(1.2)	13	(13)	0.2	(0.2)	0.2	(0.1)	106	(106)	0.5	(0.5)	0.5	(0.4)
Peromyscus spp.																		
white-footed mice	17	(18)	2.2	(2.2)	2.1	(2.1)	149	(154)	2.4	(2.4)	2.3	(2.2)	375	(382)	1.8	(1.8)	1.7	(1.7)
Peromyscus maniculatus																		
deer mouse							0	(9)	0.0	(0.1)	0.0	(0.1)	0	(9)	0.0	(0.0)	0.0	(0.0)
Peromyscus boylii or *truei*																		
brush or pinyon mouse	2	(2)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.0	(0.0)	0.0	(0.0)	13	(13)	0.0	(0.0)	0.0	(0.0)
Onochomys leucogaster																		
northern grasshopper mouse																		
Neotoma spp.																		
wood rats	24	(30)	3.1	(3.8)	2.9	(3.5)	117	(124)	1.9	(1.9)	1.8	(1.8)	382	(403)	1.9	(1.9)	1.8	(1.8)
Neotoma cinerea																		
bushy-tailed wood rat	7	(7)	0.9	(0.8)	0.8	(0.8)	27	(28)	0.4	(0.4)	0.4	(0.4)	40	(43)	0.1	(0.2)	0.1	(0.1)
Neotoma mexicana																		
Mexican wood rat	1	(1)	0.1	(0.1)	0.1	(0.1)							6	(7)	0.0	(0.0)	0.0	(0.0)
Microtus spp.																		
voles	16	(18)	2.1	(2.2)	1.9	(2.1)	65	(66)	1.0	(1.0)	1.0	(0.9)	114	(124)	0.5	(0.5)	0.5	(0.5)
Microtus montanus																		
montane vole							1	(1)	0.0	(0.0)	0.0	(0.0)	20	(20)	0.0	(0.0)	0.0	(0.0)
Microtus longicaudus																		
long-tailed vole							1	(1)	0.0	(0.0)	0.0	(0.0)	3	(7)	0.0	(0.0)	0.0	(0.0)
Microtus mexicanus																		
Mexican vole	3	(3)	0.3	(0.3)	0.3	(0.3)	0	(4)	0.0	(0.0)	0.0	(0.0)	8	(12)	0.0	(0.0)	0.0	(0.0)
Microtus pennsylvanicus																		
meadow vole													0	(1)	0.0	(0.0)	0.0	(0.0)
Ondatra zibethicus																		
muskrat	2	(2)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.0	(0.0)	0.0	(0.0)	8	(9)	0.0	(0.0)	0.0	(0.0)
Zapodidae																		
jumping mice													1	(1)	0.0	(0.0)	0.0	(0.0)
Erethizon dorsatum																		
porcupine	2	(2)	0.2	(0.2)	0.2	(0.2)	91	(94)	1.5	(1.4)	1.4	(1.3)	297	(327)	1.4	(1.5)	1.4	(1.4)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Carnivora																		
carnivores	3	(3)	0.3	(0.3)	0.3	(0.3)	39	(39)	0.6	(0.6)	0.6	(0.5)	113	(114)	0.5	(0.5)	0.5	(0.5)
Canidae																		
canids	2	(2)	0.2	(0.2)	0.2	(0.2)	23	(27)	0.3	(0.4)	0.3	(0.4)	80	(93)	0.3	(0.4)	0.3	(0.4)
Canis spp.																		
dog, coyote, or wolf	1	(1)	0.1	(0.1)	0.1	(0.1)	85	(112)	1.4	(1.7)	1.3	(1.6)	290	(348)	1.4	(1.6)	1.3	(1.5)
Canis familiaris																		
domestic dog							34	(43)	0.5	(0.6)	0.5	(0.6)	424	(451)	2.1	(2.1)	2.0	(2.0)
Canis familiaris or *latrans*																		
dog or coyote							2	(2)	0.0	(0.0)	0.0	(0.0)	12	(12)	0.0	(0.0)	0.0	(0.0)
Canis latrans																		
coyote	4	(4)	0.5	(0.5)	0.4	(0.4)	27	(33)	0.4	(0.5)	0.4	(0.4)	86	(92)	0.4	(0.4)	0.4	(0.4)
Canis lupus																		
gray wolf							2	(3)	0.0	(0.0)	0.0	(0.0)	8	(11)	0.0	(0.0)	0.0	(0.0)
Vulpes spp.																		
red or kit foxes							0	(1)	0.0	(0.0)	0.0	(0.0)	0	(2)	0.0	(0.0)	0.0	(0.0)
Vulpes vulpes																		
red fox	9	(9)	1.1	(1.1)	1.1	(1.0)	32	(42)	0.5	(0.6)	0.5	(0.6)	104	(120)	0.5	(0.5)	0.4	(0.5)
Vulpes or *Urocyon* spp.																		
foxes							2	(2)	0.0	(0.0)	0.0	(0.0)	6	(6)	0.0	(0.0)	0.0	(0.0)
Urocyon cinereoargenteus																		
gray fox							9	(9)	0.1	(0.1)	0.1	(0.1)	10	(10)	0.0	(0.0)	0.0	(0.0)
Ursus spp.																		
bears							7	(9)	0.1	(0.1)	0.1	(0.1)	25	(30)	0.1	(0.1)	0.1	(0.1)
Ursus americanus																		
black bear							1	(1)	0.0	(0.0)	0.0	(0.0)	4	(5)	0.0	(0.0)	0.0	(0.0)
Bassariscus astutus																		
ringtail													3	(3)	0.0	(0.0)	0.0	(0.0)
Mustelidae																		
mustelids							2	(2)	0.0	(0.0)	0.0	(0.0)	3	(4)	0.0	(0.0)	0.0	(0.0)
Martes americana																		
marten							2	(3)	0.0	(0.0)	0.0	(0.0)	4	(6)	0.0	(0.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustela spp. weasels							4	(4)	0.0	(0.0)	0.0	(0.0)	18	(18)	0.0	(0.0)	0.0	(0.0)
Mustela vison mink							1	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Mustela frenata long-tailed weasel	1	(1)	0.1	(0.1)	0.1	(0.1)	5	(5)	0.0	(0.0)	0.0	(0.0)	14	(14)	0.0	(0.0)	0.0	(0.0)
Gulo gulo wolverine													1	(1)	0.0	(0.0)	0.0	(0.0)
Taxidea taxus badger	3	(3)	0.3	(0.3)	0.3	(0.3)	8	(10)	0.1	(0.1)	0.1	(0.1)	26	(32)	0.1	(0.1)	0.1	(0.1)
Spilogale putorius spotted skunk							6	(6)	0.1	(0.0)	0.0	(0.0)	8	(8)	0.0	(0.0)	0.0	(0.0)
Mephitis mephitis striped skunk							25	(25)	0.4	(0.3)	0.3	(0.3)	26	(27)	0.1	(0.1)	0.1	(0.1)
Felidae cats							0	(1)	0.0	(0.0)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)
Lynx spp. bobcat or lynx							2	(4)	0.0	(0.0)	0.0	(0.0)	8	(11)	0.0	(0.0)	0.0	(0.0)
Lynx rufus bobcat	5	(6)	0.6	(0.7)	0.6	(0.7)	39	(44)	0.6	(0.6)	0.6	(0.6)	96	(105)	0.4	(0.5)	0.4	(0.4)
Felis concolor mountain lion													1	(2)	0.0	(0.0)	0.0	(0.0)
Equus spp. horses							3	(3)	0.0	(0.0)	0.0	(0.0)	6	(6)	0.0	(0.0)	0.0	(0.0)
Equus caballus horse							1	(1)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Artiodactyla artiodactyls	41	(43)	5.4	(5.4)	5.0	(5.0)	775	(779)	12.9	(12.2)	12.3	(11.5)	2167	(2191)	10.8	(10.4)	10.2	(9.8)
Cervidae deer	2	(2)	0.2	(0.2)	0.2	(0.2)	169	(169)	2.8	(2.6)	2.6	(2.5)	1016	(1019)	5.0	(4.8)	4.8	(4.5)
Cervus elaphus American elk	6	(6)	0.7	(0.7)	0.7	(0.7)	42	(48)	0.7	(0.7)	0.6	(0.7)	190	(216)	0.9	(1.0)	0.8	(0.9)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Odocoileus hemionus																		
mule deer	64	(66)	8.4	(8.4)	7.9	(7.7)	578	(628)	9.6	(9.9)	9.1	(9.3)	1731	(1851)	8.6	(8.8)	8.1	(8.3)
Antilocapra americana																		
pronghorn	3	(3)	0.3	(0.3)	0.3	(0.3)	24	(31)	0.4	(0.4)	0.3	(0.4)	115	(132)	0.5	(0.6)	0.5	(0.5)
Antilocapra or *Ovis* spp.																		
pronghorn or sheep							1	(1)	0.0	(0.0)	0.0	(0.0)	8	(8)	0.0	(0.0)	0.0	(0.0)
Ovis spp.																		
sheep							2	(2)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Ovis canadensis																		
bighorn	7	(7)	0.9	(0.8)	0.8	(0.8)	61	(71)	1.0	(1.1)	0.9	(1.0)	161	(179)	0.8	(0.8)	0.7	(0.8)
Ovis aries																		
domestic sheep							4	(4)	0.0	(0.0)	0.0	(0.0)	7	(7)	0.0	(0.0)	0.0	(0.0)
Ovis or *Capra* spp.																		
sheep or goat							4	(4)	0.0	(0.0)	0.0	(0.0)	4	(4)	0.0	(0.0)	0.0	(0.0)
Bos taurus																		
domestic cow							38	(40)	0.6	(0.6)	0.6	(0.5)	49	(51)	0.2	(0.2)	0.2	(0.2)
Bos or *Bison*																		
cow or bison							1	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Total Mammalia	759	(783)	100.0	(100.0)	93.8	(91.5)	5962	(6336)	100.0	(100.0)	94.8	(94.2)	20 031	(20 979)	100.0	(100.0)	94.7	(94.2)
Aves:																		
Gaviiformes																		
loons							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Ciconiformes																		
deep water waders							0	(4)	0.0	(1.1)	0.0	(0.0)	0	(4)	0.0	(0.3)	0.0	(0.0)
Anatidae																		
geese and ducks													2	(2)	0.1	(0.1)	0.0	(0.0)
Anserinae																		
geese							1	(1)	0.3	(0.2)	0.0	(0.0)	11	(11)	1.0	(0.8)	0.0	(0.0)
Branta canadensis																		
Canada goose							2	(3)	0.6	(0.8)	0.0	(0.)	12	(19)	1.1	(1.5)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Anas spp.																		
surface-feeding ducks	1	(1)	2.0	(1.5)	0.1	(0.1)	1	(1)	0.3	(0.2)	0.0	(0.0)	6	(7)	0.5	(0.5)	0.0	(0.0)
Anas platyrhynchos																		
mallard													3	(4)	0.2	(0.3)	0.0	(0.0)
Oxyura jamaicensis																		
ruddy duck													5	(6)	0.4	(0.4)	0.0	(0.0)
Falconiformes																		
vultures, hawks, and falcons	0	(5)	0.0	(7.8)	0.0	(0.5)	3	(4)	1.0	(1.1)	0.0	(0.0)	12	(19)	1.1	(1.5)	0.0	(0.0)
Cathartes aura																		
turkey vulture							0	(2)	0.0	(0.5)	0.0	(0.0)	1	(8)	0.0	(0.6)	0.0	(0.0)
Accipitridae																		
hawks and eagles	4	(4)	8.3	(6.2)	0.4	(0.4)	14	(14)	4.7	(3.9)	0.2	(0.2)	22	(22)	2.0	(1.7)	0.1	(0.0)
Accipiter spp.																		
hawks													0	(1)	0.0	(0.0)	0.0	(0.0)
Accipiter gentilis																		
goshawk							1	(1)	0.3	(0.2)	0.0	(0.0)	2	(2)	0.1	(0.1)	0.0	(0.0)
Accipiter striatus																		
sharp-shinned hawk							5	(5)	1.6	(1.4)	0.0	(0.0)	7	(7)	0.6	(0.5)	0.0	(0.0)
Accipiter cooperii																		
Cooper's hawk													2	(2)	0.1	(0.1)	0.0	(0.0)
Buteo spp.																		
buteos	3	(3)	6.2	(4.6)	0.3	(0.3)	7	(8)	2.3	(2.2)	0.1	(0.1)	19	(20)	1.7	(1.6)	0.0	(0.0)
Buteo jamaicensis																		
red-tailed hawk							0	(2)	0.0	(0.5)	0.0	(0.0)	7	(10)	0.6	(0.8)	0.0	(0.0)
Buteo swainsoni																		
Swainson's hawk													1	(1)	0.0	(0.0)	0.0	(0.0)
Aquila or *Haliaeetus* spp.																		
eagles	0	(1)	0.0	(1.5)	0.0	(0.1)	2	(2)	0.6	(0.5)	0.0	(0.0)	3	(4)	0.2	(0.3)	0.0	(0.0)
Aquila chrysaetos																		
golden eagle							2	(2)	0.6	(0.5)	0.0	(0.0)	16	(16)	1.5	(1.2)	0.0	(0.0)
Haliaeetus leucocephalus																		
bald eagle													1	(1)	0.0	(0.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Falco mexicanus																		
prairie falcon													0	(1)	0.0	(0.0)	0.0	(0.0)
Falco sparverius																		
American kestrel							0	(1)	0.0	(0.2)	0.0	(0.0)	16	(17)	1.5	(1.3)	0.0	(0.0)
Galliformes																		
fowl-like birds	1	(1)	2.0	(1.5)	0.1	(0.1)	5	(6)	1.6	(1.6)	0.0	(0.0)	12	(14)	1.1	(1.1)	0.0	(0.0)
Tetraonidae																		
grouse	13	(13)	27.0	(20.3)	1.6	(1.5)	106	(118)	35.6	(33.3)	1.6	(1.7)	302	(331)	28.5	(26.7)	1.4	(1.4)
Centrocercus urophasianus																		
sage grouse	1	(1)	2.0	(1.5)	0.1	(0.1)	4	(4)	1.3	(1.1)	0.0	(0.0)	18	(18)	1.6	(1.4)	0.0	(0.0)
Gallus domesticus																		
chicken							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Meleagris gallopavo																		
turkey	10	(17)	20.8	(26.5)	1.2	(1.9)	73	(90)	24.5	(25.4)	1.1	(1.3)	386	(464)	36.4	(37.5)	1.8	(2.0)
Grus canadensis																		
sandhill crane	1	(1)	2.0	(1.5)	0.1	(0.1)	4	(6)	1.3	(1.6)	0.0	(0.0)	28	(34)	2.6	(2.7)	0.1	(0.1)
Tringa melanoleuca																		
greater yellowlegs													0	(1)	0.0	(0.0)	0.0	(0.0)
Zenaida macroura																		
mourning dove							0	(2)	0.0	(0.5)	0.0	(0.0)	3	(6)	0.2	(0.4)	0.0	(0.0)
Otus asio																		
screech owl													1	(1)	0.0	(0.0)	0.0	(0.0)
Bubo virginianus																		
great horned owl							4	(7)	1.3	(1.9)	0.0	(0.1)	16	(21)	1.5	(1.6)	0.0	(0.0)
Glaucidium gnoma																		
pygmy owl							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Asio spp.																		
long- or short-eared owl													1	(1)	0.0	(0.0)	0.0	(0.0)
Asio otus																		
long-eared owl							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Colaptes auratus																		
common flicker							1	(1)	0.3	(0.2)	0.0	(0.0)	7	(7)	0.6	(0.5)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Passeriformes																		
perching birds	4	(4)	8.3	(6.2)	0.4	(0.4)	27	(28)	9.0	(7.9)	0.4	(0.4)	50	(52)	4.7	(4.2)	0.2	(0.2)
Tyrannus verticalis																		
western kingbird													1	(1)	0.0	(0.0)	0.0	(0.0)
Corvidae																		
jays, crows, and magpies	7	(7)	14.5	(10.9)	0.8	(0.8)	1	(2)	0.3	(0.5)	0.0	(0.0)	12	(13)	1.1	(1.0)	0.0	(0.0)
Corvus spp.																		
raven or crow													0	(1)	0.0	(0.0)	0.0	(0.0)
Corvus corax																		
common raven							14	(17)	4.7	(4.8)	0.2	(0.2)	28	(31)	2.6	(2.5)	0.1	(0.1)
Corvus brachyrhynchos																		
common crow							2	(3)	0.6	(0.8)	0.0	(0.0)	5	(7)	0.4	(0.5)	0.0	(0.0)
Cyanocitta stelleri																		
Steller's jay	0	(1)	0.0	(1.5)	0.0	(0.1)	5	(6)	1.6	(1.6)	0.0	(0.0)	5	(7)	0.4	(0.5)	0.0	(0.0)
Gymnorhinus cyanocephalus																		
pinyon jay	0	(2)	0.0	(3.1)	0.0	(0.2)							0	(2)	0.0	(0.1)	0.0	(0.0)
Aphelocoma coerulescens																		
scrub jay	3	(3)	6.2	(4.6)	0.3	(0.3)	2	(2)	0.6	(0.5)	0.0	(0.0)	5	(5)	0.4	(0.4)	0.0	(0.0)
Pica pica																		
black-billed magpie							3	(3)	1.0	(0.8)	0.0	(0.0)	10	(10)	0.9	(0.8)	0.0	(0.0)
Turdidae																		
thrushes and bluebirds							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Sialia currucoides																		
mountain bluebird							0	(1)	0.0	(0.2)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)
Turdus migratorius																		
American robin							2	(2)	0.6	(0.5)	0.0	(0.0)	2	(4)	0.1	(0.3)	0.0	(0.0)
Lanius excubitor																		
northern shrike							1	(1)	0.3	(0.2)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Sturnella spp.																		
meadowlarks													1	(1)	0.0	(0.0)	0.0	(0.0)
Xanthocephalus xanthocephalus																		
yellow-headed blackbird													0	(1)	0.0	(0.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7						Other*						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Fringillidae																		
finch-like birds													1	(1)	0.0	(0.0)	0.0	(0.0)
Pipilo chlorura																		
green-tailed towhee													11	(12)	1.0	(0.9)	0.0	(0.0)
Total Aves	48	(64)	100.0	(100.0)	5.9	(7.4)	297	(354)	100.0	(100.0)	4.7	(5.2)	1059	(1237)	100.0	(100.0)	5.0	(5.5)
Reptilia:																		
Squamata																		
lizards and snakes							3	(3)	30.0	(27.2)	0.0	(0.0)	3	(3)	20.0	(18.7)	0.0	(0.0)
Sauria																		
lizard	2	(2)	100.0	(100.0)	0.2	(0.2)	1	(1)	10.0	(9.0)	0.0	(0.0)	3	(3)	20.0	(18.7)	0.0	(0.0)
Sceloporus undulatus elongatus																		
northern plateau lizard							1	(1)	10.0	(9.0)	0.0	(0.0)	1	(1)	6.6	(6.2)	0.0	(0.0)
Serpentes																		
snakes							5	(5)	50.0	(45.4)	0.0	(0.0)	8	(8)	53.3	(50.0)	0.0	(0.0)
Crotalus viridis																		
western rattlesnake							0	(1)	0.0	(9.0)	0.0	(0.0)	0	(1)	0.0	(6.2)	0.0	(0.0)
Total Reptilia	2	(2)	100.0	(100.0)	0.2	(0.2)	10	(11)	100.0	(100.0)	0.1	(0.1)	15	(16)	100.0	(100.0)	0.0	(0.0)
Amphibia:																		
Anura																		
frogs and toads							17	(17)	100.0	(100.0)	0.2	(0.2)	21	(21)	91.3	(91.3)	0.0	(0.0)
Bufo spp.																		
true toads													2	(2)	8.6	(8.6)	0.0	(0.0)
Total Amphibia							17	(17)	100.0	(100.0)	0.2	(0.2)	23	(23)	100.0	(100.0)	0.1	(0.1)
Osteichthyes:																		
Cypriniformes																		
cyprinids							1	(1)	50.0	(25.0)	0.0	(0.0)	1	(1)	50.0	(10.0)	0.0	(0.0)

Table 4.38 – NISP in the identifiable macrofaunal assemblage – Continued

Taxon	Modeling Period 7 N	% class	% total	Other* N	% class	% total	Total N	% class	% total
Catostomidae									
suckers	0 (6)	0.7 (100.0)	0.0 (0.7)	0 (2)	0.0 (50.0)	0.0 (0.0)	0 (8)	0.0 (80.0)	0.0 (0.0)
Catostomus spp. flannelmouth or bluehead suckers				1 (1)	50.0 (25.0)	0.0 (0.0)	1 (1)	50.0 (10.0)	0.0 (0.0)
Total Osteichthyes	0 (6)	100.0 (100.0)	0.0 (0.7)	2 (4)	100.0 (100.0)	0.0 (0.0)	2 (10)	100.0 (100.0)	0.0 (0.0)
Total assemblage	809 (855)		100.0 (100.0)	6288 (6722)		100.0 (100.0)	21 130 (22 265)		100.0 (100.0)

Figures in parentheses indicate counts and percentages when bones that compare favorably to that taxon are included.
NISP – Number of individual specimens.
* Identifiable at least to order.
† Other – Not assigned to period.

Table 4.39 – NISP in the identifiable microfaunal assemblage*

Taxon	N		% class		% total	
Mammalia:						
Soricidae						
shrews	72	(72)	20.3	(19.7)	19.4	(18.8)
Lagomorpha						
pikas, rabbits, and hares	2	(2)	0.6	(0.6)	0.5	(0.5)
Leporidae						
rabbits and hares	1	(1)	0.3	(0.3)	0.3	(0.3)
Sylvilagus spp.						
cottontails	94	(98)	26.5	(26.9)	25.3	(25.6)
Sylvilagus nuttallii						
Nuttall's cottontail	1	(1)	0.3	(0.3)	0.3	(0.3)
Sylvilagus audubonii						
desert cottontail	1	(1)	0.3	(0.3)	0.3	(0.3)
Lepus spp.						
jackrabbits	25	(26)	7.1	(7.1)	6.7	(6.8)
Rodentia						
rodents	17	(17)	4.8	(4.7)	4.6	(4.4)
Sciuridae						
squirrels	7	(7)	2.0	(1.9)	1.9	(1.8)
Marmota flaviventris						
yellow-bellied marmot	2	(2)	0.6	(0.6)	0.5	(0.5)
Spermophilus lateralis						
golden-mantled ground squirrel	3	(3)	0.9	(0.8)	0.8	(0.8)
Spermophilus variegatus						
rock squirrel	1	(1)	0.3	(0.3)	0.3	(0.3)
Cynomys gunnisoni						
Gunnison's prairie dog	16	(16)	4.5	(4.4)	4.3	(4.2)
Thomomys spp.						
pocket gophers	10	(10)	2.8	(2.7)	2.7	(2.6)
Thomomys bottae						
valley pocket gopher	2	(2)	0.6	(0.6)	0.5	(0.5)
Cricetidae						
New World rats and mice	6	(6)	1.7	(1.7)	1.6	(1.6)
Peromyscus spp.						
white-footed mice	58	(58)	16.3	(15.9)	15.6	(15.1)
Peromyscus maniculatus						
deer mouse	0	(4)	0.0	(1.1)	0.0	(1.0)
Peromyscus boylii or *truei*						
brush or pinyon mouse	6	(6)	1.7	(1.7)	1.6	(1.6)
Neotoma spp.						
wood rats	5	(5)	1.4	(1.4)	1.3	(1.3)
Microtus spp.						
voles	8	(8)	2.2	(2.2)	2.2	(2.1)
Erethizon dorsatum						
porcupine	5	(5)	1.4	(1.4)	1.3	(1.3)
Canis familiaris						
domestic dog	1	(1)	0.3	(0.3)	0.3	(0.3)
Vulpes vulpes						
red fox	3	(3)	0.9	(0.9)	0.8	(0.8)
Artiodactyla						
artiodactyls	5	(5)	1.4	(1.4)	1.3	(1.3)
Cervus elaphus						
American elk	0	(1)	0.0	(0.3)	0.0	(0.3)
Odocoileus hemionus						
mule deer	4	(4)	1.1	(1.1)	1.1	(1.0)
Total Mammalia	355	(365)	100.0	(100.0)	95.5	(95.4)
Aves:						
Meleagris gallopavo						
turkey	4	(4)	28.6	(26.7)	1.1	(1.0)
Colaptes auratus						
common flicker	1	(1)	7.1	(6.7)	0.3	(0.3)
Passeriformes						
perching birds	9	(9)	64.3	(60.0)	2.4	(2.4)
Cyanocitta stelleri						
Steller's jay	0	(1)	0.0	(6.7)	0.0	(0.3)
Total Aves	14	(15)	100.0	(100.0)	3.8	(4.0)
Reptilia:						
Serpentes						
snakes	1	(1)	33.4	(33.4)	0.3	(0.3)
Pituophis melanoleucus						
gopher snake	2	(2)	66.7	(66.7)	0.5	(0.5)
Total Reptilia	3	(3)	100.0	(100.0)	0.8	(0.8)
Total assemblage	372	(383)			100.0	(100.0)

* Identifiable at least to order.
Figures in parentheses indicate counts and percentages when bones that compare favorably to that taxon are included.
NISP – Number of individual specimens.

all the Dolores black-tailed and white-tailed jackrabbit remains as *Lepus* spp.

Because good reason exists to expect both species in the Dolores vicinity, some important biogeographical implications might result from the resolution of this problem. Armstrong (1972:90) states that the white-tailed jackrabbit occurs in mountain parks in southwestern Colorado, while the black-tailed jackrabbit is found in dry valley habitats. Records of white-tailed jackrabbits in pinyon-juniper woodlands, ponderosa pine forests, scrub oak or mountain brush, sagebrush, and mountain meadows in southwestern Colorado have been summarized in Bissell and Dillon (1982:7) and Neusius (1985a:table 13). The black-tailed jackrabbit is known from pinyon-juniper woodland and scrub oak or mountain brush habitat types according to these same sources.

Most importantly, the Escalante Sector is situated close to the juncture of the modern ranges of these 2 species. It is known that the range of the black-tailed jackrabbit has expanded at the expense of the white-tailed jackrabbit in eastern Colorado during historic times. Although Armstrong (1972:90) discounts it due to the complex topography, there is at least a possibility of range change in southwestern Colorado as well. The Dolores data may be an important indication of such change, particularly if, in contrast to the modern situation, the white-tailed jackrabbit proves to be more common than the black-tailed jackrabbit.

Rodentia – Rodents

A fairly large number of remains have been assigned to the order Rodentia; some of these, mostly incisoriform teeth fragments, could not be identified further. Since a wide variety of rodents are known to occur in Colorado (Armstrong 1972:94) and in the Escalante Sector, the presence of rodent bone is not at all surprising. The key question raised is whether these represent intrusive individuals, or the prey of the Dolores Anasazi. No simple resolution to this problem is available, but the figures in tables 4.38 and 4.39 have been adjusted in all analyses so as to remove bones from rodent burrows or other obviously disturbed contexts.

Sciuridae – Squirrels

According to Armstrong (1972:95-96), 18 squirrel species occur today in Colorado. Ten species are recorded from southwestern Colorado (Bissell and Dillon 1982:8-10): chipmunk (*Eutamias minimus, Eutamias quadrivittatus*), yellow-bellied marmot (*Marmota flaviventris*), white-tailed antelope squirrel (*Ammospermophilus leucurus*), ground squirrel (*Spermophilus*

spilosoma, Spermophilus lateralis), *Spermophilus variegatus,* Gunnison's prairie dog (*Cynomys gunnisoni*), Abert's squirrel (*Sciurus aberti*), and chickaree (*Tamiasciurus hudsonicus*). The lack of the more boreal Abert's squirrel and chickaree in the DAP assemblage should be noted, as it does not result from inadequate comparative materials, and there is no reason to expect that the remains of these species would be less well preserved than other remains.

***Eutamias* spp. – Chipmunks**

Two species of chipmunk, the least chipmunk, (*Eutamias minimus*) and the Colorado chipmunk (*Eutamias quadrivittatus*), are known from southwestern Colorado (Bissell and Dillon 1982:8; Armstrong 1972:96-113). The least chipmunk has the broader range of the 2 and inhabits a variety of habitats in southwestern Colorado, including ponderosa pine forest, pinyon-juniper, scrub oak, or mountain brush, mountain meadows, aspen stands, and riparian woodland (Neusius 1985a:table 13). The Colorado chipmunk is known from the ponderosa pine, pinyon-juniper, and scrub oak or mountain brush habitat types. These species of chipmunk are quite similar in appearance, and Armstrong (1972:106) recommends careful study of their ecology and morphology (refer to Telleen [1978] for information on E. *minimus* elsewhere in Colorado).

***Marmota flaviventris* – Yellow-bellied Marmot**

The yellow-bellied marmot is the largest member of the squirrel family found in southwestern Colorado. According to Armstrong (1972:113), it is largely confined to the mountainous areas and prefers rocky outcrops between about 1650 and 4200 m (5400 and 13 760 ft.) It is known to occur near rock outcrops in several of the habitat types in the Escalante sector, including pinyon-juniper woodland, scrub oak or mountain bursh, and riparian transition woodlands (Bissell and Dillon 1982:8).

***Amnospermophilus leucurus* – White-tailed Antelope Squirrel**

This animal is found in the semidesertic habitats of western Colorado, seldom above 2130 m (7000 ft) (Armstrong 1972:117). In southwestern Colorado, it is reported in pinyon-juniper woodland and scrub oak or mountain brush habitats, types similar to those that have been reconstructed for the Escalante Sector prehistorically (Petersen 1985a). Remains of this animal are either unassigned temporally, or are from a context dating to Modeling Period 3 or Modeling Period 4, or sometime between A.D. 800 and 880.

***Spermophilus* spp., *Spermophilus spilosoma, Spermophilus lateralis, Spermophilus variegatus* – Ground Squirrels, Spotted Ground Squirrel, Golden-mantled Ground Squirrel, Rock Squirrel**

The remains of ground squirrels are reasonably common in the DAP faunal assemblage. Three types, the spotted ground squirrel, the golden-mantled ground squirrel, and the rock squirrel, are known from southwestern Colorado (Bissell and Dillon 1982:9; Armstrong 1972:127-134). All 3 of these have been recognized in the Dolores assemblage, and a few bones have not been assigned beyond genus.

The spotted ground squirrel is known from areas of sandy soil in southwestern Colorado (Armstrong 1972:127), but not from any of the habitat types reconstructed for the Dolores area (Neusius 1985a; table 13). The golden-mantled ground squirrel occurs in western Colorado between 1590 and 3810 m (5200 and 12 500 ft) (Armstrong 1972:131). Bissell and Dillon (1982:9) report its presence in southwestern Colorado in pinyon-juniper and aspen woodlands similar to those probably found in the Escalante Sector prehistorically. The rock squirrel is the largest ground squirrel in southwestern Colorado, and ground squirrel identification is facilitated by this size difference. As its name indicates, this animal is associated with rocky areas but also is reported from ponderosa pine, pinyon-juniper, riparian woodland, mountain meadow, and scrub oak or mountain brush habitats. It also has been found in croplands (Neusius 1985a:table 13; Bissell and Dillon 1982:9; Armstrong 1972:129).

Because these animals burrow, their presence in archaeological sites is particularly suspect. On the other hand, ground squirrels are known to have been used for food by historic Southwestern groups (Underhill 1930; Gnabasik 1981:85, 126; Hawley 1950:22; Hill 1937:54). None of the remains of these species from obvious rodent burrows or disturbed areas has been used in analyses.

***Cynomys gunnisoni* – Gunnison's Prairie Dog**

Gunnison's prairie dog is the smallest species of prairie dog found in Colorado. It inhabits a variety of xeric habitats found at the lower elevations in southwestern Colorado (Armstrong 1972:138-139), but is also known from mountain meadows (Bissell and Dillon 1982:9). The modern range of the white-tailed prairie dog (*Cynomys leucurus*) does not encompass the Escalante Sector, but as noted by Neusius (1985a:table 13), this species does occur in adjacent latilongs. For this reason, the prairie dog remains in the Dolores faunal assemblage might profitably be compared to skeletons from both species. However, the habitat preferences of the

white-tailed prairie dog do not differ greatly from those of the Gunnison's prairie dog in southwestern Colorado. Prairie dog remains also may be intrusive, although prairie dogs were collected by ethnohistoric groups (Neusius 1985c:table 16).

Geomyidae, *Thomomys* spp., *Thomomys bottae, Thomomys talpoides* – Pocket Gophers, Valley Pocket Gopher, Northern Pocket Gopher

Pocket gopher remains are reasonably numerous in the Dolores faunal assemblage. Two species, the valley pocket gopher and the northern pocket gopher, have modern ranges adjacent to or including the Escalante Sector. The valley pocket gopher is the usual species in the warm valleys of southwestern Colorado and Mesa Verde (Armstrong 1972:149; Douglas 1969). The northern pocket gopher has less restrictive ecological requirements but generally is found to the north and east of the Escalante Sector and at higher elevations than the valley pocket gopher (Armstrong 1972:154; Bissell and Dillon 1982:10). Given these modern distributions, the rarity of the northern pocket gopher in the Dolores assemblage is expected.

Pocket gophers generally are restricted to areas of deep soil because they are burrowing creatures. This attribute also makes them likely candidates for intrusion into archaeological sites. They are known to frequent agricultural areas (Bissel and Dillon 1982:10) and may be considered targets for garden hunting (Henderson and Harrington 1914:32). Use of pocket gophers as food has been documented for the Tarahumar and Tepehuan Indians of northern Mexico (Pennington 1963:92, 1969:125). As with the other rodent remains listed in tables 4.38 and 4.39, the pocket gopher remains from obviously disturbed contexts were not included in analyses.

Heteromyidae, *Perognathus apache, Dipodomys ordii* – Pocket Mice and Kangaroo Rats, Apache Pocket Mouse, Ord's Kangaroo Rat

The remains of these animals are quite rare in the Dolores assemblage. The Apache pocket mouse occurs in the arid valleys of southwestern Colorado (Armstrong 1972:172) and is known from Mesa Verde National Park (Douglas 1963). This species constructs its burrows in sand beneath brush and cactus (Armstrong 1972:171), but is also known from pinyon-juniper woodlands (Bissell and Dillon 1982:11). Ord's kangaroo rat also is associated with xeric habitats at low elevations and prefers sandy soils (Armstrong 1972:177). It might have been found in areas of sagebrush within the Escalante Sector prehistorically. Like the pocket gophers, these animals may be intrusive or they may be associated with garden hunting.

***Castor canadensis* – Beaver**

The beaver occurs throughout the state (Armstrong 1972:183:184; Bissell and Dillon 1982:12), although it is restricted to riparian habitats. Within the Escalante Sector, the Dolores River and its tributaries may have supported beaver populations, with tributaries such as Beaver Creek being extremely probable locations for such populations. Marshy areas, such as may have been present in Sagehen Flats, also might have provided habitats suitable for the beaver.

Cricetidae – New World Rats and Mice

The remains of various Cricetidae are quite common in the Dolores faunal assemblage. These materials are difficult to identify beyond the family level. Postcranial identifications require excellent comparative material and even then may not be feasible. The Faunal Studies Section was conservative in identifying cricetid remains, and as a result, quite a few bones were not identified beyond the level of family. Nonetheless, 3 main groups of cricetids – white-footed mice (*Peromyscus* spp.), wood rats (*Neotoma* spp.), and voles (*Microtus* spp.) – were recognized. The absence of the western harvest mouse (*Reithrodontomys megalotis*) should be noted.

***Peromyscus* spp., *Peromyscus maniculatus, Peromyscus boylii* or *truei* – White-footed Mice, Deer Mouse, Brush or Pinyon Mouse**

White-footed mice probably were abundant in southwestern Colorado, with the deer mouse being particularly ubiquitous (Anderson 1961:50-53; Bissell and Dillon 1982:12-13). The success of the deer mouse can be attributed to its use of a broad variety of habitat types (Armstrong 1972:194-195). However, its preference for disturbed and early successional habitats (Bissell and Dillon 1982:12) should have made it particularly common in the garden habitat. Despite its small size, it might have been procured by the Anasazi; Underhill (1930) recorded the use of this species for food.

Both the brush mouse and the pinyon mouse are less common. The brush mouse prefers rocky or barren areas in pinyon-juniper or brush (Armstrong 1972:208; Bissell and Dillon 1982:12). The pinyon mouse is dependent on pinyon-juniper trees for resting sites and winter food (Armstrong 1972:209) but occurs in a broader range of habitats (Neusius 1985a:table 13; Bissell and Dillon 1982:13). Once again, any remains listed in table 4.38 and 4.39 that obviously are intrusive have been excluded from subsequent analyses.

***Onochomys leucogaster* – Northern Grasshopper Mouse**

This animal frequents semiarid grasslands and shrublands (Armstrong 1972:212) and also is known from croplands (Bissell and Dillon 1982:13). The rarity of remains assigned to this species may be partially attributable to limitations of comparative material and to the conservative nature of DAP identifications.

***Neotoma* spp., *Neotoma cinerea, Neotoma mexicana* – Wood rats, Bushy-tailed Wood Rat, Mexican Wood Rat**

Three species of wood rat occur today within the Escalante Sector: the bushy-tailed wood rat, the Mexican wood rat, and the white-throated wood rat (*Neotoma albigula*). In general, the Anasazi Heritage Center comparative collection, even when augmented by skeletal loans, was not adequate for species identification. Some remains were speciated prior to the creation of the EAG in 1981, and these are listed in tables 4.38 and 4.39. Further work with the wood rat remains might be informative environmentally, because the ecology of Colorado wood rats is fairly well understood (Finley 1958). In southwestern Colorado, the white-throated wood rat generally occupies the lowest elevations and the most arid sites, while the Mexican wood rat occurs in the foothills and lower mountains and prefers horizontal rock shelters for its dens. The bushy-tailed wood rat is found at moderate to high elevations, probably even above timberline, and uses vertical fissures and caves for its dens (Armstrong 1972:220, 225).

***Microtus* spp., *Microtus montanus, Microtus longicaudus, Microtus mexicanus, Microtus pennsylvanicus* – Voles, Montane Vole, Long-tailed Vole, Mexican Vole, Meadow Vole**

Three species of voles, the montane vole, the long-tailed vole, and the Mexican vole, are reported in the vicinity of the Escalante Sector. In addition, the meadow vole is found in an adjacent latilong (Bissell and Dillon 1982:14-15), although Armstrong's (1972:fig. 81) distribution map would place the meadow vole at some distance from the Escalante Sector and generally across the Continental Divide. According to Armstrong, this animal is restricted to wetlands with abundant standing water, so the mountains present a barrier to expansion (Armstrong 1972:235). The presence of a possible meadow vole bone in the DAP collection (table 4.38) is therefore surprising.

The montane and long-tailed voles are sympatic in Colorado. The montane vole is reported from riparian transition woodlands, oak brush, and marshes similar to those reconstructed for the Escalante Sector prehistorically (Petersen 1985a). It is also known from croplands (Bissell and Dillon 1982:14). The long-tailed vole has more flexible habitat requirements and is found from below 1520m (5000 ft) to well above timberline (Armstrong 1972:240).

The Mexican vole has been reported only from southwestern Colorado, primarily from Mesa Verde National Park (Armstrong 1972:243, Anderson 1961:55). It is adapted to drier and more open habitats than are the montane and long-tailed voles. However, Bissell and Dillon (1982:15) report that it occurs in ponderosa pine forest. Since this species is rare in Colorado today, its presence in the Dolores assemblage may be important biogeographically.

***Ondatra ziebethicus* – Muskrat**

Only a few muskrat bones occur in the Dolores faunal assemblage (table 4.38). This may reflect a small population in the Escalante Sector prehistorically. As Armstrong (1972:246) notes, suitable habitat, including marshes and ponds, are scarce in the mountains of Colorado; these habitats probably were even scarcer before the days of Euro-American ranching. However, the muskrat often is found in beaver ponds in mountain streams.

Zapodidae* – *Jumping Mouse

The western jumping mouse (*Zapus princeps*) is common in the mountains of Colorado, including those adjacent to the Escalante Sector (Armstrong 1982:249; Bissell and Dillon 1982:16). It often is associated with willows and is known from riparian transition as well as ponderosa pine and other forest types. The rarity of remains from jumping mice in the Dolores faunal assemblage, and the failure to identify remains beyond the level of family, could be due to poor comparative material.

***Erethizon dorsatum* – Porcupine**

In Colorado, the porcupine is an animal of the mountains, particularly of the coniferous forests (Armstrong 1972:292). Porcupines occur in the riparian forests of the Colorado mountains as well (Bissell and Dillon 1982:16). This animal might be expected to be rarer in the faunal assemblages from sites located in the more open, unwooded parts of the Escalante Sector.

Carnivora, Canidae, Mustelidae, Felidae – Carnivores, Canids, Mustelids, Felids

Just as a wide variety of carnivores probably were available in southwestern Colorado prehistorically, a variety of taxa belonging to this order have been recognized in the Dolores faunal assemblage. Some of the bone and

teeth fragments recovered could not be identified beyond the level of order; other fragments could be placeed at the family level (e.g., Canidae, Mustelidae, and Felidae).

***Canis* spp., *Canis familiaris, Canis familiaris* or *latrans, Canis latrans, Canis lupus* – Dog, Coyote, or Wolf; Domestic Dog; Domestic Dog or Coyote; Coyote; Gray Wolf**

Two wild species belonging to the genus *Canis* are known from Colorado. These are the coyote and the wolf; however, the wolf has been more or less extirpated in historic times (Bissell and Dillon 1982:17). In addition, the domestic dog was expected and does occur in the Dolores faunal assemblage. The variety of domestic dog at Dolores appears to be very similar to the small Indian dog or "Small Pueblo Dog" (Olsen 1972, 1974: Clark et al. 1985; Emslie 1978). A more detailed discussion of the prehistoric domestic dogs in the Dolores area, including material information, is contained in Clark et al. (1985).

The coyote occurred prehistorically in reasonably large numbers in the Colorado mountains. Armstrong (1972:255) attributes this to the abundance of ecological edges resulting from the mosaic of vegetation in the mountains. Such a mosaic certainly is reconstructed for the Escalante Sector (Petersen 1985a, 1985c). The coyote is known from all habitat types reconstructed for the Escalante Sector.

The habitat preference of the gray wolf in Colorado is much more difficult to reconstruct because of its extirpation. This predator persisted in parts of Colorado, notably in mountain valleys and on the western slope of the Rocky Mountains, well into the 20th century (Armstrong 1972:258-259).

***Vulpes* spp., *Vulpes vulpes, Vulpes* or *Urocyon* spp., *Urocyon cinereoargenteus* – Red or Kit Foxes, Red Fox, Red or Gray Fox, Gray Fox**

The nomenclature used in this volume follows that of the Colorado Division of Wildlife, which does not refer to the red fox as *Vulpes fulva* (Bissell and Dillon 1982:17; Bissell 1978). Remains of foxes occur in smaller numbers than those of other types of canids within the DAP faunal assemblage. The red fox is particularly well represented. This species of fox occurs in large numbers in the mountains of Colorado, including those of southwestern Colorado, where it is associated with riparian woodland, marsh, and mountain meadow habitats (Bissell and Dillon 1982:17). This species is also common in agricultural areas. The kit fox apparently is not represented at Dolores, although it is present today in western Colorado (Armstrong 1972:262; Bissell and Dillon 1982:17). The gray fox is found in pygmy conifer woodlands (e.g., pinyon-juniper) and brushy areas at lower elevations in Colorado (Armstrong 1972:264). The uncommonness of gray fox bones in the Dolores assemblage is noteworthy, as this animal is found in many of the habitat types reconstructed by Petersen (1985a) for the Escalante Sector (Bissell and Dillon 1982:17; Neusius 1985a:table 13).

***Ursus* spp., *Ursus americanus* – Bears, Black Bear**

Bear remains are rare in the DAP faunal assemblage despite the probability that bear populations in the Escalante Sector were high prehistorically (Armstrong 1972:269; chap. 7). The black bear is known to frequent riparian transition woodlands similar to those reconstructed for the Escalante Sector in prehistoric times (Bissell and Dillon 1982:17). No remains of grizzly bear (*Ursus arctos*) were identified, although the presence of this species in the adjacent San Juan Mountains historically is well documented.

***Bassariscus astutus* – Ringtail**

The ringtail inhabits the broken terrain of the Southwest (Armstrong 1972:265). It is found in pinyon-juniper woodland, scrub oak or mountain brush, and mountain meadow habitats in Colorado (Bissell and Dillon 1982:18) and is common at Mesa Verde National Park (Anderson 1961:58). Only 3 bones in the DAP assemblage have been assigned to this species (table 4.38), all of which came from contexts dated between A.D. 780 and 840.

Perhaps most significantly, the ringtail is the only procyonid in this assemblage. Since the raccoon (*Procyon lotor)* occurs in the area today (Bissell and Dillon 1982:18), its absence from the DAP assemblage is very conspicuous and may indicate that its past distribution differs from its distribution today. Armstrong (1972:267) speculates that the range of raccoon has expanded in historic times, as it thrives in well-settled areas. The raccoon seems to be absent from, or rare, in Anasazi sites in general (e.g., Akins 1984; R. Leonard, personal communication).[6] Further study of the biogeographical issues with respect to Anasazi sites and raccoons might be productive.

***Martes americana* – Marten**

Remains of martens are rare in the Dolores assemblage, as might be expected for any boreal mammal. In Colorado, martens are restricted to lodgepole pine (which does not occur in southwest Colorado today) or spruce-fir forest and usually are found above 2740 m (9000 ft)

[6]Black Mesa Archaeological Project, Center for Archaeological Investigations, Southern Illinois University, Carbondale.

(Armstrong 1972:274). Bissell and Dillon (1982:18) list this species as a presumed breeder in the southwestern part of the state, while Armstrong (1972:fig. 98) indicates that the range of martens in Montezuma County is confined to the northeasternmost corner. Benz (1984:211) notes that the presence of this species in the DAP assemblage might support an argument for colder climate or for more distant hunting. However, proving either case is difficult with only 6 bone fragments from contexts representing several time periods (table 4.38).

***Mustela* spp., *Mustela vison, Mustela frenata* – Weasels, Mink, Long-tailed Weasels**

Four species within the genus *Mustela* may have occurred within the Escalante Sector (Neusius 1985a:table 13). These include ermine (*Mustela erminea*) and the black-footed ferret (*Mustela nigripes*), as well as the mink and the long-tailed weasel, the only 2 recognized in the Dolores faunal assemblage. The uncommonness of weasel bones may be due, at least in part, to inadequate comparative material, but large quantities of bone assignable to weasel were not expected.

The mink is not common in Colorado today and is largely restricted to the margins of ponds (Armstrong 1972:280) and to riparian woodlands (Bissell and Dillon 1982:19). In contrast, the long-tailed weasel has broad ecological requirements and might have been found in all of the habitats reconstructed for the prehistoric Escalante Sector (Armstrong 1972:276-277; Bissell and Dillon 1982:18). The ermine is not particularly common in Colorado, but has been reported from scrub oak or mountain brush, mountain meadow habitats, and from southwestern Colorado. As for the black-footed ferret, it is now nearly extirpated, but was common in the western valleys of Colorado in the past. It may have been distributed primarily in habitats supporting prairie dogs (Armstrong 1972:279).

***Gulo gulo* – Wolverine**

Only 1 bone has been identified to this species (table 4.38), which is not found in southwestern Colorado today (Bissell and Dillon 1982:19). Even if this animal did have a wider range prehistorically, it is a boreal mammal confined to high altitude forests (Armstrong 1972:282; Bissell and Dillon 1982:19), and is not likely to have been present in the Escalante Sector itself.

***Taxidea taxus* – Badger**

The badger is an animal of open habitats, but it is reported from pinyon-juniper woodland as well (Bissell and Dillon 1982:19; Armstrong 1972:283). This animal probably was common within the more open parts of the Escalante Sector. Because it is a burrowing animal, it could represent intrusion in archaeological sites. However, like the rodents, any of the remains listed in table 4.38 that obviously were intrusive have not been included in subsequent analyses. Records of the use of this animal by Southwestern groups also are available (Neusius 1985c:table 16).

***Spilogale putorius, Mephitis mephitis* – Spotted Skunk, Striped Skunk**

Both the spotted and the striped skunk probably were present in the Escalante Sector prehistorically, and both probably are represented in the Dolores faunal assemblage. The spotted skunk is the most abundant species in the area today (Anderson 1961:60; Armstrong 1972:286); it frequents pinyon-juniper or riparian woodlands, as well as sagebrush habitats (Bissell and Dillon 1982:19). However, the striped skunk has much broader ecological and altitudinal requirements and may have frequented the areas of Anasazi fields (Armstrong 1972:288; Bissell and Dillon 1982:19).

***Lynx* spp., *Lynx rufus* – Bobcat or Lynx, Bobcat**

The bobcat is the primary species of this genus, which should have been present in the Escalante Sector, since the Canada lynx (*Lynx canadensis*) occurs at high altitudes in coniferous forest (Bissell 1978:16; Armstrong 1972:297). The bobcat is reported from a variety of habitats, including several reconstructed for the Escalante Sector. These are ponderosa pine, Douglas-fir, riparian transition woodland, scrub oak or mountain brush, and marshes (Bissell and Dillon 1982:20). Today, the bobcat is most common in the canyons and foothills of the western slope of the Rockies (Armstrong 1972:298).

***Felis concolor* – Mountain Lion**

The mountain lion may have occurred in the riparian transition woodlands and ponderosa pine forests of the Escalante Sector in prehistoric times (Neusius 1985a:table 13). Mountain lions are present in the area today and were sighted by early DAP field crews. Only 2 bones have been assigned to this species (table 4.38).

***Equus* spp., *Equus caballus* – Horses, Horse**

The few horse remains recovered from Dolores sites obviously represent domestic animals of historic origin. The presence of this species in contexts assigned to prehistoric time periods clearly requires re-evaluation: the identification of the bones themselves should be checked, and the contextual associations should be reviewed. Since this verification step has not yet been possible, all remains identified as horse have been deleted from further analyses.

Artiodactyla – Artiodactyls

Artiodactyl remains are extremely common in the Dolores faunal assemblage, as might be expected based on the large amounts of food and raw material these animals provide and on the ethnographic (Neusius 1985c:table 16) and archaeological (e.g., Akins 1984; Binford et al. 1982; Bertram and Draper 1983) records. Much of the DAP material could not be further identified as a result of fragmentation and poor preservation. This is consistent with the general pattern in faunal assemblages from DAP sites: lower proportions of large mammal remains relative to small mammal remains could be identified even to order. The reasons for this have not been fully investigated, but, in general, the effects of postdepositional processes should lead to the reverse pattern. Artiodactyls may be more similar morphologically than various types of small mammals, and this may hinder identification. However, it seems intuitively unlikely that this factor fully explains the observed pattern. Instead, differential processing by the Anasazi may be responsible. This possibility deserves further study.

Cervidae – Deer

Cervids are the most common type of artiodactyl represented in the Dolores assemblage. Quite a few fragments were not identifiable beyond the family level. This conforms to the general pattern concerning large mammals mentioned above. However, much of the cervid material is cranial, including a large number of antler fragments. This may well be an example of artificial inflation by NISP, although the ratio of MNI to NISP is not a great deal lower for cervids than for indeterminate artiodactyls (0.068 for Cervidae, 0.114 for Artidactyla).

***Cervus elaphus* – American Elk**

The nomenclature used here follows that of Bissell and Dillon (1982) and indicates that the American elk is conspecific with the red deer. This position is now widely held by taxonomists, although the former name (*Cervus canadensis*) is still in use in some circles.

The American elk was the largest animal available to the inhabitants of the Dolores area. As a result, its presence in the faunal assemblage is to be expected. However, this animal has a seasonal cycle, and it is absent from the Escalante Sector during the warmer parts of the year. Neusius and Phagan (1983) have argued that this cycle seriously affected the hunting strategies of the Dolores Anasazi. The elk could have frequented the ponderosa pine, Douglas-fir, scrub oak or mountain brush, mountain meadow, and aspen habitat types when present within the Escalante Sector.

***Odocoileus hemionus* – Mule Deer**

The remains of mule deer occur more commonly than those of any other artiodactyl in this assemblage. This animal is large and abundant and a predictable prey choice for humans. It also practices a seasonal cycle of altitudinal relocation in search of food. Although present in small numbers even in the summer, mule deer populations would have been largest during the colder months of the year. Hunting strategies certainly would have taken this into account (Neusius and Phagan 1983). Mule deer are known from pinyon-juniper woodland, Douglas-fir forest, riparian transition woodland, scrub oak or mountain brush, and sagebrush habitats (Bissell and Dillon 1982:21). Armstrong (1972:304) states that this animal prefers forest edge, woodland, and brush habitats. Mule deer also may have been attracted to Anasazi fields and gardens because of this preference. However, if summer populations were small, this may not have been a serious consideration.

***Antilocapra americana* – Pronghorn**

The pronghorn was less important to the Dolores Anasazi than to many other Anasazi groups (e.g., Akins 1984). This can be attributed to the less arid, more wooded environment of the Escalante Sector. The antelope was extirpated from this part of Colorado historically, and as a result, it is difficult to fully reconstruct its habitat preferences (Armstrong 1972:307; Bissell and Dillon 1982:21). The pronghorn may have been present in the Sagehen Flats section of the Escalante Sector during summer months; however, antelope herds probably generally were located to the south and west in the Montezuma Valley. During most winters, the snow depth in the Escalante Sector probably would have been too great for pronghorn (Schmidt and Gilbert 1978; Wallace 1940).

***Ovis canadensis* – Bighorn**

Bighorns almost certainly were present in the Escalante Sector during some part of the year. They are known from sagebrush and scrub oak or mountain brush communities (Bissell and Dillon 1982:21) and formerly occurred at moderate elevations in Colorado (Armstrong 1972:310). Their distribution and habits have been so seriously disrupted in historic times that it is difficult to predict these prehistorically. However, some evidence indicates that these animals also relocated altitudinally in an annual cycle according to snow depth and food (Packard 1946:7).

***Ovis aries* – Domestic Sheep**

As was the case with horse bones, domestic sheep bones are unequivocably of historic origin. Their presence in

contexts currently assigned to the prehistoric period must be re-examined. Either the taxonomic identification or the temporal assignment is incorrect. For the time being, these bones have been deleted from analyses.

***Antilocapra* or *Ovis* spp., *Ovis* spp., *Ovis* or *Capra* spp. – Antelope or Sheep, Sheep, Sheep or Goat**

A small number of bones were clearly antilocaprid or caprine, but due to fragmentation or inadequate comparative material, they could not be identified. In table 4.38, these bones are listed in the categories given above. The sheep or goat fragments have been deleted from further analysis because they are believed to be historic.

***Bos taurus, Bos* or *Bison* spp. – Domestic Cow, Cow or Bison**

A number of fragments in the Dolores faunal assemblage were identified as domestic cow. The remains of domestic cow must be historic in origin, and problems are similar to those raised for horse and sheep with the temporal assignment of much of this material. In this case, more serious attention should be given to the identifications themselves than in the other instances. In 1 instance, a bone originally assigned to cow has been reassigned to either *Bos* or *Bison* spp. on the basis of morphological similarities and the context in which it was found.

Bison are known to have occurred in most of Colorado except in southwestern Colorado (Armstrong 1972:308). However, some bison remains have been recovered from Anasazi sites in the area (Hayes and Lancaster 1975:appendix 1; Emslie 1977:90-91). For this reason, all the bones in these categories should be reexamined and proper comparative material consulted.

Gaviiformes – Loons

The most probable species represented by the single bone assigned to the order of loons (table 4.38) is the common loon (*Gavis immer*). This species is a migrant in southwestern Colorado, in Colorado, and the upper Colorado River drainage in general (Chase et al. 1982:1; Hayward 1967:16; Bergtold 1928:56). Chase et al. (1982:1) report that the arctic loon (*Gavia arctica*) occurs only on an accidental basis in extreme southwestern Colorado. The preference of loons for lakes and reservoirs makes its occurrence in the Dolores record somewhat surprising. Although a number of small reservoirs occur in the area today, few natural lakes can be assumed to have been present prehistorically.

Ciconiformes – Deep Water Waders

A number of species representing this order could have been present in the Escalante Sector prehistorically (Neusius 1985a:table 13; Chase et al. 1982:3-4). These include the heron (*Ardea herodias, Nycticorax nycticorax),* the snowy egret (*Egretta thula*), the American bittern (*Botaurus lentiginosus*), and the white-faced ibis (*Plegadis chihi*). Of these, only the great blue heron is a resident (Chase et al. 1982:3). The Anasazi Heritage Center comparative collection did not permit further identification of the four bones that appear to represent this order (table 4.38).

Anatidae – Geese and Ducks

A small number of bone fragments have been assigned to this family. As indicated in Neusius (1985a:table 13), there is reason to expect that a wide variety of ducks and geese were in the area during at least part of the year in prehistoric times. At least this is the case today (Chase et al. 1982:5-10). The apparent failure of the Dolores Anasazi to exploit waterfowl suggests that populations of ducks and geese were smaller prehistorically. Certainly, Hayward (1967:4-6) is correct that natural lakes were uncommon throughout the upper Colorado drainage until recently, and this would have affected bird populations. The extent to which historic stock ponds and irrigation have improved the aquatic habitats of the Escalante Sector is unclear, but it would be unwise to ignore this possibility in considering the general lack of waterfowl remains in Dolores faunal assemblages.

Anserinae, *Branta canadensis* – Geese, Canada Goose

The Canada goose is the only resident goose of southwestern Colorado today, but the snow goose (*Chen caerulescens*) is a migrant in the area (Chase et al. 1982: 5-6). Hayward (1967:19) indicates that the Canada goose can be found nesting above the banks of the larger streams in the upper Colorado River basin. This bird often is found in croplands as well as in aquatic habitats.

***Anas* spp., *Anas platyrhynchos, Oxyura jamaicensis* – Surface-feeding Ducks, Mallard, Ruddy Duck**

A number of ducks are found in the area today (Chase et al. 1982:6-10). Both the variety and density of these species may have been less prehistorically. Neusius (1985a:table 13) lists all these species as possibly available, because the magnitude of change in aquatic habitats as the result of historic water-control activities has not been determined. The mallard is the only resident duck in the area, although some other species, including the ruddy duck, breed in southwestern Colorado. Like

the Canada goose, the mallard is known from croplands, as well as from aquatic and riparian habitats (Chase et al. 1982:6). The ruddy duck is known more exclusively from marshes and lakes.

Falconiformes, Accipitridae – Vultures, Hawks, and Falcons; Hawks and Eagles

These taxa were assigned to particularly fragmentary pieces of bone that apparently represented hawks, eagles, falcons, and vultures. Most of the Falconiformes remains recovered from Dolores sites appear to represent species of Accipitridae, although Cathartidae and Falconidae also were identified in the Dolores assemblage.

***Cathartes aura* – Turkey Vulture**

The turkey vulture breeds in southwestern Colorado today and is found in riparian transition habitats and near cliffs (Chase et al. 1982:11). This species was rare in the Dolores faunal assemblage, as might be expected for such a large bird of prey. Some ethnographic record shows the use of this bird's feathers for ceremonial or medicinal purposes (Neusius 1985c:table 16; Hill 1937; Pennington 1969) by non-Puebloan groups in the greater Southwest.

***Accipiter* spp., *Accipiter gentilis, Accipiter striatus, Accipiter cooperii* – Hawks, Goshawk, Sharp-shinned Hawk, Cooper's Hawk**

All 3 of the species in this genus probably were residents of the Excalante Sector in prehistoric times (Neusius 1985a:table 13; Chase et al. 1982:11-12). Several records of the use of the sharp-shinned hawk and Cooper's hawk by native groups in the greater Southwest are reported in Neusius (1985c:table 16). In general, these hawks do not seem to have been food sources.

The sharp-shinned hawk has been reported from a wide variety of habitats, including coniferous and deciduous forest, sagebrush, and agricultural habitats, but it is not common in Colorado today (Chase et al. 1982:11). The Cooper's hawk also is uncommon, but is reported in coniferous forest, mountain meadow, riparian and aspen woodland, and scrub oak or mountain brush habitats (Chase et al. 1982:12). Records for the goshawk also are from coniferous and deciduous forests, although they occur in some sagebrush areas in the winter (Chase et al. 1982:12).

***Buteo* spp., *Buteo jamaicensis, Buteo swainsoni* - Buteos, Red-tailed Hawk, Swainson's Hawk**

Four species of buteos might have occurred in the Escalante Sector prehistorically (Neusius 1985a:table 13). These include the rough-legged hawk (*Buteo lagopus*), which is a winter visitor in the area (Chase et al. 1982:13), and the ferruginous hawk (*Buteo regalis*), as well as Swainson's and red-tailed hawks. Of these, only the red-tailed hawk is a resident today (Chase et al. 1982:12). Hayward (1967:22) considers this species to be the "most common soaring hawk" in the upper Colorado River basin. The red-tailed hawk is found in coniferous forests, deciduous forests, and agricultural areas. It also can be seen in urban areas in Colorado today. Swainson's hawk is reported to breed in riparian transition woodlands, grasslands, and agricultural areas in adjacent latilongs, but not within the Cortez latilong in which the Escalante Sector is located (Chase et al. 1982:12).

***Aquila* or *Haliaeetus* spp., *Aquila chrysaetos, Haliaeetus leucocephalus* - Eagles, Golden Eagle, Bald Eagle**

Both golden and bald eagles are residents of the Escalante Sector today (Chase et al. 1982:11, 13; Hayward 1967:23). The golden eagle is more common than the bald eagle and, during some part of the year, is found in all of the habitat types reconstructed for the Escalante Sector. It also is known from agricultural areas today. The bald eagle is somewhat more restricted to aquatic, riparian, and other deciduous forest habitats, although it is also reported from sagebrush, agricultural, and urban habitats during the winter months. Tyler (1979) considers this bird to be important in Pueblo Indian mythology and ceremonies.

***Falco mexicanus, Falco sparverius* – Prairie Falcon, American Kestrel**

Both the prairie falcon and the American Kestrel are residents of the Escalante Sector today. According to Hayward (1967:24), the American kestrel is more common than the prairie falcon, but Chase et al. (1982:14) indicate that the prairie falcon is uncommon in Colorado only during the breeding season. Both these species have been reported from a variety of habitats. The prairie falcon is known from almost all the habitat types reconstructed for the Escalante Sector prehistorically during the breeding season, but it is restricted to open and brushy habitats, including croplands, mountain meadows, mountain brush, and sagebrush, during the rest of the year. The American kestrel is found throughout the year in mountain brush, sagebrush, mountain meadow, and agricultural habitats; during the breeding season, it is found in ponderosa pine and pinyon-juniper woodlands as well. This bird also is known from riparian and aspen forest habitats when not breeding (Chase et al. 1982:13).

Galliformes – Fowl-like Birds

The majority of the avian remains from Dolores have been assigned to taxa within this order. Grouse (Tetraonidae) and turkey (*Meleagris gallopavo*) are the most

common avian taxa in the faunal assemblage. A few remains were not identifiable beyond order.

Tetraonidae, *Centrocercus urophasianus* – Grouse, Sage Grouse

Three species of grouse might be represented in the Dolores assemblage. These are sage grouse, blue grouse (*Dendragapus obscurus*), and sharp-tailed grouse (*Pedioecetes phasianellus*) (Neusius 1985a: table 13; Chase et al. 1982:14-15). The Anasazi Heritage Center comparative collection lacked proper materials for distinguishing these osteological remains. A few bones were identified to sage grouse prior to 1981.[7]

The habitat preferences of these 3 species of grouse are somewhat different, which makes species determination a worthwhile undertaking. The sage grouse is very closely associated with sagebrush habitats, although it tends to prefer large, flat areas of sagebrush rather than sagebrush areas in broken terrain (Rogers 1964:7, 13, 19; Chase et al. 1982:15). The sharp-tailed grouse is found in grassy areas where trees and shrubs are interspersed (Rogers 1969:7, 14). Following Chase et al. (1982:15), possible habitats for this species within the Escalante Sector prehistorically include ponderosa pine forest, mountain brush, sagebrush, mountain meadow, and agricultural areas (Neusius 1985a: table 13). The blue grouse is the most closely associated with woodland habitats of the 3 species (Rogers 1968:16-18). Chase et al. (1982:14) report the species present in riparian transition woodland, aspen woodland, coniferous woodland (except pinyon-juniper), mountain brush, mountain meadow, and even alpine transition habitats.

***Gallus domesticus* – Domestic Chicken**

One bone in the Dolores faunal assemblage appears to represent the domestic chicken (table 4.38). This bone obviously is of historic origin, although the context from which it came has been assigned to a prehistoric time period. This is another instance in which further study is warranted. This bone has been deleted from analyses of the Dolores assemblage.

***Meleagris gallopavo* – Turkey**

The remains of turkey are more common in the Dolores faunal assemblage than those of any other avian taxon. Nevertheless, fewer than 500 fragments of bone have been assigned to turkey (tables 4.38 and 4.39). These bones may represent wild turkeys or domestic turkeys or both. However, a definitive statement is not possible without additional research.

Several unresolved issues with respect to the turkey in the Southwest hindered the resolution of this problem. The primary issue is whether the turkey was a native wild bird that was domesticated by the Anasazi or was already domesticated outside the Southwest (most probably in Mesoamerica) and traded in for its feathers and its ceremonial value. In the latter case, the modern wild turkey would have to be considered a feral descendant of a domestic bird (McKusick 1980; Rea 1980). Related issues revolve around the Pleistocene and early Holocene record for turkey in the Southwest (Rea 1980), the first appearance of turkey in Anasazi faunal records (Schorger 1966), the use of turkey for food as opposed to for ceremonial functions (Lange 1950), and the osteological distinctions between wild and domestic birds. Each of these questions, if answered, would provide a basis for evaluating the primary issue of the orgions of the bird. Once this was resolved, the significance of turkey to the Anasazi might be considered. However, to date, none of these issues has been adequately explored.

The remains of turkey occur throughout the Dolores Anasazi sequence. No remains came from contexts dated prior to A.D. 600, and very few came from contexts dated prior to A.D. 720. An increase in numbers occurs over time until A.D. 980, after which only a few bones occur. However, there are few excavated contexts dating after A.D. 980 at Dolores.

No evidence for turkey keeping exists in the Dolores record: there are no guano deposits and no obvious pens. One fairly complete turkey skeleton occurs in a burned storage room belonging to the McPhee Community Cluster, but this instance alone cannot provide the evidence for domestication. Osteological measurements provide inconclusive support for domestication as well. This is due in part to the fact that good descriptions of osteological differences between wild turkeys and various races of domestic turkey were unavailable. Finally, most of the turkey bones recovered were found disarticulated. There is a fairly even representation of forelimb (28.4 percent) and hindlimb (25.4 percent) body part fragments. Although additional study is required, these preliminary indicators suggest use of turkeys for food rather than for feathers alone.

***Grus canadensis* – Sandhill Crane**

The sandhill crane migrates through adjacent parts of Colorado today (Chase et al. 1982:17; Hayward 1967:26), and because of its presence in the Dolores record, is presumed to have been present in the general area prehistorically. However, the bird is not common today. It is known from sagebrush, agricultural, and

[7]Identifications made by Steven D. Emslie, consultant, Center for Western Studies, Flagstaff.

aquatic habitats. No attempt has been made to distinguish between the greater (*Grus canadensis tabida*) and the lesser sandhill crane (*Grus canadensis canadensis*) (Drewien and Bizeau 1974).

***Tringa melanoleuca* – Greater Yellowlegs**

As shown in Neusius (1985a: table 13), a wide variety of shorebirds might have occurred in the Escalante Sector during part of the year. Of these, the greater yellowlegs, a sandpiper, is the only one identified in the Dolores faunal assemblage. While this may be attributed in part to inadequate comparative material, it probably reflects infrequent use of those birds that migrate through Colorado in varying numbers. The greater yellowlegs is a fairly common migrant today and is found in marshes, lakes, and rivers, as well as in mud flats (Chase et al. 1982:19), but its numbers prehistorically are unknown.

***Zenaida macroura* – Mourning Dove**

Today, the mourning dove is found in large numbers during the breeding season in southwestern Colorado (Chase et al. 1982:29). There are a few isolated winter records as well (Hayward 1967:32). Habitat types in which it might have been found if it occurred prehistorically include riparian transition woodland, ponderosa pine forest, mountain brush, sagebrush, mountain meadow, and agricultural (Neusius 1985a: table 13). Its use for food and in ceremonies among Southwestern groups is well documented ethnographically (Neusius 1985c:table 16).

***Bubo virginianus* – Great Horned Owl**

The great horned owl is a common resident in southwestern Colorado (Hayward 1967:33; Chase et al. 1982:30). It is known from all types of woodlands that may have occurred in the Escalante Sector and from agricultural areas also (Neusius 1985a:table 13). Its presence in the Dolores faunal record is not at all surprising.

***Otus asio, Glaucidium gnoma, Asio* spp., *Asio otus* – Screech Owl, Pygmy Owl, Long or Short-eared Owl, Long-eared Owl**

The presence of remains of other types of owls is a bit more surprising since, though present, these species are not common in the area today (Chase et al. 1982:30-31). Several habitat types reconstructed for the Escalante Sector prehistorically might be represented by these few bones, notably woodland, sagebrush, and agricultural areas. If the short-eared owl (*Asio flammeus*) is indeed present, meadowlands and marshes also could be represented.

***Colaptes auratus* – Common Flicker (C. cafer included)**

The only woodpecker identified in the Dolores faunal assemblage is the common flicker. This bird is a common resident in southwestern Colorado (Chase et al. 1982:36), and it occurs in all types of wooded areas (Bailey and Niedrach 1965:484). Chase et al. 1982:36) also report its presence in mountain brush habitats during the winter. The lack of other woodpeckers in the Dolores record can be attributed, at least in part, to lack of adequate comparative material.

Passeriformes – Perching Birds

A wide variety of Passeriformes probably were available to the prehistoric inhabitants of the Dolores area. A few of these species have been identified, and some bones have been identified only to order. Comparative material belonging to the Anasazi Heritage Center was inadequate for identifying Passeriformes. More material undoubtedly would have been identified had this not been the case.

***Tyrannus verticalis* – Western Kingbird**

The western kingbird is a fairly common breeder in southwestern Colorado today (Hayward 1967:38). Its breeding habitats include agricultural areas, riparian transition woodlands, and pinyon-juniper woodlands, according to Chase et al. (1982:39). Bailey and Niedrach (1965:511) list several records of this bird from southwestern Colorado, although they note that it is more abundant in the eastern part of the state.

Corvidae – Crows, Jays, and Magpies

Remains of taxa belonging to this family have been recognized more frequently than those of other Passeriformes in the Dolores faunal assemblage. Although this might reflect the general abundance of these birds, ease of identification and more adequate comparative material certainly are partly responsible.

***Corvus spp., Corvus corax, Corvus brachyrhynchos* – Raven or Crow, Common Raven, Common Crow**

Both crows and ravens should have been present in a variety of habitats within the Escalante Sector prehistorically (Neusius 1985a:table 13). Most importantly, these birds may have frequented gardens and fields as they do today and should have been targets of garden hunting. Their presence in the Dolores faunal assemblage is to be expected.

***Cyanocitta stelleri, Gymnorhinus cyanocephalus, Aphelocoma coerulescens* – Steller's Jay, Pinyon Jay, Scrub Jay**

These 3 species of jay probably occurred in the prehistoric Escalante Sector (Neusius 1985a:table 13). All are residents in southwestern Colorado today (Chase et al. 1982:41). The Steller's jay is reported from montane coniferous forest and mountain brush habitats by Hayward (1967:42), and according to Chase et al. (1982:41), is known from coniferous and aspen forests. Similarly, Bailey and Niedrach (1965:557) place this bird in ponderosa pine habitats within the transition life zone. The pinyon jay is common in pinyon-juniper woodlands, as the name suggests (Bailey and Niedrach 1965:571; Hayward 1967:42). Chase et al. (1982:41) report the presence of this bird in riparian transition woodland, mountain brush, and sagebrush habitats, as well as in pinyon-juniper woodlands. The scrub jay also is fairly common in southwestern Colorado today (Bailey and Niedrach 1965:560; Hayward 1967:42). It might have been found prehistorically in either pinyon-juniper woodlands or mountain brush (Neusius 1985a:table 13).

***Pica pica* – Black-billed Magpie**

The black-billed magpie is conspicuous and common in the Escalante Sector today. It frequents riparian transition woodland, mountain brush, sagebrush, and agricultural areas (Chase et al. 1982:41). It also might have been a target of garden hunting. Its use in ceremonies by Southwestern groups is well documented ethnographically (Neusius 1985c:table 16).

Turdidae, *Sialia currucoides, Turdus migratorius* – Thrushes and Bluebirds, Mountain Bluebird, American Robin

A few bones were identified to species within this family, but the collection of the Anasazi Heritage Center generally was inadequate for this purpose. The mountain bluebird is a resident and breeder in southwestern Colorado and is common in Colorado in general (Chase et al. 1982:46; Bailey and Niedrach 1965:632; Hayward 1967:46). Habitats in which it may have been found during part of the year include aspen, pinyon-juniper, ponderosa pine woodland, mountain brush, sagebrush, mountain meadow, and agricultural. The American robin is a common bird throughout much of North America and is a resident of southwestern Colorado (Bailey and Niedrach 1965:610; Chase et al. 1982:47; Hayward 1967:47). The only habitat types reconstructed for the prehistoric Escalante Sector in which the robin probably did not occur are aquatic habitats and mountain meadows (Neusius 1985a:table 13).

***Lanius excubitor* – Northern Shrike**

The northern shrike is a winter visitor in southwestern Colorado, but it is uncommon today (Hayward 1967:48; Chase et al. 1982:49). Bailey and Niedrach (1965:649) indicate that this bird arrives in Colorado in October. Riparian transition, pinyon-juniper woodland, mountain brush, sagebrush, mountain meadow, and agricultural areas are among the possible habitats for this bird.

***Sturnella* spp. – Meadowlarks**

The western meadowlark (*Sturnella neglecta*) is the probable species represented by this taxon, as eastern meadowlark certainly does not occur in this part of Colorado today (Chase et al. 1982:66; Bailey and Niedrach 1965:713-715). Hayward (1967:52) reports that this bird is particularly common on farmlands near water. Neusius (1985a:table 13) lists it as possibly present in pinyon-juniper woodlands, sagebrush, and mountain meadows.

***Xanthocephalus xanthocephalus* – Yellow-headed Blackbird**

Only 1 bone has been assigned tentatively to this species (table 4.38), but its presence would not be particularly surprising, as it is a common breeder in the area today. It builds its nests in marshes, and thus is associated with this type of habitat (Bailey and Niedrach 1965:715-719; Chase et al. 1982:66; Hayward 1967:52).

Fringellidae, *Pipilo chlorura* – Finch-like Birds, Green-tailed Towhee

This is another passerine family apparently represented in the Dolores faunal assemblage. The green-tailed towhee bones were identified prior to the formation of the Faunal Studies Section (table 4.38).[8] This bird is a breeder in the area today and is found in the riparian transition woodland, mountain brush, sagebrush, and mountain meadow habitat types (Chase et al. 1982:60; Hayward 1967:55 Bailey and Niedrach 1965:792).

Squamata, Sauria, Serpentes – Lizards and Snakes, Lizards, Snakes

Reptilian remains are very rare in the Dolores faunal assemblage, although several species should have been available (Neusius 1985a:table 13). This seems to be due to a real lack of such materials, as well as to the inadequacy of DAP reptilian comparative materials.

[8]Identifications made by Steven D. Emslie (consultant, Center for Western Studies, Flagstaff) based on better comparative materials than those available at the Dolores facility.

After all, placement in one of the general categories should have been possible for most fragments even without comparative skeletons.

***Sceloporus undulatus elongatus* – Northern Plateau Lizard**

One bone was identified to northern plateau lizard prior to the formation of the Faunal Studies Section (table 4.38).[9] This lizard is common in the area today and is known from ponderosa pine, Douglas-fir, pinyon-juniper, sagebrush, mountain brush, and cliff and talus slope habitats (Hammerson and Langlois 1981:13). Douglas (1966:726) reports that this species occurs within a variety of habitats near rocky terrain within Mesa Verde National Park.

***Pituophis melanoleucus* – Gopher Snake**

Two bones in the microfaunal assemblage have been assigned to gopher snake (table 4.39). This is the only instance in which a taxon recognized in the microfaunal assemblage was not recognized in the macrofaunal assemblage. The gopher snake occurs in Colorado today (Hammerson and Langlois 1981:20) in habitats similar to those reconstructed for the Escalante Sector (Petersen 1985a), and Neusius (1985a:table 13) lists it as possibly being available within the Escalante Sector prehistorically. It is known from all habitat types reconstructed for the prehistoric Escalante Sector except aspen and agricultural areas.

***Crotalus viridis* – Western Rattlesnake**

The western rattlesnake occurs in the Escalante Sector today and probably did so prehistorically (Hammerson and Langlois 1981:23; Neusius 1985a:table 13). Subspecific determination has not been attempted. This species may have been found along the talus slopes and cliffs of the Dolores Canyon, and in sagebrush areas, pinyon-juniper woodlands, and riparian transition woodlands.

Anura, *Bufo* spp. – Frogs and Toads, True Toads

A few remains of amphibians were recovered from Dolores archaeological sites. In general, comparative material was inadequate for identification, although 2 fragments have been identified to the genus *Bufo* (table 4.38). A variety of habitats might be represented by these bones, as indicated in Neusius (1985a:table 13).

Cypriniformes, Catostomidae, *Catostumus* spp. – Cyprinids, Suckers, Flannelmouth or Bluehead Sucker

Although approximately 150 bone fragments in the Dolores assemblage have been identified to fish, reliable identifications beyond the Class level generally have not been possible. Those remains that have been identified further are all cyprinid, probably sucker. The large minnow, Colorado squawfish (*Ptychocheilus lucius*), also may be present, but further comparative work is required, as this species is not now known from the Dolores drainage (Holden and Stalnaker 1975). Fish probably were procured from the Dolores River itself, as its tributaries do not have consistently adequate flow.

Relative Abundance

The relative abundance of taxa and the changes in relative abundance over time are key questions in most archaeological faunal analyses. However, the measurement of relative abundance is a complex matter. Four relative measures commonly used by zooarchaeologists are NISP, MNI, estimated meat weight represented, and bone weight of each taxon. Although bone weight figures are not available for the DAP assemblages, and only NISP values have been computed for the microfaunal assemblages (tables 4.37 and 4.39), both NISP and MNI figures are available for the macrofaunal assemblages (tables 4.36, 4.38, 4.40, and 4.41). Meat estimates can be calculated by multiplying the MNI figures by an average meat weight for each taxon. However, caution should be exercised when interpreting the results of each of these measures of relative abundance and in using percentages based on them (cf. Grayson 1973, 1978, 1984). Anyone seeking to use the data should be familiar with potential problems in interpreting relative abundance.

The MNI values listed in tables 4.40 and 4.41 were computed using the DAP MNI program described in Udick and Gross (1985). Bones first were grouped within taxa by household; bones not assigned to a particular household were grouped by temporal-spatial element or episode (refer to chap. 5 for explanations of these terms). If even an element or episode assignment was not possible, all bones assigned to each modeling period at each site were grouped as a single unit. Once sorted in this manner, MNI's were calculated for most skeletal elements by matching portions according to proximity and completeness, axiality and completeness, and laterality and completeness for each side of the body. Matches were not attempted for axiality unless proximity was not coded, nor for laterality unless both proximity and axiality were not coded. Fragments were assumed to represent already-counted individuals, unless the MNI obtained without fragments was less than the number of fragments; in this case, an additional

[9]Identifications made by Steven D. Emslie, consultant, Center for Western Studies, Flagstaff.

Table 4.40 – MNI in the total macrofaunal assemblage

	Modeling Period 1									Modeling Period 2								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	1	2.7	2.0	12	8.0	7.3	13	6.9	6.1	2	2.1	1.7	20	4.6	4.2	22	4.1	3.7
Small	13	35.1	27.0	81	54.0	49.3	94	50.2	44.3	28	29.7	24.1	300	69.6	64.2	328	62.4	56.2
Medium	10	27.0	20.8	18	12.0	10.9	28	14.9	13.2	23	24.4	19.8	42	9.7	8.9	65	12.3	11.1
Medium or large	4	10.8	8.3				4	2.1	1.8	10	10.6	8.6				10	1.9	1.7
Large	9	24.3	18.7	39	26.0	23.7	48	25.6	22.5	31	32.9	26.7	69	16.0	14.7	100	19.0	17.1
Total Mammalia	37	100.0	77.0	150	100.0	91.4	187	100.0	88.2	94	100.0	81.0	431	100.0	92.2	525	100.0	90.0
Mammalia or Aves	3	100.0	6.2				3	100.0	1.4	9	100.0	7.7				9	100.0	1.5
Aves:																		
Indeterminate	5	62.5	10.4				19	86.3	8.9	6	54.5	5.1				42	89.3	7.2
Small	0	0.0	0.0				0	0.0	0.0	1	9.0	0.8				1	2.1	0.1
Medium	2	25.0	4.1				2	9.0	0.9	3	27.2	2.5				3	6.3	0.5
Large	1	12.5	2.0				1	4.5	0.4	1	9.0	0.8				1	2.1	0.1
Total Aves	8	100.0	16.6	14	100.0	8.5	22	100.0	10.3	11	100.0	9.4	36	100.0	7.7	47	100.0	8.0
Osteichthyes	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Reptilia	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	100.0	0.8	0	0.0	0.0	1	100.0	0.1
Amphibia	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Vertebrata, indeterminate	0	0.0	0.0				0	0.0	0.0	1	100.0	0.8				1	100.0	0.1
Total assemblage	48		100.0	164		100.0	212		100.0	116		100.0	467		100.0	583		100.0

Table 4.40 – MNI in the total macrofaunal assemblage – Continued

	Modeling Period 3									Modeling Period 4								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	2	1.7	1.3	28	5.8	5.3	30	5.0	4.4	13	9.1	6.4	24	6.3	5.8	37	7.1	6.0
Small	37	32.7	24.1	310	64.7	59.1	347	58.6	51.2	35	24.6	17.4	225	59.8	55.2	260	50.1	42.7
Medium	31	27.4	20.2	48	10.0	9.1	79	13.3	11.6	28	19.7	13.9	34	9.0	8.3	62	11.9	10.1
Medium or large	10	8.8	6.5				10	1.6	1.4	23	16.1	11.4				23	4.4	3.7
Large	33	29.2	21.5	93	19.4	17.7	126	21.2	18.6	43	30.2	21.3	93	24.7	22.8	136	26.2	22.3
Total Mammalia	113	100.0	73.8	479	100.0	91.4	592	100.0	87.4	142	100.0	70.6	376	100.0	92.3	518	100.0	85.1
Mammalia or Aves	14	100.0	9.1				14	100.0	2.0	20	100.0	9.9				20	100.0	3.2
Aves:																		
Indeterminate	10	45.4	6.5				54	81.8	7.9	7	26.9	3.4				37	66.0	6.0
Small	4	18.1	2.6				4	6.0	0.5	6	23.0	2.9				6	10.7	0.9
Medium	3	13.6	1.9				3	4.5	0.4	5	19.2	2.4				5	8.9	0.8
Large	5	22.7	3.2				5	7.5	0.7	8	30.7	3.9				8	14.2	1.3
Total Aves	22	100.0	14.3	44	100.0	8.3	66	100.0	9.7	26	100.0	12.9	30	100.0	7.5	56	100.0	9.2
Osteichthyes	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	100.0	0.4	0	0.0	0.0	1	100.0	0.1
Reptilia	1	100.0	0.6	0	0.0	0.0	1	100.0	0.1	1	100.0	0.4	1	100.0	0.2	2	100.0	0.3
Amphibia	0	0.0	0.0	1	100.0	0.1	1	100.0	0.1	2	100.0	0.9	0	0.0	0.0	2	100.0	0.3
Vertebrata, indeterminate	3	100.0	1.9				3	100.0	0.4	9	100.0	4.4				9	100.0	1.4
Total assemblage	153		100.0	524		100.0	677		100.0	201		100.0	407		100.0	608		100.0

Table 4.40 – MNI in the total macrofaunal assemblage – Continued

	Modeling Period 5									Modeling Period 6								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	16	4.4	3.3	68	8.6	7.7	84	7.3	6.2	6	10.9	7.0	18	5.3	4.5	24	6.0	4.9
Small	67	18.5	14.1	475	60.2	54.4	542	47.1	40.2	14	25.4	16.4	197	58.1	49.6	211	53.5	43.7
Medium	59	16.3	12.4	63	7.9	7.2	122	10.6	9.0	13	23.6	15.2	50	14.7	12.5	63	15.9	13.0
Medium or large	139	38.5	29.2				139	12.0	10.3	6	10.9	7.0				6	1.5	1.2
Large	80	22.1	16.8	182	23.0	20.8	262	22.8	19.4	16	29.0	18.8	74	21.8	18.6	90	22.8	18.6
Total Mammalia	361	100.0	76.0	788	100.0	90.3	1149	100.0	85.3	55	100.0	64.7	339	100.0	85.3	394	100.0	81.7
Mammalia or Aves	33	100.0	6.9				33	100.0	2.4	9	100.0	10.5				9	100.0	1.8
Aves:																		
Indeterminate	23	36.5	4.8				105	72.4	7.7	5	38.4	5.8				63	88.7	13.0
Small	11	17.4	2.3				11	7.5	0.8	3	23.0	3.5				3	4.2	0.6
Medium	14	22.2	2.9				14	9.6	1.0	3	23.0	3.5				3	4.2	0.6
Large	15	23.8	3.1				15	10.3	1.1	2	15.3	2.3				2	2.8	0.4
Total Aves	63	100.0	13.2	82	100.0	9.4	145	100.0	10.7	13	100.0	15.2	58	100.0	14.6	71	100.0	14.7
Osteichthyes	5	100.0	1.0	0	0.0	0.0	5	100.0	0.3	5	100.0	5.8	0	0.0	0.0	5	100.0	1.0
Reptilia	0	0.0	0.0	1	100.0	0.1	1	100.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Amphibia	1	100.0	0.2	1	100.0	0.1	2	100.0	0.1	2	100.0	2.3	0	0.0	0.0	2	100.0	0.4
Vertebrata, indeterminate	12	100.0	2.5				12	100.0	0.8	1	100.0	1.1				1	100.0	0.2
Total assemblage	475		100.0	872		100.0	1347		100.0	85		100.0	397		100.0	482		100.0

Table 4.40 – MNI in the total macrofaunal assemblage – Continued

	Modeling Period 7									Other†								
	Indeterminate			Identifiable*			Total			Indeterminate			Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:																		
Indeterminate	5	8.4	5.2	15	7.0	6.0	20	7.3	5.8	23	8.7	6.0	92	7.5	6.6	115	7.7	6.5
Small	19	32.2	20.0	150	70.4	60.2	169	62.1	49.1	77	29.2	20.1	781	64.1	56.6	858	57.9	48.7
Medium	12	20.3	12.6	16	7.5	6.4	28	10.2	8.1	53	20.1	13.8	126	10.3	9.1	179	12.0	10.1
Medium or large	9	15.2	9.4				9	3.3	2.6	48	18.2	12.5				48	3.2	2.7
Large	14	23.7	14.7	32	15.0	12.8	46	16.9	13.3	62	23.5	16.2	219	17.9	15.8	281	18.9	15.9
Total Mammalia	59	100.0	62.1	213	100.0	85.5	272	100.0	79.0	263	100.0	68.8	1218	100.0	88.3	1481	100.0	84.1
Mammalia or Aves	9	100.0	9.4				9	100.0	2.6	28	100.0	7.3				28	100.0	1.5
Aves:																		
Indeterminate	8	61.5	8.4				41	89.1	11.9	21	34.4	5.4				168	80.7	9.5
Small	1	7.6	1.0				1	2.1	0.2	9	14.7	2.3				9	4.3	0.5
Medium	0	0.0	0.0				0	0.0	0.0	14	22.9	3.6				14	6.7	0.7
Large	4	30.7	4.2				4	8.6	1.1	17	27.8	4.4				17	8.1	0.9
Total Aves	13	100.0	13.6	33	100.0	13.2	46	100.0	13.3	61	100.0	15.9	147	100.0	10.6	208	100.0	11.8
Osteichthyes	4	100.0	4.2	1	100.0	0.4	5	100.0	1.4	7	100.0	1.8	3	100.0	0.2	10	100.0	0.5
Reptilia	1	100.0	1.0	2	100.0	0.8	3	100.0	0.8	2	100.0	0.5	7	100.0	0.5	9	100.0	0.5
Amphibia	3	100.0	3.1	0	0.0	0.0	3	100.0	0.8	5	100.0	1.3	3	100.0	0.2	8	100.0	0.4
Vertebrata, indeterminate	6	100.0	6.3				6	100.0	1.7	16	100.0	4.1				16	100.0	0.9
Total assemblage	95		100.0	249		100.0	344		100.0	382		100.0	1378		100.0	1760		100.0

Table 4.40 – MNI in the total macrofaunal assemblage – Continued

	Indeterminate			Total Identifiable*			Total		
	N	% class	% total	N	% class	% total	N	% class	% total
Mammalia:									
Indeterminate	68	6.0	4.3	277	6.9	6.2	345	6.7	5.7
Small	290	25.8	18.6	2519	63.0	56.5	2809	54.8	46.7
Medium	229	20.3	14.7	397	9.9	8.9	626	12.2	10.4
Medium or large	249	22.1	16.0				249	4.8	4.1
Large	288	25.6	18.5	801	20.0	17.9	1089	21.2	18.1
Total Mammalia	1124	100.0	72.2	3994	100.0	89.5	5118	100.0	85.1
Mammalia or Aves	125	100.0	8.0				125	100.0	2.0
Aves:									
Indeterminate	85	39.1	5.4				529	80.0	8.7
Small	35	16.1	2.2				35	5.2	0.5
Medium	44	20.2	2.8				44	6.6	0.7
Large	53	24.4	3.4				53	8.0	0.8
Total Aves	217	100.0	13.9	444	100.0	9.9	661	100.0	10.9
Osteichthyes	22	100.0	1.4	4	100.0	0.0	26	100.0	0.4
Reptilia	6	100.0	0.3	11	100.0	0.2	17	100.0	0.2
Amphibia	13	100.0	0.8	5	100.0	0.1	18	100.0	0.2
Vertebrata, indeterminate	48	100.0	3.0				48	100.0	0.7
Total assemblage	1555		100.0	4458		100.0	6013		100.0

A blank indicates that the number and percentages for the corresponding category were not calculated.
MNI – Minimum number of individuals.
† Other – Not assigned to period.
* Identifiable at least to order.

individual was counted. The MNI obtained for each side-element combination was then listed and the highest value selected. This was manually compared with data on skeletal elements for which the program was not suitable. Such elements included skull elements and phalanges and vertebrae for which the number varied depending on taxon. The coding of skull elements was difficult to interpret nonsubjectively. If necessary, MNI values were raised to correspond to those obtained by hand.

Once MNI values were obtained for each household, element or episode, and modeling period at each site, all MNI's for each modeling period were summed for the entire project, and then all modeling periods were summed. More detailed information on the program used can be found in Udick and Gross (1985).

Tables 4.36, 4.38, 4.40, and 4.41 provide NISP and MNI values for the DAP macrofaunal assemblages, by modeling period. Breakdowns are provided for both total and identifiable assemblages. The information in these tables has not yet been studied in detail, but it should enable the reader to address the issue of temporal change in faunal exploitation strategies among the Dolores Anasazi. This can be done either at a very general level using the class breakdowns in tables 4.36 and 4.40, or in a more detailed manner using only the identifiable assemblage information presented in tables 4.38 and 4.41.

The data in the aforementioned tables could be used to study a number of specific questions or topics of special interest. First, comparisons with the species composition predicted in the resource availability section of this chapter should be undertaken. To what extent does relative biomass appear to have affected inclusion in the diet, and when little or no correlation exists, is this a reflection of the crudeness of the biomass

Table 4.41 – MNI in the identifiable macrofaunal assemblage*

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mammalia:																		
Insectivora																		
insectivores																		
Soricidae																		
shrews							1	(1)	0.2	(0.2)	0.20	(0.2)						
Microsorex hoyi																		
pygmy shrew							2	(2)	0.4	(0.4)	0.4	(0.4)						
Lagomorpha																		
pikas, rabbits, and hares	1	(1)	0.7	(0.6)	0.6	(0.6)	1	(1)	0.2	(0.2)	0.2	(0.2)	4	(4)	0.8	(0.8)	0.8	(0.7)
Ochotona princeps																		
pika																		
Leporidae																		
rabbits and hares	2	(2)	1.4	(1.3)	1.3	(1.2)	8	(8)	1.9	(1.8)	1.8	(1.7)	4	(4)	0.8	(0.8)	0.8	(0.7)
Sylvilagus spp.																		
cottontails	18	(20)	13.2	(13.3)	12.2	(12.1)	75	(76)	18.6	(17.6)	17.2	(16.2)	42	(43)	9.3	(8.9)	8.6	(8.2)
Sylvilagus nuttallii																		
Nuttall's cottontail							5	(6)	1.2	(1.3)	1.1	(1.2)	13	(15)	2.9	(3.1)	2.6	(2.8)
Sylvilagus audubonii																		
desert cottontail	4	(4)	2.9	(2.6)	2.7	(2.4)	21	(21)	5.2	(4.8)	4.8	(4.4)	12	(12)	2.6	(2.5)	2.4	(2.2)
Lepus spp.																		
jackrabbits	15	(15)	11.0	(10.0)	10.2	(9.1)	40	(42)	9.9	(9.7)	9.2	(8.9)	38	(39)	8.4	(8.1)	7.8	(7.4)
Lepus americanus																		
snowshoe hare							2	(2)	0.4	(0.4)	0.4	(0.4)	1	(1)	0.2	(0.2)	0.2	(0.1)
Lepus townsendii																		
white-tailed jackrabbit	1	(2)	0.7	(1.3)	0.6	(1.2)	2	(4)	0.4	(0.9)	0.4	(0.8)	6	(9)	1.3	(1.8)	1.2	(1.7)
Lepus californicus																		
black-tailed jackrabbit	0	(1)	0.0	(0.6)	0.0	(0.6)							2	(4)	0.4	(0.8)	0.4	(0.7)
Rodentia																		
rodents	4	(4)	2.9	(2.6)	2.7	(2.4)	8	(8)	1.9	(1.8)	1.8	(1.7)	9	(9)	2.0	(1.8)	1.8	(1.7)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Sciuridae																		
squirrels	5	(5)	3.6	(3.3)	3.4	(3.0)	17	(17)	4.2	(3.9)	3.9	(3.6)	16	(16)	3.5	(3.3)	3.2	(3.0)
Eutamias spp.																		
chipmunks																		
Marmota flaviventris																		
yellow-bellied marmot	6	(6)	4.4	(4.0)	4.0	(3.6)	17	(17)	4.2	(3.9)	3.9	(3.6)	33	(38)	7.3	(7.9)	6.7	(7.2)
Amnospermophilus leucurus																		
white-tailed antelope squirrel																		
Spermophilus spp.																		
ground squirrels													1	(1)	0.2	(0.2)	0.2	(0.1)
Spermophilus spilosoma																		
spotted ground squirrel	1	(1)	0.7	(0.6)	0.6	(0.6)	3	(4)	0.7	(0.9)	0.6	(0.8)						
Spermophilus lateralis																		
golden-mantled ground squirrel							1	(2)	0.2	(0.4)	0.2	(0.4)	4	(5)	0.8	(1.0)	0.8	(0.9)
Spermophilus variegatus																		
rock squirrel	3	(3)	2.2	(2.0)	2.0	(1.8)	7	(8)	1.7	(1.8)	1.6	(1.7)	13	(14)	2.9	(2.9)	2.6	(2.6)
Cynomys gunnisoni																		
Gunnison's prairie dog	12	(12)	8.8	(8.0)	8.1	(7.3)	24	(26)	5.9	(6.0)	5.5	(5.5)	11	(11)	2.4	(2.2)	2.2	(2.0)
Geomyidae																		
pocket gophers							1	(1)	0.2	(0.2)	0.2	(0.2)	1	(1)	0.2	(0.2)	0.2	(0.1)
Thomomys spp.																		
pocket gophers	2	(2)	1.4	(1.3)	1.3	(1.2)	10	(10)	2.4	(2.3)	2.3	(2.1)	18	(19)	4.0	(3.9)	3.6	(3.6)
Thomomys bottae																		
valley pocket gopher	0	(3)	0.0	(2.0)	0.0	(1.8)	5	(5)	1.2	(1.1)	1.1	(1.0)	12	(12)	2.6	(2.5)	2.4	(2.2)
Thomomys talpoides																		
northern pocket gopher																		
Heteromyidae																		
pocket mice, kangaroo rats																		
Perognathus apache																		
Apache pocket mouse																		

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Dipodomys ordii																		
Ord's kangaroo rat	0	(1)	0.0	(0.6)	0.0	(0.6)	0	(2)	0.0	(0.4)	0.0	(0.4)						
Castor canadensis																		
beaver	2	(3)	1.4	(2.0)	1.3	(1.8)	4	(4)	0.9	(0.9)	0.9	(0.8)	7	(7)	1.5	(1.4)	1.4	(1.3)
Cricetidae																		
New World rats and mice							7	(7)	1.7	(1.6)	1.6	(1.4)	4	(4)	0.8	(0.8)	0.8	(0.7)
Peromyscus spp.																		
white-footed mice							15	(15)	3.7	(3.4)	3.4	(3.2)	13	(13)	2.9	(2.7)	2.6	(2.4)
Peromyscus maniculatus																		
deer mouse																		
Peromyscus boylii or *truei*																		
brush or pinyon mouse							2	(2)	0.4	(0.4)	0.4	(0.4)	1	(1)	0.2	(0.2)	0.2	(0.1)
Onochomys leucogaster																		
northern grasshopper mouse							1	(1)	0.2	(0.2)	0.2	(0.2)						
Neotoma spp.																		
wood rats	1	(1)	0.7	(0.6)	0.6	(0.6)	6	(6)	1.4	(1.3)	1.3	(1.2)	20	(20)	4.4	(4.1)	4.1	(3.8)
Neotoma cinerea																		
bushy-tailed wood rat							1	(2)	0.2	(0.4)	0.2	(0.4)	2	(3)	0.4	(0.6)	0.4	(0.5)
Neotoma mexicana																		
Mexican wood rat							1	(1)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.4	(0.4)	0.4	(0.3)
Microtus spp.																		
voles	1	(2)	0.7	(1.3)	0.6	(1.2)	4	(4)	0.9	(0.9)	0.9	(0.8)	8	(8)	1.7	(1.6)	1.6	(1.5)
Microtus montanus																		
montane vole							3	(3)	0.7	(0.6)	0.6	(0.6)	1	(1)	0.2	(0.2)	0.2	(0.1)
Microtus longicaudus																		
long-tailed vole													1	(1)	0.2	(0.2)	0.2	(0.1)
Microtus mexicanus																		
Mexican vole													3	(3)	0.6	(0.6)	0.6	(0.5)
Microtus pennsylvanicus																		
meadow vole							0	(1)	0.0	(0.2)	0.0	(0.2)						
Ondatra zibethicus																		
muskrat							0	(1)	0.0	(0.2)	0.0	(0.2)	1	(1)	0.2	(0.2)	0.2	(0.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Zapodidae																		
jumping mice																		
Erethizon dorsatum																		
porcupine	4	(4)	2.9	(2.6)	2.7	(2.4)	9	(9)	2.2	(2.0)	2.0	(1.9)	14	(17)	3.1	(3.5)	2.8	(3.2)
Carnivora																		
carnivores	4	(4)	2.9	(2.6)	2.7	(2.4)	2	(2)	0.4	(0.4)	0.4	(0.4)	6	(6)	1.3	(1.2)	1.2	(1.1)
Canidae																		
canids	1	(1)	0.7	(0.6)	0.6	(0.6)	2	(2)	0.4	(0.4)	0.4	(0.4)	3	(4)	0.6	(0.8)	0.6	(0.7)
Canis spp.																		
dog, coyote, or wolf	3	(3)	2.2	(2.0)	2.0	(1.8)	7	(8)	1.7	(1.8)	1.6	(1.7)	7	(9)	1.5	(1.8)	1.4	(1.7)
Canis familiaris																		
domestic dog	5	(5)	3.6	(3.3)	3.4	(3.0)	14	(14)	3.4	(3.2)	3.2	(2.9)	10	(10)	2.2	(2.0)	2.0	(1.9)
Canis familiaris or *latrans*																		
dog or coyote																		
Canis latrans																		
coyote	2	(2)	1.4	(1.3)	1.3	(1.2)	4	(4)	0.9	(0.9)	0.9	(0.8)	3	(3)	0.6	(0.6)	0.6	(0.5)
Canis lupus																		
gray wolf	1	(1)	0.7	(0.6)	0.6	(0.6)	0	(1)	0.0	(0.2)	0.0	(0.2)						
Vulpes spp.																		
red or kit foxes																		
Vulpes vulpes																		
red fox	1	(1)	0.7	(0.6)	0.6	(0.6)	4	(5)	0.9	(1.1)	0.9	(1.0)	2	(3)	0.4	(0.6)	0.4	(0.5)
Vulpes or *Urocyon* spp.																		
foxes																		
Urocyon cinereoargenteus																		
gray fox							1	(1)	0.2	(0.2)	0.2	(0.2)						
Ursus spp.																		
bears	1	(1)	0.7	(0.6)	0.6	(0.6)							2	(2)	0.4	(0.4)	0.4	(0.3)
Ursus americanus																		
black bear	0	(1)	0.0	(0.6)	0.0	(0.6)												
Bassariscus astutus																		
ringtail							1	(1)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.4	(0.4)	0.4	(0.3)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustelidae																		
mustelids																		
Martes americana																		
marten													1	(1)	0.2	(0.2)	0.2	(0.1)
Mustela spp.																		
weasels																		
Mustela vison																		
mink																		
Mustela frenata																		
long-tailed weasel							1	(1)	0.2	(0.2)	0.2	(0.2)	2	(2)	0.4	(0.4)	0.4	(0.3)
Gulo gulo																		
wolverine																		
Taxidea taxus																		
Badger							2	(2)	0.4	(0.4)	0.4	(0.4)	1	(1)	0.2	(0.2)	0.2	(0.1)
Spilogale putorius																		
spotted skunk																		
Mephitis mephitis																		
striped skunk													1	(2)	0.2	(0.4)	0.2	(0.3)
Felidae																		
cats																		
Lynx spp.																		
bobcat or lynx													1	(1)	0.2	(0.2)	0.2	(0.1)
Lynx rufus																		
bobcat	3	(3)	2.2	(2.0)	2.0	(1.8)	3	(3)	0.7	(0.6)	0.6	(0.6)	4	(4)	0.8	(0.8)	0.8	(0.7)
Felis concolor																		
mountain lion																		
Artiodactyla																		
artiodactyls	11	(11)	8.0	(7.3)	7.4	(6.7)	20	(24)	4.9	(5.5)	4.6	(5.1)	35	(36)	7.8	(7.5)	7.1	(6.8)
Cervidae																		
deer	5	(5)	3.6	(3.3)	3.4	(3.0)	8	(8)	1.9	(1.8)	1.8	(1.7)	4	(4)	0.8	(0.8)	0.8	(0.7)
Cervus elaphus																		
American elk	1	(1)	0.7	(0.6)	0.6	(0.6)	2	(3)	0.4	(0.6)	0.4	(0.6)	4	(6)	0.8	(1.2)	0.8	(1.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Odocoileus hemionus mule deer	12	(15)	8.8	(10.0)	8.1	(9.1)	21	(24)	5.2	(5.5)	4.8	(5.1)	27	(29)	6.0	(6.0)	5.5	(5.5)
Antilocapra americana pronghorn	1	(1)	0.7	(0.6)	0.6	(0.6)	3	(3)	0.7	(0.6)	0.6	(0.6)	11	(11)	2.4	(2.2)	2.2	(2.0)
Antilocapra or *Ovis* spp. pronghorn or sheep																		
Ovis spp. sheep																		
Ovis canadensis bighorn	3	(3)	2.2	(2.0)	2.0	(1.8)	4	(6)	0.9	(1.3)	0.9	(1.2)	5	(5)	1.1	(1.0)	1.0	(0.9)
Bos or *Bison* cow or bison																		
Total Mammalia	136	(150)	100.0	(100.0)	92.5	(91.4)	402	(431)	100.0	(100.0)	92.6	(92.2)	448	(479)	100.0	(100.0)	91.9	(91.4)
Aves:																		
Gaviiformes loons																		
Ciconiformes deep water waders																		
Anatidae geese and ducks													1	(1)	2.6	(2.2)	0.2	(0.1)
Anserinae geese													1	(1)	2.6	(2.2)	0.2	(0.1)
Branta canadensis Canada goose	1	(2)	9.0	(14.2)	0.6	(1.2)	1	(1)	3.1	(2.7)	0.2	(0.2)	1	(1)	2.6	(2.2)	0.2	(0.1)
Anas spp. surface-feeding ducks													1	(1)	2.6	(2.2)	0.2	(0.1)
Anas platyrhynchos mallard													0	(1)	0.0	(2.2)	0.0	(0.1)
Oxyura jamaicensis ruddy duck													1	(1)	2.6	(2.2)	0.2	(0.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage*– Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Falconiformes																		
vultures, hawks and falcons							2	(2)	6.2	(5.5)	0.4	(0.4)	1	(1)	2.6	(2.2)	0.2	(0.1)
Cathartes aura																		
turkey vulture							1	(1)	3.1	(2.7)	0.2	(0.2)						
Accipitridae																		
hawks and eagles																		
Accipiter spp.																		
hawks																		
Accipiter gentilis																		
goshawk																		
Accipiter striatus																		
sharp-shinned hawk																		
Accipiter cooperii																		
Cooper's hawk																		
Buteo spp.																		
buteos																		
Buteo jamaicensis																		
red-tailed hawk													1	(1)	2.6	(2.2)	0.2	(0.1)
Buteo swainsoni																		
Swainson's hawk																		
Aquila or *Haliaeetus* spp.																		
eagles																		
Aquila chrysaetos																		
golden eagle	1	(1)	9.0	(7.1)	0.6	(0.6)							2	(2)	5.2	(4.5)	0.4	(0.3)
Haliaeetus leucocephalus																		
bald eagle																		
Falco mexicanus																		
prairie falcon																		
Falco sparverius																		
American kestrel							3	(3)	9.3	(8.3)	0.6	(0.6)	1	(1)	2.6	(2.2)	0.2	(0.1)
Galliformes																		
fowl-like birds							1	(1)	3.1	(2.7)	0.2	(0.2)						

Table 4.41 – MNI in the identifiable macrofaunal assemblage*– Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Tetraonidae																		
grouse	4	(4)	36.3	(28.5)	2.7	(2.4)	4	(5)	12.5	(13.8)	0.9	(1.0)	9	(12)	23.6	(27.2)	1.8	(2.2)
Centrocercus urophasianus																		
sage grouse																		
Meleagris gallopavo																		
turkey	1	(2)	9.0	(14.2)	0.6	(1.2)	7	(7)	21.8	(19.4)	1.6	(1.4)	6	(6)	15.7	(13.6)	1.2	(1.1)
Grus canadensis																		
sandhill crane							3	(4)	9.3	(11.1)	0.6	(0.8)	2	(4)	5.2	(9.0)	0.4	(0.7)
Tringa melanoeuca																		
greater yellowlegs																		
Zenaida macroura																		
mourning dove	0	(1)	0.0	(7.1)	0.0	(0.6)							1	(1)	2.6	(2.2)	0.2	(0.1)
Otus asio																		
screech owl																		
Bubo virginianus																		
great horned owl													2	(2)	5.2	(4.5)	0.4	(0.3)
Glaucidium gnoma																		
pygmy owl																		
Asio spp.																		
long- or short-eared owl													1	(1)	2.6	(2.2)	0.2	(0.1)
Asio otus																		
long-eared owl																		
Colaptes auratus																		
common flicker	1	(1)	9.0	(7.1)	0.6	(0.6)	2	(2)	6.2	(5.5)	0.4	(0.4)	1	(1)	2.6	(2.2)	0.2	(0.1)
Passeriformes																		
perching birds	1	(1)	9.0	(7.1)	0.6	(0.6)	3	(3)	9.3	(8.3)	0.6	(0.6)	1	(1)	2.6	(2.2)	0.2	(0.1)
Tyrannus verticalis																		
western kingbird																		
Corvidae																		
jays, crows, and magpies							1	(1)	3.1	(2.7)	0.2	(0.2)						
Corvus spp.																		
raven or crow																		

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 1						Modeling Period 2						Modeling Period 3					
	N		% class		% total		N		% class		% total		N		% class		% total	
Corvus corax																		
common raven	1	(1)	9.0	(7.1)	0.6	(0.6)	1	(1)	3.1	(2.7)	0.2	(0.2)	1	(1)	2.6	(2.2)	0.2	(0.1)
Corvus brachyrhynchos																		
common crow													1	(1)	2.6	(2.2)	0.2	(0.1)
Cyanocitta stelleri																		
Steller's jay																		
Cymnorhinus cyanocephalus																		
pinyon jay																		
Aphelocoma coerulescens																		
scrub jay																		
Pica pica																		
black-billed magpie													2	(2)	5.2	(4.5)	0.4	(0.3)
Turdidae																		
thrushes and bluebirds																		
Sialia currucoides																		
mountain bluebird																		
Turdus migratorius																		
American robin							0	(1)	0.0	(2.7)	0.0	(0.2)						
Lanius excubitor																		
northern shrike																		
Sturnella spp.																		
meadowlarks							1	(1)	3.1	(2.7)	0.2	(0.2)						
Xanthocephalus																		
xanthocephalus																		
yellow-headed blackbird																		
Fringillidae																		
finch-like birds							1	(1)	3.1	(2.7)	0.2	(0.2)						
Pipilo chlorura																		
green-tailed towhee	1	(1)	9.0	(7.1)	0.6	(0.6)	1	(2)	3.1	(5.5)	0.2	(0.4)	1	(1)	2.6	(2.2)	0.2	(0.1)
Total Aves	11	(14)	100.0	(100.0)	7.4	(8.5)	32	(36)	100.0	(100.0)	7.3	(7.7)	38	(44)	100.0	(100.0)	7.8	(8.3)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Marmota flaviventris yellow-bellied marmot	18	(22)	5.5	(5.8)	5.2	(5.4)	15	(17)	2.2	(2.1)	2.09	(1.9)	6	(7)	1.9	(2.0)	1.7	(1.7)
Amnospermophilus leucurus white-tailed antelope squirrel																		
Spermophilus spp. ground squirrels	1	(1)	0.3	(0.2)	0.2	(0.2)												
Spermophilus spilosoma spotted ground squirrel													0	(1)	0.0	(0.2)	0.0	(0.2)
Spermophilus lateralis golden-mantled ground squirrel	5	(7)	1.5	(1.8)	1.4	(1.7)	4	(4)	0.6	(0.5)	0.5	(0.4)	1	(1)	0.3	(0.2)	0.2	(0.2)
Spermophilus variegatus rock squirrel	4	(4)	1.2	(1.0)	1.1	(0.9)	12	(15)	1.8	(1.9)	1.6	(1.7)	9	(11)	2.9	(3.2)	2.5	(2.7)
Cynomys gunnisoni Gunnison's prairie dog	17	(20)	5.2	(5.3)	4.9	(4.9)	26	(31)	3.9	(3.9)	3.5	(3.5)	24	(25)	7.9	(7.3)	6.8	(6.2)
Geomyidae pocket gophers																		
Thomomys spp. pocket gophers	11	(13)	3.4	(3.4)	3.1	(3.1)	24	(25)	3.6	(3.1)	3.3	(2.8)	6	(7)	1.9	(2.0)	1.7	(1.7)
Thomomys bottae valley pocket gopher	3	(3)	0.9	(0.7)	0.8	(0.7)	6	(6)	0.9	(0.7)	0.8	(0.6)	4	(4)	1.3	(1.1)	1.1	(1.0)
Thomomys talpoides northern pocket gopher																		
Heteromyidae pocket mice, kangaroo rats							0	(1)	0.0	(0.1)	0.0	(0.1)						
Perognathus apache Apache pocket mouse							0	(1)	0.0	(0.1)	0.0	(0.1)	1	(1)	0.3	(0.2)	0.2	(0.2)
Dipodomys ordii Ord's kangaroo rat							0	(1)	0.0	(0.1)	0.0	(0.1)	0	(1)	0.0	(0.2)	0.0	(0.2)
Castor canadensis beaver	7	(8)	2.1	(2.1)	2.0	(1.9)	13	(15)	1.9	(1.9)	1.7	(1.7)	6	(7)	1.9	(2.0)	1.7	(1.7)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cricetidae																		
New World rats and mice	2	(2)	0.6	(0.5)	0.5	(0.4)	5	(5)	0.7	(0.6)	0.6	(0.5)	2	(2)	0.6	(0.5)	0.5	(0.5)
Peromyscus spp.																		
white-footed mice	6	(6)	1.8	(1.5)	1.7	(1.4)	15	(16)	2.2	(2.0)	2.0	(1.8)	1	(1)	0.3	(0.2)	0.2	(0.2)
Peromyscus maniculatus																		
deer mouse																		
Peromyscus boylii or *truei*																		
brush or pinyuon mouse																		
Onochomys leucogaster																		
northern grasshopper mouse	0	(1)	0.0	(0.2)	0.0	(0.2)	0	(1)	0.0	(0.1)	0.0	(0.1)						
Neotoma spp.																		
wood rats	13	(16)	4.0	(4.2)	3.7	(3.9)	16	(17)	2.4	(2.1)	2.2	(1.9)	8	(9)	2.6	(2.6)	2.2	(2.2)
Neotoma cinerea																		
bushy-tailed wood rat	1	(1)	0.3	(0.2)	0.2	(0.2)												
Neotoma mexicana																		
Mexican wood rat													0	(1)	0.0	(0.2)	0.0	(0.2)
Microtus spp.																		
voles	4	(4)	1.2	(1.0)	1.1	(0.9)	7	(11)	1.0	(1.3)	0.9	(1.2)	1	(1)	0.3	(0.2)	0.2	(0.2)
Microtus montanus																		
montane vole																		
Microtus longicaudus																		
long-tailed vole													1	(2)	0.3	(0.5)	0.2	(0.5)
Microtus mexicanus																		
Mexican vole																		
Microtus pennsylvanicus																		
meadow vole																		
Ondatra ziebethicus																		
muskrat	1	(1)	0.3	(0.2)	0.2	(0.2)							1	(1)	0.3	(0.2)	0.2	(0.2)
Zapodidae																		
jumping mice													1	(1)	0.3	(0.2)	0.2	(0.2)
Erethizon dorsatum																		
porcupine	9	(15)	2.7	(3.9)	2.6	(3.6)	9	(12)	1.3	(1.5)	1.2	(1.3)	13	(16)	4.3	(4.7)	3.7	(4.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Carnivora																		
carnivores	6	(6)	1.8	(1.5)	1.7	(1.4)	8	(9)	1.2	(1.1)	1.1	(1.0)	3	(3)	0.9	(0.8)	0.8	(0.7)
Canidae																		
canids	1	(1)	0.3	(0.2)	0.2	(0.2)	5	(8)	0.7	(1.0)	0.6	(0.9)	3	(4)	0.9	(1.1)	0.8	(1.0)
Canis spp.																		
dog, coyote, or wolf	9	(10)	2.7	(2.6)	2.6	(2.4)	20	(25)	3.0	(3.1)	2.7	(2.8)	3	(4)	0.9	(1.1)	0.8	(1.0)
Canis familiaris																		
domestic dog	3	(3)	0.9	(0.7)	0.8	(0.7)	12	(19)	1.8	(2.4)	1.6	(2.1)	4	(6)	1.3	(1.7)	1.1	(1.5)
Canis familiaris or *latrans*																		
dog or coyote							1	(1)	0.1	(0.1)	0.1	(0.1)	1	(1)	0.3	(0.2)	0.2	(0.2)
Canis latrans																		
coyote	1	(1)	0.3	(0.2)	0.2	(0.2)	2	(2)	0.3	(0.2)	0.2	(0.2)	5	(5)	1.6	(1.4)	1.4	(1.2)
Canis lupus																		
gray wolf	1	(1)	0.3	(0.2)	0.2	(0.2)	0	(1)	0.0	(0.1)	0.0	(0.1)	1	(1)	0.3	(0.2)	0.2	(0.2)
Vulpes spp.																		
red or kit foxes													1	(1)	0.3	(0.2)	0.2	(0.2)
Vulpes vulpes																		
red fox							1	(1)	0.1	(0.1)	0.1	(0.1)	5	(7)	1.6	(2.0)	1.4	(1.7)
Vulpes or *Urocyon* spp.																		
foxes							0	(1)	0.0	(0.1)	0.0	(0.1)						
Urocyon cinereoargenteus																		
gray fox																		
Ursus spp.																		
bears	3	(4)	0.9	(1.0)	0.8	(0.9)	1	(1)	0.1	(0.1)	0.1	(0.1)	2	(2)	0.6	(0.5)	0.5	(0.5)
Ursus americanus																		
black bear							1	(1)	0.1	(0.1)	0.1	(0.1)	1	(1)	0.3	(0.2)	0.2	(0.2)
Bassariscus astutes																		
ringtail																		
Mustelidae																		
mustelids							0	(1)	0.0	(0.1)	0.0	(0.1)						
Martes americana																		
marten							0	(1)	0.0	(0.1)	0.0	(0.1)	1	(1)	0.3	(0.2)	0.2	(0.2)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustela spp.																		
weasels	1	(1)	0.3	(0.2)	0.2	(0.2)							3	(3)	0.9	(0.8)	0.8	(0.7)
Mustela vison																		
mink																		
Mustela frenata																		
long-tailed weasel	1	(1)	0.3	(0.2)	0.2	(0.2)							2	(2)	0.6	(0.5)	0.5	(0.5)
Gulo gulo																		
wolverine							1	(1)	0.1	(0.1)	0.1	(0.1)						
Taxidea taxus																		
badger	1	(1)	0.3	(0.2)	0.2	(0.2)	3	(5)	0.4	(0.6)	0.4	(0.5)	1	(2)	0.3	(0.5)	0.2	(0.5)
Spilogale putorius																		
spotted skunk	1	(1)	0.3	(0.2)	0.2	(0.2)							1	(1)	0.3	(0.2)	0.2	(0.2)
Mephitis mephitis																		
striped skunk																		
Felidae																		
cats																		
Lynx spp.																		
bobcat or lynx	1	(2)	0.3	(0.5)	0.2	(0.4)	2	(2)	0.3	(0.2)	0.2	(0.2)						
Lynx rufus																		
bobcat	4	(4)	1.2	(1.0)	1.1	(0.9)	4	(5)	0.6	(0.6)	0.5	(0.5)	5	(6)	1.6	(1.7)	1.4	(1.5)
Felis concolor																		
mountain lion													0	(1)	0.0	(0.2)	0.0	(0.2)
Artiodactyla																		
artiodactyls	24	(26)	7.4	(6.9)	6.9	(6.3)	57	(58)	8.6	(7.3)	7.8	(6.6)	18	(20)	5.9	(5.8)	5.1	(5.0)
Cervidae																		
deer	12	(12)	3.7	(3.1)	3.4	(2.9)	14	(15)	2.1	(1.9)	1.9	(1.7)	6	(6)	1.9	(1.7)	1.7	(1.5)
Cervus elaphus																		
American elk	4	(7)	1.2	(1.8)	1.1	(1.7)	6	(9)	0.9	(1.1)	0.8	(1.0)	6	(6)	1.9	(1.7)	1.7	(1.5)
Odocoileus hemionus																		
mule deer	29	(33)	9.0	(8.7)	8.3	(8.1)	57	(74)	8.6	(9.3)	7.8	(8.4)	20	(23)	6.6	(6.7)	5.7	(5.7)
Antilocapra americana																		
pronghorn	3	(6)	0.9	(1.5)	0.8	(1.4)	8	(10)	1.2	(1.2)	1.1	(1.1)	4	(4)	1.3	(1.1)	1.1	(1.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Antilocapra or *Ovis* spp. pronghorn or sheep							2	(2)	0.3	(0.2)	0.2	(0.2)						
Ovis spp. sheep																		
Ovis canadensis bighorn	3	(4)	0.9	(1.0)	0.8	(0.9)	10	(11)	1.5	(1.3)	1.3	(1.2)	6	(10)	1.9	(2.9)	1.7	(2.5)
Bos or *Bison* cow or bison																		
Total Mammalia	322	(376)	100.0	(100.0)	93.0	(92.3)	659	(788)	100.0	(100.0)	90.8	(90.3)	301	(339)	100.0	(100.0)	86.0	(85.3)
Aves:																		
Ciconiformes loons																		
Ciconifmores deep water waders																		
Anatidae geese and ducks																		
Anserinae geese							2	(2)	3.1	(2.4)	0.2	(0.2)	2	(2)	4.0	(3.4)	0.5	(0.5)
Branta canadensis Canada goose	1	(2)	4.3	(6.6)	0.2	(0.4)	1	(3)	1.5	(3.6)	0.1	(0.3)	1	(2)	2.0	(3.4)	0.2	(0.5)
Anas spp. surface-feeding ducks							2	(3)	3.1	(3.6)	0.2	(0.3)	1	(1)	2.0	(1.7)	0.2	(0.2)
Anas platyrhynchos mallard							1	(1)	1.5	(1.2)	0.1	(0.1)	2	(2)	4.0	(3.4)	0.5	(0.5)
Oxyura jamaicensis ruddy duck																		
Falconiformes vultures, hawks, and falcons	3	(3)	13.0	(10.0)	0.8	(0.7)	0	(1)	0.0	(1.2)	0.0	(0.1)						

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cathartes aura																		
turkey vulture													0	(1)	0.0	(1.7)	0.0	(0.2)
Accipitridae																		
hawks and eagles							3	(3)	4.6	(3.6)	0.4	(0.3)						
Accipiter spp.																		
hawks							0	(1)	0.0	(1.2)	0.0	(0.1)						
Accipiter gentilis																		
goshawk													1	(1)	2.0	(1.7)	0.2	(0.2)
Accipiter striatus																		
sharp-shinned hawk													1	(1)	2.0	(1.7)	0.2	(0.2)
Accipiter cooperii																		
Cooper's hawk							1	(1)	1.5	(1.2)	0.1	(0.1)	1	(1)	2.0	(1.7)	0.2	(0.2)
Buteo spp.																		
buteos	1	(1)	4.3	(3.3)	0.2	(0.2)	3	(3)	4.6	(3.6)	0.4	(0.3)	1	(1)	2.0	(1.7)	0.2	(0.2)
Buteo jamaicensis																		
red-tailed hawk							1	(2)	1.5	(2.4)	0.1	(0.2)	1	(1)	2.0	(1.7)	0.2	(0.2)
Buteo swainsoni																		
Swainson's hawk													1	(1)	2.0	(1.7)	0.2	(0.2)
Aquila or *Haliaeetus* spp.																		
eagles													1	(1)	2.0	(1.7)	0.2	(0.2)
Aquila chrysaetos																		
golden eagle	1	(1)	4.3	(3.3)	0.2	(0.2)	1	(1)	1.5	(1.2)	0.1	(0.1)	4	(4)	8.1	(6.8)	1.1	(1.0)
Haliaeetus leucocephalus																		
bald eagle													1	(1)	2.0	(1.7)	0.2	(0.2)
Falco mexicanus																		
prairie falcon							0	(1)	0.0	(1.2)	0.0	(0.1)						
Falco sparverius																		
American kestrel													1	(1)	2.0	(1.7)	0.2	(0.2)
Galliformes																		
fowl-like birds	1	(2)	4.3	(6.6)	0.2	(0.4)	1	(1)	1.5	(1.2)	0.1	(0.1)						
Tetraonidae																		
grouse	7	(7)	30.4	(23.3)	2.0	(1.7)	16	(18)	25.0	(21.9)	2.2	(2.0)	10	(12)	20.4	(20.6)	2.8	(3.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Centrocercus urophasianus																		
sage grouse	1	(1)	4.3	(3.3)	0.2	(0.2)	2	(2)	3.1	(2.4)	0.2	(0.2)	2	(2)	4.0	(3.4)	0.5	(0.5)
Meleagris gallopavo																		
turkey	6	(10)	26.0	(33.3)	1.7	(2.4)	18	(23)	28.1	(28.0)	2.4	(2.6)	7	(9)	14.2	(15.5)	2.0	(2.2)
Grus canadensis																		
sandhill crane							2	(2)	3.1	(2.4)	0.2	(0.2)	1	(1)	2.0	(1.7)	0.2	(0.2)
Tringa melanoleuca																		
greater yellowlegs													0	(1)	0.0	(1.7)	0.0	(0.2)
Zenaida macroura																		
mourning dove							1	(1)	1.5	(1.2)	0.1	(0.1)	1	(1)	2.0	(1.7)	0.2	(0.2)
Otus asio																		
screech owl							1	(1)	1.5	(1.2)	0.1	(0.1)						
Bubo virginianus																		
great horned owl	0	(1)	0.0	(3.3)	0.0	(0.2)	2	(2)	3.1	(2.4)	0.2	(0.2)	3	(4)	6.1	(6.8)	0.8	(1.0)
Glaucidium gnoma																		
pygmy owl																		
Asio spp.																		
long- or short-eared owl																		
Asio otus																		
long-eared owl																		
Colaptes auratus																		
common flicker																		
Passeriformes																		
perching birds	2	(2)	8.6	(6.6)	0.5	(0.4)	1	(2)	1.5	(2.4)	0.1	(0.2)	1	(1)	2.0	(1.7)	0.2	(0.2)
Tyrannus verticalis																		
western kingbird													1	(1)	2.0	(1.7)	0.2	(0.2)
Corvidae																		
jays, crows, and magpies							2	(2)	3.1	(2.4)	0.2	(0.2)						
Corvus spp.																		
raven or crow							0	(1)	0.0	(1.2)	0.0	(0.1)						
Corvus corax																		
common raven							3	(3)	4.6	(3.6)	0.4	(0.3)	2	(2)	4.0	(3.4)	0.5	(0.5)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4						Modeling Period 5						Modeling Period 6					
	N		% class		% total		N		% class		% total		N		% class		% total	
Corvus brachyrhynchos common crow							0	(1)	0.0	(1.2)	0.0	(0.1)						
Cyanocitta stelleri Steller's jay																		
Gymnorhinus cyanocephalus pinyon jay																		
Aphelocoma coerulescens scrub jay																		
Pica pica black-billed magpie													2	(2)	4.0	(3.4)	0.5	(0.5)
Turdidae thrushes and bluebirds																		
Sialia currucoides mountain bluebird																		
Turdus migratorius American robin							0	(1)	0.0	(1.2)	0.0	(0.1)						
Lanius excubitor northern shrike																		
Sturnella spp. meadowlarks																		
Xanthocephalus xanthocephalus yellow-headed blackbird													0	(1)	0.0	(1.7)	0.0	(0.2)
Fringillidae finch-like birds																		
Pipilo chlorura green-tailed towhee																		
Total Aves	23	(30)	100.0	(100.0)	6.6	(7.3)	64	(82)	100.0	(100.0)	8.8	(9.4)	49	(58)	100.0	(100.0)	14.0	(14.6)
Reptilia:																		
Squamata lizards and snakes																		

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 4 N	% class	% total	Modeling Period 5 N	% class	% total	Modeling Period 6 N	% class	% total
Sauria									
lizard									
Sceloporus undulatus elongatus									
northern plateau lizard									
Serpentes									
snakes	1 (1)	100.0 (100.0)	0.2 (0.2)	1 (1)	100.0 (100.0)	0.1 (0.1)			
Crotalus viridis									
western rattlesnake									
Total Reptilia	1 (1)	100.0 (100.0)	0.2 (0.2)	1 (1)	100.0 (100.0)	0.1 (0.1)			
Amphibia:									
Anura									
frogs and toads									
Bufo spp.									
true toads				1 (1)	100.0 (100.0)	0.1 (0.1)			
Total Amphibia				1 (1)	100.0 (100.0)	0.1 (0.1)			
Osteichthyes:									
Cypriniformes									
cyprinids									
Catostomidae									
suckers									
Catostomus spp.									
flannelmouth or bluehead sucker									
Total Osteichthyes									
Total assemblage	346 (407)		100.0 (100.0)	725 (872)		100.0 (100.0)	350 (397)		100.0 (100.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mammalia:																		
Insectivora																		
insectivores													0	(1)	0.0	(0.0)	0.0	(0.0)
Soricidae																		
shrews							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)
Microsorex hoyi																		
pygmy shrew													3	(3)	0.0	(0.0)	0.0	(0.0)
Lagomorpha																		
pikas, rabbits, and hares	1	(1)	0.5	(0.4)	0.4	(0.4)	1	(1)	0.0	(0.0)	0.0	(0.0)	9	(9)	0.2	(0.2)	0.2	(0 2)
Ochotona princeps																		
pika	1	(1)	0.5	(0.4)	0.4	(0.4)							4	(4)	0.1	(0.1)	0.1	(0.0)
Leporidae																		
rabbits and hares	7	(8)	3.6	(3.7)	3.1	(3.2)	27	(27)	2.6	(2.2)	2.3	(1.9)	8Î	(82)	2.3	(2.0)	2.1	(1.8)
Sylvilagus spp.																		
cottontails	29	(31)	15.1	(14.5)	13.2	(12.4)	148	(162)	14.4	(13.3)	12.8	(11.7)	475	(509)	13.6	(12.7)	12.3	(11.4)
Sylvilagus nuttallii																		
Nuttall's cottontail	3	(5)	1.5	(2.3)	1.3	(2.0)	14	(19)	1.3	(1.5)	1.2	(1.3)	45	(58)	1.2	(1.4)	1.1	(1.3)
Sylvilagus audubonii																		
desert cottontail	6	(6)	3.1	(2.8)	2.7	(2.4)	24	(25)	2.3	(2.0)	2.0	(1.8)	114	(116)	3.2	(2.9)	2.9	(2.6)
Lepus spp.																		
jackrabbits	13	(14)	6.7	(6.5)	5.9	(5.6)	70	(82)	6.8	(6.7)	6.0	(5.9)	311	(339)	8.9	(8.4)	8.0	(7.6)
Lepus americanus																		
snowshoe hare							6	(7)	0.5	(0.5)	0.5	(0.5)	15	(16)	0.4	(0.4)	0.3	(0.3)
Lepus townsendii																		
white-tailed jackrabbit							20	(33)	1.9	(2.7)	1.7	(2.3)	50	(92)	1.4	(2.3)	1.2	(2.0)
Lepus californicus																		
black-tailed jackrabbit							5	(17)	0.4	(1.3)	0.4	(1.2)	14	(48)	0.4	(1.2)	0.3	(1.0)
Rodentia																		
rodents	10	(10)	5.2	(4.6)	4.5	(4.0)	25	(25)	2.4	(2.0)	2.1	(1.8)	93	(93)	2.6	(2.3)	2.4	(2.0)
Sciuridae																		
squirrels	12	(12)	6.2	(5.6)	5.4	(4.8)	38	(38)	3.7	(3.1)	3.3	(2.7)	141	(145)	4.0	(3.6)	3.6	(3.2)
Eutamias spp.																		
chipmunks							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Marmota flaviventris yellow-bellied marmot	1	(1)	0.5	(0.4)	0.4	(0.4)	28	(43)	2.7	(3.5)	2.4	(3.1)	124	(151)	3.5	(3.7)	3.2	(3.3)
Amnospermophilus leucurus white-tailed antelope squirrel							2	(2)	0.1	(0.1)	0.1	(0.1)	2	(2)	0.0	(0.0)	0.0	(0.0)
Spermophilus spp. ground squirrels							1	(4)	0.0	(0.3)	0.0	(0.2)	3	(6)	0.0	(0.1)	0.0	(0.1)
Spermophilus spilosoma spotted ground squirrel							5	(6)	0.4	(0.4)	0.4	(0.4)	9	(12)	0.2	(0.3)	0.2	(0.2)
Spermophilus lateralis golden-mantled ground squirrel	2	(2)	1.0	(0.9)	0.9	(0.8)	6	(8)	0.5	(0.6)	0.5	(0.5)	23	(29)	0.6	(0.7)	0.5	(0.6)
Spermophilus variegatus rock squirrel	5	(6)	2.6	(2.8)	2.2	(2.4)	26	(33)	2.5	(2.7)	2.2	(2.3)	79	(94)	2.2	(2.3)	2.0	(2.1)
Cynomys gunnisoni Gunnison's prairie dog	11	(11)	5.7	(5.1)	5.0	(4.4)	37	(40)	3.6	(3.2)	3.2	(2.9)	162	(176)	4.6	(4.4)	4.2	(3.9)
Geomyidae pocket gophers							1	(1)	0.0	(0.0)	0.0	(0.0)	3	(3)	0.0	(0.0)	0.0	(0.0)
Thomomys spp. pocket gophers	6	(6)	3.1	(2.8)	2.7	(2.4)	50	(56)	4.8	(4.5)	4.3	(4.0)	127	(138)	3.6	(3.4)	3.2	(3.0)
Thomomys bottae valley pocket gopher	4	(4)	2.0	(1.8)	1.8	(1.6)	9	(9)	0.8	(0.7)	0.7	(0.6)	43	(46)	1.2	(1.1)	1.1	(1.0)
Thomomys talpoides northern pocket gopher	0	(1)	0.0	(0.4)	0.0	(0.4)	1	(1)	0.0	(0.0)	0.0	(0.0)	1	(2)	0.0	(0.0)	0.0	(0.0)
Heteromyidae pocket mice, kangaroo rats													0	(1)	0.0	(0.0)	0.0	(0.0)
Perognathus apache Apache pocket mouse							0	(1)	0.0	(0.0)	0.0	(0.0)	1	(3)	0.0	(0.0)	0.0	(0.0)
Dipodomys ordii Ord's kangaroo rat	0	(1)	0.0	(0.4)	0.0	(0.4)	0	(2)	0.0	(0.1)	0.0	(0.1)	0	(8)	0.0	(0.2)	0.0	(0.1)
Castor canadensis beaver	5	(5)	2.6	(2.3)	2.2	(2.0)	21	(26)	2.0	(2.1)	1.8	(1.8)	65	(75)	1.8	(1.8)	1.6	(1.6)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cricetidae																		
New World rats and mice	4	(4)	2.0	(1.8)	1.8	(1.6)	10	(10)	0.9	(0.8)	0.8	(0.7)	34	(34)	0.9	(0.8)	0.8	(0.7)
Peromyscus spp.																		
white-footed mice	7	(8)	3.6	(3.7)	3.1	(3.2)	55	(58)	5.3	(4.7)	4.7	(4.2)	112	(117)	3.2	(2.9)	2.9	(2.6)
Peromyscus maniculatus																		
deer mouse							0	(2)	0.0	(0.1)	0.0	(0.1)	0	(2)	0.0	(0.0)	0.0	(0.0)
Peromyscus boylii or *truei*																		
brush or pinyon mouse	1	(1)	0.5	(0.4)	0.4	(0.4)	1	(1)	0.0	(0.0)	0.0	(0.0)	5	(5)	0.1	(0.1)	0.1	(0.1)
Onochomys leucogaster																		
northern grasshopper mouse													1	(3)	0.0	(0.0)	0.0	(0.0)
Neotoma spp.																		
wood rats	7	(11)	3.6	(5.1)	3.1	(4.4)	34	(39)	3.3	(3.2)	2.9	(2.8)	105	(119)	3.0	(2.9)	2.7	(2.6)
Neotoma cinerea																		
bushy-tailed wood rat	2	(2)	1.0	(0.9)	0.9	(0.8)	4	(5)	0.3	(0.4)	0.3	(0.3)	10	(13)	0.2	(0.3)	0.2	(0.2)
Neotoma mexicana																		
mexican wood rat	1	(1)	0.5	(0.4)	0.4	(0.4)							4	(5)	0.1	(0.1)	0.1	(0.1)
Microtus spp.																		
voles	8	(10)	4.1	(4.6)	3.6	(4.0)	29	(30)	2.8	(2.4)	2.5	(2.1)	62	(70)	1.7	(1.7)	1.6	(1.5)
Microtus montanus																		
montane vole													4	(4)	0.1	(0.1)	0.1	(0.0
Microtus longicaudus																		
long-tailed vole							1	(1)	0.0	(0.0)	0.0	(0.0)	3	(4)	0.0	(0.1)	0.0	(0.0)
Microtus mexicanus																		
Mexican vole	1	(1)	0.5	(0.4)	0.4	(0.4)	0	(3)	0.0	(0.2)	0.0	(0.2)	4	(7)	0.1	(0.1)	0.1	(0.1)
Microtus pennsylvanicus																		
meadow vole													0	(1)	0.0	(0.0)	0.0	(0.0)
Ondatra zibethicus																		
muskrat	1	(1)	0.5	(0.4)	0.4	(0.4)	1	(1)	0.0	(0.0)	0.0	(0.0)	5	(6)	0.1	(0.1)	0.1	(0.1)
Zapodidae																		
jumping mice													1	(1)	0.0	(0.0)	0.0	(0.0)
Erethizon dorsatum																		
porcupine	1	(1)	0.5	(0.4)	0.4	(0.4)	26	(29)	2.5	(2.3)	2.2	(2.1)	85	(103)	2.4	(2.5)	2.2	(2.3)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Carnivora																		
carnivores	3	(3)	1.5	(1.4)	1.3	(1.2)	16	(16)	1.5	(1.3)	1.3	(1.1)	48	(49)	1.3	(1.2)	1.2	(1.0)
Canidae																		
canids	1	(1)	0.5	(0.4)	0.4	(0.4)	10	(13)	0.9	(1.0)	0.8	(0.9)	26	(34)	0.7	(0.8)	0.6	(0.7)
Canis spp.																		
dog, coyote, or wolf	1	(1)	0.5	(0.4)	0.4	(0.4)	26	(33)	2.5	(2.7)	2.2	(2.3)	76	(93)	2.1	(2.3)	1.9	(2.0)
Canis familiaris																		
domestic dog							15	(19)	1.4	(1.5)	1.3	(1.3)	63	(76)	1.8	(1.9)	1.6	(1.7)
Canis familiaris or *latrans*																		
dog or coyote							2	(2)	0.1	(0.1)	0.1	(0.1)	4	(4)	0.1	(0.1)	0.1	(0.0)
Canis latrans																		
coyote	2	(2)	1.0	(0.9)	0.9	(0.8)	9	(11)	0.8	(0.9)	0.7	(0.7)	28	(30)	0.8	(0.7)	0.7	(0.6)
Canis lupus																		
gray wolf							2	(2)	0.1	(0.1)	0.1	(0.1)	5	(7)	0.1	(0.1)	0.1	(0.1)
Vulpes spp.																		
red or kit foxes							1	(1)	0.0	(0.0)	0.0	(0.0)	2	(2)	0.0	(0.0)	0.0	(0.0)
Vulpes vulpes																		
red fox	1	(1)	0.5	(0.4)	0.4	(0.4)	7	(10)	0.6	(0.8)	0.6	(0.7)	21	(28)	0.6	(0.7)	0.5	(0.6)
Vulpes or *Urocyon* spp.																		
foxes							0	(1)	0.0	(0.0)	0.0	(0.0)	0	(2)	0.0	(0.0)	0.0	(0.0)
Urocyon cinereoargenteus																		
gray fox							4	(4)	0.3	(0.3)	0.3	(0.2)	5	(5)	0.1	(0.1)	0.1	(0.1)
Ursus spp.																		
bears							4	(6)	0.3	(0.4)	0.3	(0.4)	13	(16)	0.3	(0.4)	0.3	(0.3)
Ursus americanus																		
black bear							1	(1)	0.0	(0.0)	0.0	(0.0)	3	(4)	0.0	(0.1)	0.0	(0.0)
Bassariscus astutus																		
ringtail													3	(3)	0.0	(0.0)	0.0	(0.0)
Mustelidae																		
mustelids							2	(2)	0.1	(0.1)	0.1	(0.1)	2	(3)	0.0	(0.0)	0.0	(0.0)
Martes americana																		
marten							2	(3)	0.1	(0.2)	0.1	(0.2)	4	(6)	0.1	(0.1)	0.1	(0.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Mustela spp.																		
weasels							2	(2)	0.1	(0.1)	0.1	(0.1)	6	(6)	0.1	(0.1)	0.1	(0.1)
Musatela vison																		
mink							1	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Mustela frenata																		
long-tailed weasel	1	(1)	0.5	(0.4)	0.4	(0.4)	3	(3)	0.2	(0.2)	0.2	(0.2)	10	(10)	0.2	(0.2)	0.2	(0.2)
Gulo gulo																		
wolverine													1	(1)	0.0	(0.0)	0.0	(0.0)
Taxidea taxus																		
badger	1	(1)	0.5	(0.4)	0.4	(0.4)	6	(7)	0.5	(0.5)	0.5	(0.5)	15	(19)	0.4	(0.4)	0.3	(0.4)
Spilogale putorius																		
spotted skunk							3	(3)	0.2	(0.2)	0.2	(0.2)	5	(5)	0.1	(0.1)	0.1	(0.1)
Mephitis mephitis																		
striped skunk							1	(1)	0.0	(0.0)	0.0	(0.0)	2	(3)	0.0	(0.0)	0.0	(0.0)
Felidae																		
cats							0	(1)	0.0	(0.0)	0.0	(0.0)	0	(1)	0.0	(0.0)	0.0	(0.0)
Lyns spp.																		
bobcat or lynx							1	(2)	0.0	(0.1)	0.0	(0.1)	5	(7)	0.1	(0.1)	0.1	(0.1)
Lynx rufus																		
bobcat	5	(6)	2.6	(2.8)	2.2	(2.4)	10	(15)	0.9	(1.2)	0.8	(1.0)	38	(46)	1.0	(1.1)	0.9	(1.0)
Felis concolor																		
mountain lion													0	(1)	0.0	(0.0)	0.0	(0.0)
Artiodactyla																		
artiodactyls	11	(13)	5.7	(6.1)	5.0	(5.2)	60	(62)	5.8	(5.0)	5.2	(4.4)	236	(250)	6.7	(6.2)	6.1	(5.6)
Cervidae																		
deer	1	(1)	0.5	(0.4)	0.4	(0.4)	18	(18)	1.7	(1.4)	1.5	(1.3)	68	(69)	1.9	(1.7)	1.7	(1.5)
Cervus elaphus																		
American elk	2	(2)	1.0	(0.9)	0.9	(0.8)	10	(15)	0.9	(1.2)	0.8	(1.0)	35	(49)	1.0	(1.2)	0.9	(1.0)
Odocoileus hemionus																		
mule deer	10	(12)	5.2	(5.6)	4.5	(4.8)	60	(79)	5.8	(6.4)	5.2	(5.7)	236	(289)	6.7	(7.2)	6.1	(6.4)
Antilocapra americana																		
pronghorn	2	(2)	1.0	(0.9)	0.9	(0.8)	8	(13)	0.7	(1.0)	0.6	(0.9)	40	(50)	1.1	(1.2)	1.0	(1.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7 N		% class		% total		Other† N		% class		% total		Total N		% class		% total	
Antilocapra or *Ovis* spp. pronghorn or sheep							1	(1)	0.0	(0.0)	0.0	(0.0)	3	(3)	0.0	(0.0)	0.0	(0.0)
Ovis spp. sheep							2	(2)	0.1	(0.1)	0.1	(0.1)	2	(2)	0.0	(0.0)	0.0	(0.0)
Ovis canadensis bighorn	2	(2)	1.0	(0.9)	0.9	(0.8)	12	(19)	1.1	(1.5)	1.0	(1.3)	45	(60)	1.2	(1.5)	1.1	(1.3)
Bos or *Bison* cow or bison							1	(1)	0.0	(0.0)	0.0	(0.0)	1	(1)	0.0	(0.0)	0.0	(0.0)
Total Mammalia	192	(213)	100.0	(100.0)	87.6	(85.5)	1026	(1218)	100.0	(100.0)	89.2	(88.3)	3486	(3994)	100.0	(100.0)	90.3	(89.5)
Aves:																		
Gaviiformes loons							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(1)	0.2	(0.2)	0.0	(0.0)
Ciconiformes deep waters waders							0	(2)	0.0	(1.3)	0.0	(0.1)	0	(2)	0.0	(0.4)	0.0	(0.0)
Anatidae geese and ducks													1	(1)	0.2	(0.2)	0.0	(0.0)
Anserinae geese							1	(1)	0.8	(0.6)	0.0	(0.0)	6	(6)	1.6	(1.3)	0.1	(0.1)
Branta canadensis Canada goose							1	(2)	0.8	(1.3)	0.0	(0.1)	7	(13)	1.9	(2.9)	0.1	(0.2)
Anas spp. surface-feeding ducks	1	(1)	4.0	(3.0)	0.4	(0.4)	1	(1)	0.8	(0.6)	0.0	(0.0)	6	(7)	1.6	(1.5)	0.1	(0.1)
Anas platyrhynchos mallard													3	(4)	0.8	(0.9)	0.0	(0.0)
Oxyura jamaicensis ruddy duck													1	(1)	0.2	(0.2)	0.0	(0.0)
Falconiformes vultures, hawks, and falcons	0	(1)	0.0	(3.0)	0.0	(0.4)	2	(3)	1.7	(2.0)	0.1	(0.2)	8	(11)	2.2	(2.4)	0.2	(0.2)
Cathartes aura turkey vulture							0	(2)	0.0	(1.3)	0.0	(0.1)	1	(4)	0.2	(0.9)	0.0	(0.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Accipitridae																		
hawks and eagles	2	(2)	8.0	(6.0)	0.9	(0.8)	3	(3)	2.6	(2.0)	0.2	(0.2)	8	(8)	2.2	(1.8)	0.2	(0.1)
Accipiter spp.																		
hawks													0	(1)	0.0	(0.2)	0.0	(0.0)
Accipiter gentilis																		
goshawk							1	(1)	0.8	(0.6)	0.0	(0.0)	2	(2)	0.5	(0.4)	0.0	(0.0)
Accipiter striatus																		
sharp-shinned hawk							1	(1)	0.8	(0.6)	0.0	(0.0)	2	(2)	0.5	(0.4)	0.0	(0.0)
Accipiter cooperii																		
Cooper's hawk													2	(2)	0.5	(0.4)	0.0	(0.0)
Buteo spp.																		
buteos	2	(2)	8.0	(6.0)	0.9	(0.8)	6	(7)	5.3	(4.7)	0.5	(0.5)	13	(14)	3.6	(3.1)	0.3	(0.3)
Buteo jamaicensis																		
red-tailed hawk							0	(2)	0.0	(1.3)	0.0	(0.1)	3	(6)	0.8	(1.3)	0.0	(0.1)
Buteo swainsoni																		
Swainson's hawk													1	(1)	0.2	(0.2)	0.0	(0.0)
Aquila or *Haliaeetus* spp.																		
eagles	0	(1)	0.0	(3.0)	0.0	(0.4)	2	(2)	1.7	(1.3)	0.1	(0.1)	3	(4)	0.8	(0.9)	0.0	(0.0)
Aquila chrysaetos																		
golden eagle							1	(1)	0.8	(0.6)	0.0	(0.0)	10	(10)	2.8	(2.2)	0.2	(0.2)
Haliaeetus leucocephalus																		
bald eagle													1	(1)	0.2	(0.2)	0.0	(0.0)
Falco mexicanus																		
prairie falcon													0	(1)	0.0	(0.2)	0.0	(0.0)
Falco sparverius																		
American kestrel							0	(1)	0.0	(0.6)	0.0	(0.0)	5	(6)	1.4	(1.3)	0.1	(0.1)
Galliformes																		
fowl-like birds	1	(1)	4.0	(3.0)	0.4	(0.4)	2	(2)	1.7	(1.3)	0.1	(0.1)	6	(7)	1.6	(1.5)	0.1	(0.1)
Tetraonidae																		
grouse	6	(6)	24.0	(18.1)	2.7	(2.4)	23	(27)	20.5	(18.3)	2.0	(1.9)	79	(91)	22.3	(20.4)	2.0	(2.0)
Centrocercus urophasianus																		
sage grouse	1	(1)	4.0	(3.0)	0.4	(0.4)	2	(2)	1.7	(1.3)	0.1	(0.1)	8	(8)	2.2	(1.8)	0.2	(0.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Meleagris gallopavo																		
turkey	6	(10)	24.0	(30.3)	2.7	(4.0)	19	(26)	16.9	(17.6)	1.6	(1.8)	70	(93)	19.7	(20.9)	1.8	(2.0)
Grus canadensis																		
sandhill crane	1	(1)	4.0	(3.0)	0.4	(0.4)	3	(5)	2.6	(3.4)	0.2	(0.3)	12	(17)	3.3	(3.8)	0.3	(0.3)
Tringa melanoleuca																		
greater yellowlegs													0	(1)	0.0	(0.2)	0.0	(0.0)
Zenaida macroura																		
mourning dove							0	(2)	0.0	(1.3)	0.0	(0.1)	3	(6)	0.8	(1.3)	0.0	(0.1)
Otus asio																		
screech owl													1	(1)	0.2	(0.2)	0.0	(0.0)
Bubo virginianus																		
great horned owl							2	(4)	1.7	(2.7)	0.1	(0.2)	9	(13)	2.5	(2.9)	0.2	(0.2)
Glaucidium gnoma																		
pgymy owl							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(1)	0.2	(0.2)	0.0	(0.0)
Asio spp.																		
long- or short-eared owl													1	(1)	0.2	(0.2)	0.0	(0.0)
Asio otus																		
long-eared owl							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(1)	0.2	(0.2)	0.0	(0.0)
Colaptes auratus																		
common flicker							1	(1)	0.8	(0.6)	0.0	(0.0)	5	(5)	1.4	(1.1)	0.1	(0.1)
Passeriformes																		
perching birds	2	(2)	8.0	(6.0)	0.9	(0.8)	23	(24)	20.5	(16.3)	2.0	(1.7)	34	(36)	9.6	(8.1)	0.8	(0.8)
Tyrannus verticalis																		
western kingbird													1	(1)	0.2	(0.2)	0.0	(0.0)
Corvidae																		
jays, crows, and magpies	2	(2)	8.0	(6.0)	0.9	(0.8)	1	(2)	0.8	(1.3)	0.0	(0.1)	6	(7)	1.6	(1.5)	0.1	(0.1)
Corvus spp.																		
raven or crow													0	(1)	0.0	(0.2)	0.0	(0.0)
Corvus corax																		
common raven							5	(8)	4.4	(5.4)	0.4	(0.5)	13	(16)	3.6	(3.6)	0.3	(0.3)
Corvus brachyrhynchos																		
common crow							2	(3)	1.7	(2.0)	0.1	(0.2)	3	(5)	0.8	(1.1)	0.0	(0.1)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7						Other†						Total					
	N		% class		% total		N		% class		% total		N		% class		% total	
Cyanocitta stelleri																		
Steller's jay	0	(1)	0.0	(3.0)	0.0	(0.4)	1	(2)	0.8	(1.3)	0.0	(0.1)	1	(3)	0.2	(0.6)	0.0	(0.0)
Cymnorhinus cyanocephalus																		
pinyon jay	0	(1)	0.0	(3.0)	0.0	(0.4)							0	(1)	0.0	(0.2)	0.0	(0.0)
Aphelocoma coerulescens																		
scrub jay	1	(1)	4.0	(3.0)	0.4	(0.4)	1	(1)	0.8	(0.6)	0.0	(0.0)	2	(2)	0.5	(0.4)	0.0	(0.0)
Pica pica																		
black-billed magpie							2	(2)	1.7	(1.3)	0.1	(0.1)	6	(6)	1.6	(1.3)	0.1	(0.1)
Turdidae																		
thrushes and bluebirds							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(1)	0.2	(0.2)	0.0	(0.0)
Sialia currucoides																		
mountain bluebird							0	(1)	0.0	(0.6)	0.0	(0.0)	0	(1)	0.0	(0.2)	0.0	(0.0)
Turdus migratorius																		
American robin							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(3)	0.2	(0.6)	0.0	(0.0)
Lanius excubitor																		
northern shrike							1	(1)	0.8	(0.6)	0.0	(0.0)	1	(1)	0.2	(0.2)	0.0	(0.0)
Sturnella spp.																		
meadowlarks													1	(1)	0.2	(0.2)	0.0	(0.0)
Xanthocephalus xanthocephalus																		
yellow-headed blackbird													0	(1)	0.0	(0.2)	0.0	(0.0)
Fringillidae																		
finch-like birds													1	(1)	0.2	(0.2)	0.0	(0.0)
Pipilo chlorura																		
green-tailed towhee													3	(4)	0.8	(0.9)	0.0	(0.0)
Total Aves	25	(33)	100.0	(100.0)	11.4	(13.2)	112	(147)	100.0	(100.0)	9.7	(10.6)	354	(444)	100.0	(100.0)	9.1	(9.9)
Reptilia:																		
Squamata																		
lizards and snakes							1	(1)	16.6	(14.2)	0.0	(0.0)	1	(1)	10.0	(9.0)	0.0	(0.0)
Sauria																		
lizard	2	(2)	100.0	(100.0)	0.9	(0.8)	1	(1)	16.6	(14.2)	0.0	(0.0)	3	(3)	30.0	(27.2)	0.0	(0.0)

Table 4.41 – MNI in the identifiable macrofaunal assemblage* – Continued

Taxon	Modeling Period 7 N	% class	% total	Other† N	% class	% total	Total N	% class	% total
Sceloporus undulatus elongatus northern plateau lizard				1 (1)	16.6 (14.2)	0.0 (0.0)	1 (1)	10.0 (9.0)	0.0 (0.0)
Serpentes snakes				3 (3)	50.0 (42.8)	0.2 (0.2)	5 (5)	50.0 (45.4)	0.1 (0.1)
Crotalus virdis western rattlesnake				0 (1)	0.0 (14.2)	0.0 (0.0)	0 (1)	0.0 (9.0)	0.0 (0.0)
Total Reptilia	2 (2)	100.0 (100.0)	0.9 (0.8)	6 (7)	100.0 (100.0)	0.5 (0.5)	10 (11)	100.0 (100.0)	0.2 (0.2)
Amphibia:									
Anura frogs and toads				3 (3)	100.0 (100.0)	0.2 (0.2)	4 (4)	80.0 (80.0)	0.1 (0.0)
Bufo spp. true toads							1 (1)	20.0 (20.0)	0.0 (0.0)
Total Amphibia				3 (3)	100.0 (100.0)	0.2 (0.2)	5 (5)	100.0 (100.0)	0.1 (0.1)
Osteichthyes:									
Cypriniformes cyprinids				1 (1)	50.0 (33.3)	0.0 (0.0)	1 (1)	50.0 (25.0)	0.0 (0.0)
Catostomidae suckers	0 (1)	0.4 (100.0)	0.0 (0.4)	0 (1)	0.0 (33.3)	0.0 (0.0)	0 (2)	0.0 (50.0)	0.0 (0.0)
Catostomus spp. flannelmouth or blueheaad suckers				1 (1)	50.0 (33.3)	0.0 (0.0)	1 (1)	50.0 (25.0)	0.0 (0.0)
Total Osteichthyes	0 (1)	100.0 (100.0)	0.0 (0.4)	2 (3)	100.0 (100.0)	0.1 (0.2)	2 (4)	100.0 (100.0)	0.0 (0.0)
Total assemblage	219 (249)		100.0 (100.0)	1149 (1378)		100.0 (100.0)	3857 (4458)		100.0 (100.0)

* Identifiable at least to order.
Figures in parentheses indicate counts and percentages when bones that compare favorably to that taxon are included.
MNI– Minimum number of individuals.

measures used or of the selective forces operative? Second, studies could be undertaken to determine the extent to which the composition of the faunal assemblage covaries with other aspects of the Dolores record, such as population size, degree of population aggregation, and interhousehold versus intrahousehold organization of activities (chaps. 5 and 7). Third, comparisons between the microfaunal assemblage and the macrofaunal assemblage should be made. The study of microfaunal remains was primarily intended to verify the composition of the assemblage as indicated by the macrofaunal assemblage. Specifically, the goal was to determine if fish, very small rodents, insectivores, and passerine birds might be under-represented in the macrofaunal assemblage. Even a cursory glance at table 4.39 indicates that, while the remains of mammals often are less common in the microfaunal assemblage, fish, birds, reptiles, and amphibians are not necessarily more common. Instead, the lower proportion of mammals seems to be related to an increase in indeterminate vertebrate and bird-mammal remains. This suggests that greater fragmentation is responsible. As for the small rodents and insectivores, these may be somewhat more frequent in the microfaunal assemblage. Of course, statistical analysis of these subjective and general observations should be undertaken.

A fourth topic that warrants additional consideration is the general diversity of the Dolores identifiable assemblages. While lagomorphs and artiodactyls are the most commonly occurring taxa in the identifiable assemblages, these animals hardly dominate entirely. A wide variety of mammals and quite a few birds are represented. This diversity generally is not found in the Black Mesa faunal assemblage,[10] which perhaps suggests that the environmental diversity at Dolores is an important factor. This topic deserves much more attention, as this diversity may be more apparent than real.

Finally, the domestic dog (*Canis familiaris*) and the turkey (*Meleagris gallopavo*) deserve further study. The domestic dog remains from Dolores appear to represent the "Small Pueblo Dog" variety (Clark et al. 1985). Their presence in the Dolores assemblage is not at all surprising, as domestic dogs were kept by many prehistoric groups. On the other hand, the turkeys at Dolores may be either wild or domestic, and the implications for understanding the strategies of the Dolores Anasazi are significant in either case. Further attention is warranted.

In summary, many potential avenues for further research using the faunal data base are described in this section. The data have been presented in the hopes that other researchers will be able to explore some of these issues and to use the DAP faunal assemblages for comparative purposes. Interpretations of portions of the data base are presented in other DAP reports, which the reader is encouraged to consult. These reports include Neusius and Gould (1985), Neusius (1984, 1985b), Neusius and Phagan (1983), Neusius and Matthews (1985), and chapter 7 of this volume. In the conclusions for this section, a tentative outline of the strategies and variability in strategies among the Dolores Anasazi is given.

CONCLUSIONS: IMPLICATIONS FOR PROCUREMENT AND PROCESSING

Understanding the economy and adaptations of the Dolores Anasazi requires studies of resource availability and resource mix and, by implication, studies of Dolores Anasazi procurement and processing strategies. What were those strategies and how did they change in response to variability in other aspects of the system? Although final answers to these questions have not yet been obtained, some suggestions are offered here. These suggestions are tentative; however, some attempts to corroborate them have been made (Neusius and Phagan 1983; Neusius 1985b; Neusius and Gould 1985; Neusius and Matthews 1985; chap. 7).

First, game seems to have been an important part of Anasazi economics throughout the Dolores sequence. Although agriculturalists or horticulturalists, these people relied on game for protein and variety, and as part of a buffer device against crop failure (Neusius 1985b; Neusius and Matthews 1985; chap. 7). Increases or decreases in demand or in the reliability of agricultural production may have decreased or increased reliance on wild game, but at no time were these resources of little importance. Domestic animals seem to have been of minor importance in terms of subsistence and ritual.

Second, 2 key game procurement strategies seem to have been adopted. The first, sometimes called garden hunting (Linares 1976; Emslie 1981; Neusius 1984), is an expedient or opportunistic strategy in which prey are procured as encountered in the course of other activities. This activity may have been embedded in crop planting, maintenance and harvesting, and possibly in wild plant collecting. Lists of characteristic species can be developed for this strategy, but caution should be exercised when interpreting such lists: high diversity does not necessarily imply heavy usage of small game (Neusius 1984).

The second strategy is winter large-game procurement. This too was a low-cost strategy, because during the

[10]Robert D. Leonard, Black Mesa Archaeological Project, Center for Archaeological Investigations, Southern Illinois University, Carbondale, personal communication.

winter months, large game such as deer and elk tend to move to lower elevations, passing through or even congregating in the Dolores River valley (Neusius and Phagan 1983). In contrast, although these animals are excellent sources of meat and raw materials, they would have been expensive to procure in summer because they are located at higher elevations than Dolores Anasazi settlements and fields. Scheduling conflicts also would have been more of a problem during the summer.

Although not all game procurement fell into these 2 categories, most of the meat and raw material from game probably was procured in 1 of these 2 ways. If this is correct, the Dolores faunal assemblages should provide substantiating evidence. Preliminary support has been found by Neusius (1985b), Neusius and Gould (1985), and Neusius and Phagan (1983), but an exhaustive study has not been completed.

Little change in these strategies is expected during the Dolores sequence, although climatic deterioration and population increase may have affected strategies. An increase in demand or a greater need to buffer agricultural production might have made summer large-game hunting more attractive. Assuming that task groups were logistically organized, long-distance hunts during the summer months might have been adopted. Evidence for this was not found in the Grass Mesa Village or the McPhee Community faunal assemblages (Neusius and Gould 1985; Neusius 1985b). Evidence for rabbit driving, another possible strategy, also was not found (Neusius and Gould 1985), although in both cases the test procedures may be have been inadequate rather than the expectations.

As for processing strategies, these should have been nonselective, except in the case of long-distance hunting. Preliminary tests generally support this prediction (Neusius 1985b; Neusius and Gould 1985). However, it seems probable that large mammal carcasses were more extensively processed than small mammal carcasses and that this partially explains the lower proportion of identifiable large mammal bones. Increases in demand may have led to heavier use and processing of large game.

In conclusion, the DAP has generated a large and potentially valuable faunal data base primarily relevant to studies of Dolores Anasazi adaptations. Data on both resource availability and a resource mix have been gathered. Thorough interpretation of this data has not been possible under the auspices of the DAP, but the data have been useful in DAP synthetic studies and may be useful to other researchers in the future.

Section 5

GEOLOGICAL STUDIES: A REVIEW

Kenneth Lee Petersen

The geologic setting of the project area is controlled primarily by gently southerly dipping mesozoic sedimentary rock, the east-west-trending House Creek fault, and the Dolores River and its tributaries, which are entrenched into the uplifted geologic strata. Overlying much of the project area is a mantle of deep loessal sediment that historically has supported successful dry farming.

DOLORES ARCHAEOLOGICAL PROGRAM GEOLOGICAL STUDIES: AN OVERVIEW, 1978-1982

Studies of geological resources have been used to address the problem domains of the DAP general research design. Petersen et al. (1984) developed a midlevel research design that provided a more specific focus for studies conducted by the Earth Resources Section of the EAG. Topics addressed included the following: geomorphology and characteristics of site location; stratigraphy of archaeological sites and pertinent resource areas; and delineation of potential resources areas on project-wide maps of modern bedrock, landforms, soils, and stream orders.

One of the primary responsibilities of the Earth Resources Section of the EAG was to provide program archaeologists with guidelines for recording and describing stratigraphic profiles and to aid the archaeologists in interpreting those profiles. To this end, a guide was written and included in the excavation manual (Leonhardy et al. 1984:380-393). In addition, 3 early DAP site reports contain appendixes specifically dealing with geology. Clay et al. (1982:143-145) describes the bedrock geology and soils at Tres Bobos Hamlet (Site 5MT4545); Hampson (1982:123-126) comments on the bedrock, drainages, and soils at Apricot Hamlet (Site 5MT2858); and Glaser (1982:102-104) outlines the bedrock geology, soils, and drainage at Pheasant View Hamlet (Site 5MT2192). Later site reports do not have specific appendixes, but geological information was integrated into the individual reports. The DAP geologist was responsible for insuring that adequate description and interpretation of the geological data were presented in the site reports. Geological consultants also were contacted to provide both site-specific and project-wide reports (refer to chap. 1). Some of these reports have been included in *Dolores Archaeological Program: Studies in Environmental Archaeology* (Petersen et al 1985).

One of the purposes of the environmental archaeology volume (Petersen et al. 1985) was to describe the history of DAP environmental studies and to assemble in 1 place the basic data on the project environment up to the time of the volume's production. Included in that volume is a discussion of bedrock geology, general landforms, and modern stream order and drainage basins (Leonhardy and Clay 1985a); a reconnaissance soils map of the project area (Leonhardy and Clay 1985b: fig. 23);[11] and site-specific geology reports on Periman Hamlet (Site 5MT4671), Rio Vista Village (Site 5MT2182), McPhee Community Cluster (specifically, Sites 5MT4475, 5MT4477, and 5MT4479), and Grass Mesa Village (Site 5MT23) Holliday and Piety 1985). Holliday and Piety (1985) also describe the geology of the Dolores River flood plain and low terraces; they review the geomorphology, Quaternary geology, and soils of the project area; and they provide a surficial geology map of the project area. Because these authors differ to varying degrees on some specific interpretations, another chapter in the environmental archaeology volume is devoted to offering suggestions as to how the differences might be reconciled (Clay 1985a). Clay comments specifically on the mapping of the distribution of loess, river terraces, alluvial fans, and pediment. She also describes the geological origin of Sagehen Flats, the Rio Vista Village (Site 5MT2182) bench, and the noncultural surficial sediments at Grass Mesa Village (Site 5MT23).

Clay (1985b) also reports on a sedimentary study of the Sagehen Flats marsh. This report provides information on potential resources and past environmental conditions, and it illustrates the probable role that uplifting and faulting had in developing the Sagehen structural basin, factors that probably affected the entire project area. Radiocarbon dating results are used to determine when the marsh may have existed prehistorically, and what its nature and extent were. Clay concludes that the marsh probably existed intermittently during the Anasazi occupation, but was not as extensive as the modern marsh, which is largely a product of a historic irrigation canal located uphill from it.

GEOLOGICAL STUDIES AND THE GENERAL RESEARCH DESIGN: 1983-1985

Dolores Archaeological Program geological studies can be applied directly to Problem Domain 1 (Economy and Adaptation) and Problem Domain 4 (Extraregional Relationships) (Kane et al. 1983:42,55). Because Problem Domain 4 is primarily addressed by only 1 study, it will be treated first.

Problem Domain 4: Extraregional Relationships

Keane and Clay (1984) report on a variety of minerals and rocks that do not occur naturally in the project area and that were recovered during DAP archaeological excavations. All unusual rocks and minerals were characterized to determine which were local and which were exotic; sources of the exotic materials were then sought and mapped. Keane and Clay (1984) conclude that when these materials are considered on a per capita basis, the frequencies are more or less constant through time.

Keane and Clay (1984) also discuss the occurrences of local ferruginous minerals, calcite, gypsum, fossil pycnodont mollusc, quartz and other silicates, coal, weathered rock (pigment sources?), sandstone, siltstone, mudstone, limestone, pebbles and cobbles, gastroliths, and calcium carbonate. They treat the following as nonlocal materials: turquoise and other copper minerals, jet, sulfer, mica, barite, magnetite, graphite, manganite, certain fossil teeth, and galena.

Problem Domain 1: Economy and Adaptation

Several DAP studies address resource availability and use. Rock available for tool manufacture is described in brief in Leonhardy and Clay (1985a) and in various site reports. Wilson et al. (1985) look specifically at clay resources within the project area. They find that usable clay occurs in the Morrison and Burro Canyon Formations, in the middle of the Dakota Sandstone Formation, and in members of the Mancos Shale Formation. Results of analysis suggest that the Anasazi potters were selecting a small subset of available clays and that sources from the Dakota Sandstone and Mancos Shale probably were the most frequently used.

The characteristics and distribution of arable soils in the project area also was studied. The Anasazi were sedentary farmers that grew corn, beans, squash, and other crops in cleared fields near their habitations. Bedrock, major landforms, and major drainages have changed little since Anasazi times. However, soils, microtopography, small drainages, and the water table have changed even in historic times in the project area in response to climatic change, vegetation change, and the impact of humans. One of the emphases of the later geological studies has been understanding chemical, physical, and environmental limitations that affected the suitability of project soils for dry farming, and the depositional and erosional processes affecting the distribution of those soils.

[11]Subsequent to the production of the reconnaissance soils map, Cortez SCS (Soil Conservation Service) personnel mapped portions of the project area in more detail. The greatest difference between later maps and the map in the environmental archaeology volume (Leonhardy and Clay 1985b:fig. 23) is in the designation of soils at higher elevations within the project area.

A fortuitous paleontological find contributed significantly to the understanding of the history of the agriculturally important loess in the project area. In 1982, a partial skeleton of an extinct genus of musk ox (*Symbos*) was discovered during excavations at Grass Mesa Village, below the earliest level of human occupation (Clay, Canady, and Neusius 1985). A date of 15 970 ± 155 years B.P. (SI-6137) was yielded by several collagen-dated vertebrae. This date and the context of the find permitted the assignment of a more precise date range for the most recent depositional episode of loess than had been possible previously. Examination of the context and date of the musk ox suggests that the last major eolian deposition of loess might have occurred during pluvial times following rapid deglaciation in the nearby San Juan and La Plata Mountains. In addition, as the first *Symbos* specimen to be discovered in southwestern Colorado, and as 1 of the relatively few specimens to be found with both cranial and postcranial elements, the Grass Mesa musk ox is a significant paleontological find that contributes to the data base for this little-documented species.

A collection of papers deals specifically with prehistoric agricultural potential in the project area (Petersen and Orcutt 1985, comps.). The Anasazi inhabited the Dolores River valley for roughly 300 years, beginning in the A.D. 600's. After Anasazi abandonment, the project area did not sustain another long-term sedentary farming population until early Euro-American settlers began to clear and till the land late in the 19th century, since that time, the area has supported successful dry farming. Some of the questions addressed in Petersen and Orcutt (1985, comps.) deal with the role that soil as well as climate may have played in agricultural success or failure. Did changing farming capability play a part in the rapid Anasazi growth and decline in the river valley? How critical are the factors of soils fertility and distribution? How is the agricultural potential of a particular plot of ground influenced by growing season length, topographic situations, elevation, and precipitation?

A study by Darsie (1983) addresses the topic of agricultural potential of soils by using computer simulations. Darsie recorded 8 soil variables on a grid that covered the central portion of the project area. Measures of the variables were obtained from project topographic, preliminary soils, and cold air maps, as well as from SCS and Forest Service soil pedon descriptions. The 8 variables were elevation, slope, aspect, relative elevation, cold air drainage, soil depth, soil moisture-holding capacity, and soil permeability.

Using the grid of data points and a computer graphics program (SYMAP), Darsie (1983) generated maps of farming potential. Several iterations that took into account different sets of climatic conditions were produced. The maps represent a theoretical distribution of land units classified by agricultural potential, but no field checking was undertaken to test the results. Also, Darsies's (1983) chronology of climatic change in the project area is based on a preliminary report by Petersen (1983) that has since been refined (sect. 6, this chap.).

Subsequent studies were undertaken to refine or expand on the preliminary study by Darsie (1983). Clay and Petersen (1985) report on the high-resolution mapping of soils near McPhee Village and Periman Hamlet (Site 5MT4671). This study involved on-the-ground testing and mapping to evaluate the extent of arable soils available to the inhabitants of those 2 large Anasazi complexes.

A grid of soil pits at 100-m intervals was dug to measure the soil depth and to record other soil and topographic features. A 2000- by 1800-m grid of soil pits centered on McPhee Pueblo (Site 5MT4475) determined that 19 percent of the land is excellent loessal soil, and an additional 59 percent is potentially arable, but not as high quality. Thus, 78 percent of the land is potentially arable. Poor-quality or nonarable land (colluvium and bedrock) make up the remaining 22 percent.

Based on the 3200- by 300-m Periman Hamlet grid, 36 percent of the land near the Periman Hamlet site is estimated to be excellent and 33 percent is potentially arable but not as high quality; this yields a total of 69 percent potentially arable land. The remaining 31 percent is steep canyon wall, bedrock, and colluvium. Based on these results, Clay and Petersen (1985) conclude the amount of arable soil potentially available for prehistoric cultivation was extensive and probably would not have been a limiting factor when the distribution of arable soil alone is considered.

SCS personnel have mapped a large portion of the project area as part of their Montezuma County soil survey. Petersen (1985d) describes the production of 2 maps in his report that replace Leonhardy and Clay's (1985b) reconnaissance soils map. This latter map was based primarily on aerial photograph interpretations with some ground checking. Figure 4.7 is the map of SCS soil units; table 4.42 provides a key to these map units.

Table 4.42 also lists SCS agricultural capability classifications for nonirrigated land. The soil units with the same capability classifications were grouped together to produce figure 4.8. Also mapped in this figure are areas that were not mapped by the SCS but were classified on the basis of adjacent areas indicated in the SCS survey. Possibly as much as 50 percent of the land is

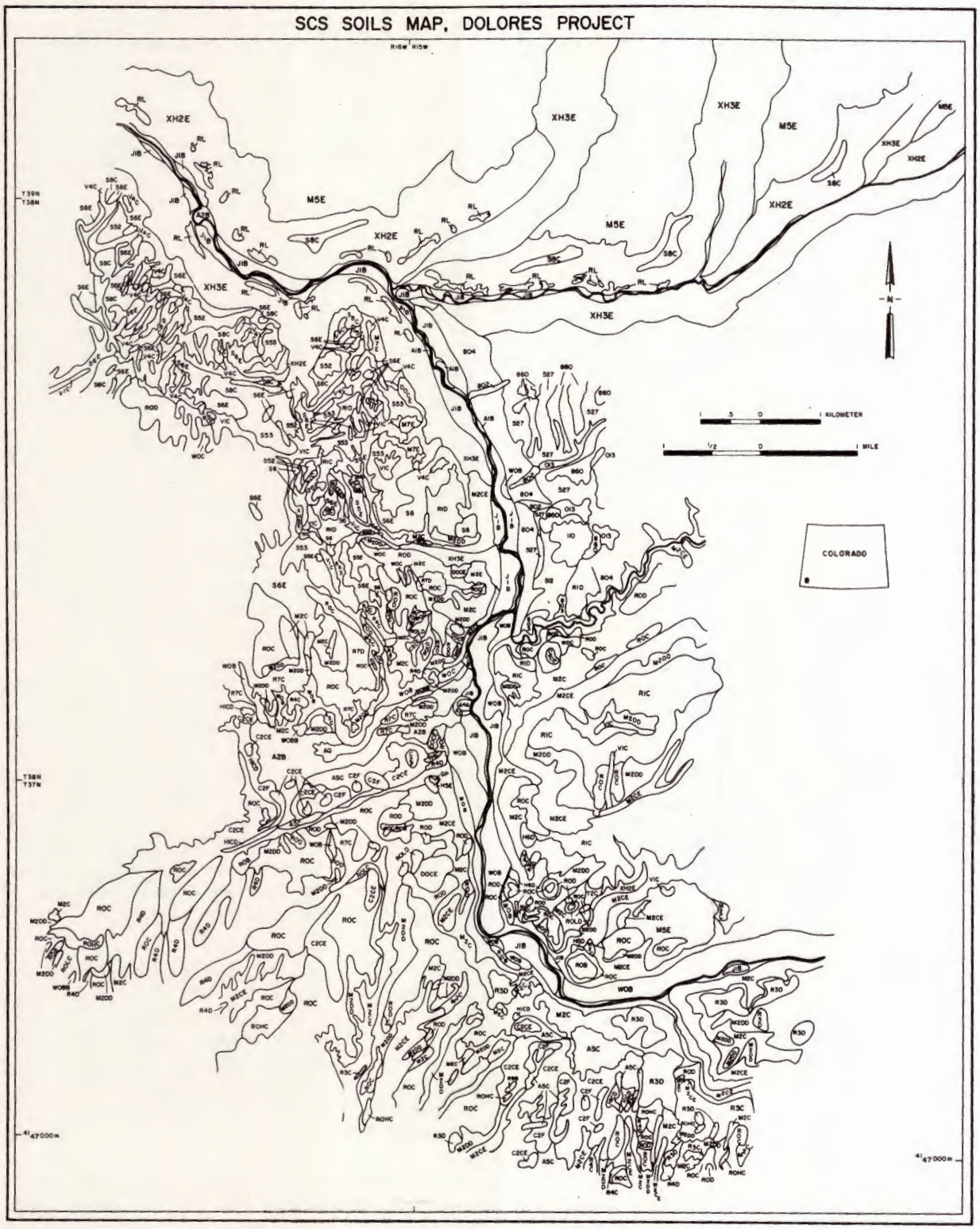

Figure 4.7 – Soil Conservation Service map of soils in the Dolores Project area. Refer to table 4.42 for key to soil mapping units. Source: Petersen (1985d:fig. 1).

Table 4.42 – Key to soil mapping units in figure 4.7

Mapping unit symbol	Series name	Degree of slope (%)	Capability N-irr
AQ	Poganeab loam	0-2	VIw
A1B	Torrifluvents-Fluvaquents	0-3	VIw
A2B	Sili silty clay loam	0-3	IIIs
A4A	Ustic Torrifluvents, gravelly substratum	0-3	VIs
A5C	Sili silty clay loam	3-6	IIIe
C2CE	Zyme very channery clay loam	3-25	VIe
C2F	Zyme very channery clay loam	25-65	VIIe
DOCE	Circleville Variant cobbly loam	3-25	VIIs
GP	Pits, gravelly	n.a.	VIIs
H1CD	Sili clay loam, bedrock substratum	3-12	IVe
H5E	Romberg-Cragola-Rock outcrop complex	25-80	VIIe
H6D	Sedillo very stony sandy loam	6-25	IVe
J1B	Sycle sandy loam	0-3	IIIc
M2C	Romberg-Cragola complex	6-25	VIIs
M2CE	Romberg-Cragola-Rock outcrop complex	25-80	VIIe
M2DD	Gladel-Pulpit complex, rocky	3-9	VIs
M5E	Iles-Granath loams	2-6	IVs
M7E	Pinata-Granath complex	3-12	VIIs
RL	Rock outcrop	n.a.	VIII
ROB	Witt Loam	1-3	IIIc
ROC	Witt loam	3-6	IIIe
ROD	Witt loam	6-12	IVe
ROHC	Pulpit loam	3-6	IIIe
ROHD	Pulpit loam	6-12	IVe
ROLC	Sharps loam	3-6	IIIe
ROLD	Sharps loam	6-12	IVe
R1C	Granath loam	3-6	IVc
R1D	Granath loam	6-10	IVe
R3C	Cahona very fine sandy loam	3-6	IIIe
R3D	Cahone very fine sandy loam	6-10	IVe
R4C	Cahona-Sharps-Witt complex	2-6	IIIe
R4D	Sharps-Cahona complex	6-12	IVe
R7C	Sharps-Pulpit loams	2-6	IIIe
R7D	Sharps-Pulpit loams	6-10	IVe
R9B	Ascalon loam	0-6	IVe
S52	Iles-Granath loams	2-6	IVc
S53	Iles-Granath loams	6-12	IVe
S6	Ormiston-Acre sandstone substratum complex	1-6	VIIs
S6E	Pramiss very stony loam	6-25	VIIs
S8C	Iles-Pramiss-Granath loams	2-6	IVc
T2C	Pinata extremely cobbly loam	0-9	VIIs
V1C	Hesperus loam	3-6	IVc
V1D	Hesperus loam	6-12	IVe
V4C	Fughes loam	2-9	IVe
WOB	Ackmen loam	1-3	IIIc
WOBB	Ackmen loam, seeped	1-3	IIIw
WOC	Ackmen loam	3-6	IIIe
XH2E	Sheek-Archuleta-Rock outcrop complex	25-80	VIIe
XH3E	Sheek-Archuleta-Rock outcrop complex	25-80	VIIe
013	Unnamed loam	0-15	IIIe
110	Unnamed very cobbly clay loam	0-30	VIe
512	Witt loam	0-10	IIIe
527	Ormiston-Kiln complex	0-5	VIIs
802	Unnamed-Unnamed complex	30-60	VIIe
803	Unnamed-Unnamed-Rock outcrop complex	15-30	VIe
804	Romberg-Cragola complex	30-60	VIIe
860	Acree-Nortez loams	0-15	IVe

Capability N-irr – Soil Conservation Service land classification–capability class for nonirrigated land (Nielsen 1979).

III – Best in project area, suitable for dry farming.
IV – Good, suitable for dry farming.
VI – Marginal, severe limitation for dry farming.
VII – Not possible for dry farming due to very severe limitations.
VIII – Not possible for dry farming.
e – Limited because subject to erosion due to steepness or slope.
w – Limited by excessive wetness.
s – Limited by shallow root zone.
c – Limited by climate, (e.g., too short a growing season, north-facing slope, too dry).
n.a. – Not applicable.

Source: Clay, Petersen, and Decker (1985:table 1).

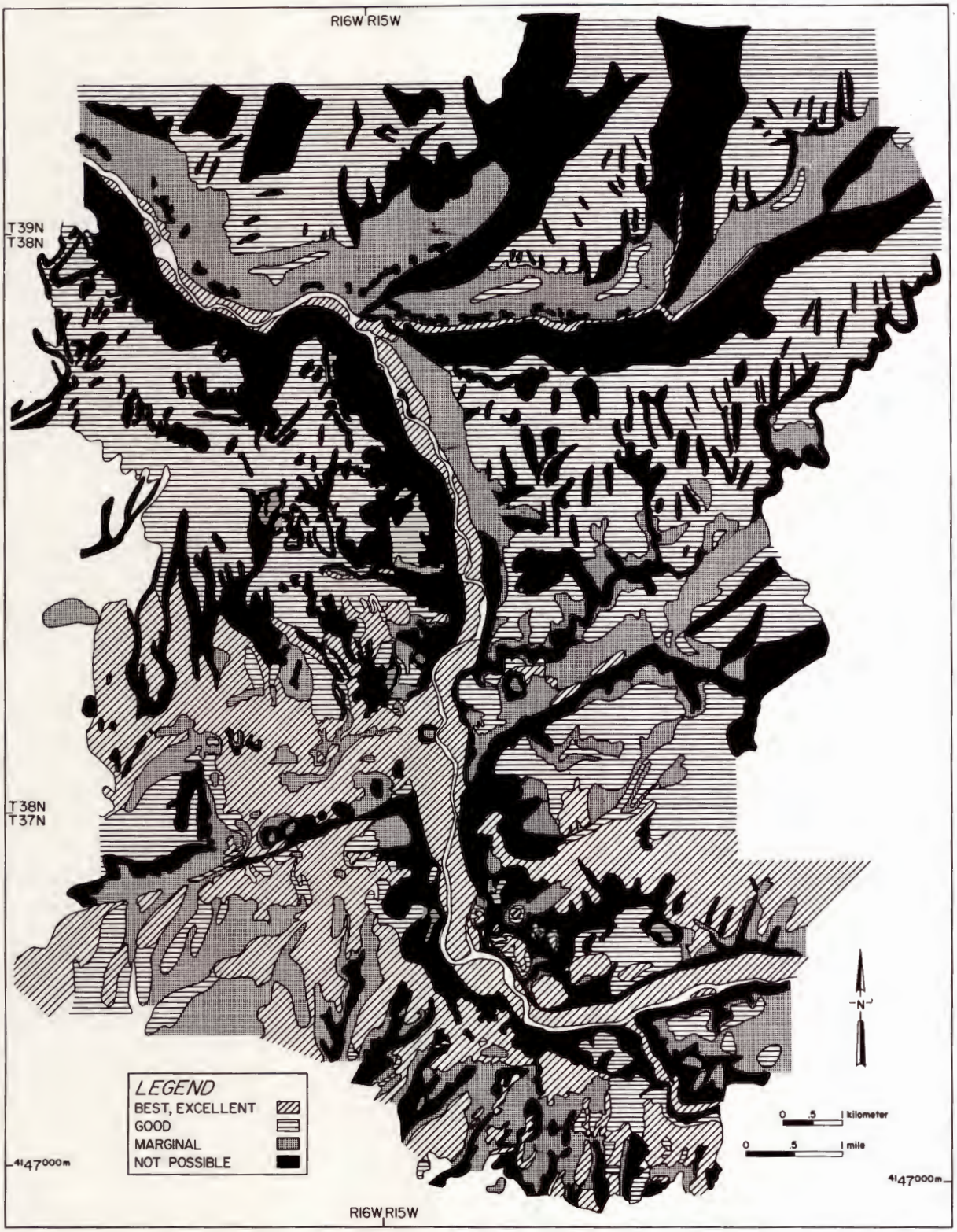

Figure 4.8 – Map of Soil Conservation Service land capability classes. Source: Petersen (1985d:fig. 2).

arable; if the results of Clay and Petersen's (1985) high-resolution mapping are any indication, this figure may be even higher.

The SCS also listed agricultural capability classifications, although their system was designed for mechanized farming. Plots too small for mechanized farming probably are scattered throughout all the soil classification units. These probably could have been farmed using Anasazi techniques.

Clay, Petersen, and Decker (1985) completed sediment and chemical analysis of most of the SCS-designated soils in the project area. Based on the 83 samples processed, the only possible limitations were stoniness, alkalinity, and clayey texture in a few of the soil series. The majority of the project area soils are derived from loessal eolian parent materials. These soils are fertile and have loamy textures suitable for dry-land agriculture. Anasazi farming techniques probably never would have used the macronutrients and micronutrients at a rate that would have led to such low levels that a particular field would have to have been abandoned.

An additional DAP study deals with how much soil may have eroded away during and since Anasazi occupation. Loessal sediments deposited in the modern marsh (Clay 1985b) indicate that soil has eroded away from the uplands in historical times and has been deposited into the marsh. The drainage area of the marsh is 1884 ha. Based on Bye's (1985:fig. 1) actual natural vegetation map, it is estimated that 36 percent of the drainage area, or 695 ha, has been cultivated or disturbed historically.

Petersen et al. (1985:31) note that agricultural practices of historic and modern farmers have resulted in complete clearing of modern fields. The plowed areas tend to be on gentle slopes (2° to 5° dip), and during spring runoff or a heavy rainstorm, as much as 10 to 20 cm of upper unvegetated sediment moves downslope. Sagebrush located below such fields has been partially buried during summer rainstorms. A water flume in the Sagehen marsh dating to A.D. 1889 was buried by 0.78 m of recent sediment (Clay 1985b).

Clay and Petersen (1985) determined that for the nearby McPhee Village, as much as 78 percent of the land could be farmed. Orcutt (1984b:table 17) estimated roughly 500 ha within a 1-km catchment would have been needed to support that community at peak population. This suggests that substantial human-caused erosion could have been possible.

One of the characteristics that Clay and Petersen (1985) recorded was soil depth. Some soil pits in the McPhee Village grid indicated that the loessal deposits over some bedrock were too thin at present to support farming, but this may not have been the case early in the Anasazi occupation. Based on the redeposition of loessal sediment into McPhee Village pitstructures and other project pitstructures, Clay and Petersen (1985) suggest that during the Anasazi occupation, possibly as much as 5 percent more land could have been farmed.

Anasazi clearance and maintenance of fields most likely had a wide-ranging effect on the environment. An environmental impact model is presented by Petersen et al. (1985), and geological evidence was examined in light of that model. In particular, the rates of human-caused erosion were examined in detail. Modern sediment deposition into an open pitstructure in the McPhee Village was studied over a 1-year period while the climatic conditions were being monitored. Based on this study, Anasazi pitstructures, when left open to the elements, probably filled quite rapidly (possibly as little as 100 years after abandonment) due to the availability of sediment on a largely disturbed landscape.

Petersen et al. (1985) also examined prehistoric sediment profiles from McPhee Village pitstructures to examine the pit fill sequences on the same landforms within 1 km of each other. Apparently, no obvious pattern to the sediment deposition occurs except for a fining toward the top of the sequence. The overriding tendency of grain size is to reflect the parent material closest to the pitstructure.

Many DAP geological studies provided answers to questions generated in the general research design. Extraregional relationships were demonstrated by Keane and Clay's (1984) study of rocks and minerals. Geological resource studies focused on the distribution and characteristics of ceramic clay and of soils suitable for dry farming. The project area consists of about 63 km^2, and of that, about 20 percent (or 12.6 km^2) has been farmed historically. The latter has been mapped as disturbed or cultivated land by Bye (1985:fig. 1). Based on soil capability alone, much more than 50 percent of the land could be farmed both today and prehistorically. However, another factor, growing season length, was determined to be critical for growing corn in the project area, as demonstrated by modern corn plots located in areas subject to cold air pooling (Schuster and Bye [1983, 1984]). The effect of changes in the length of the killing frost-free season on the amount of arable land that could grow corn prehistorically is examined briefly in the next section.

Geological Studies and the Dolores Archaeological Program Model

A generalized sociopolitical model was developed by the DAP to specify variables that might be responsible

for structural change in the Dolores Anasazi systems (refer to part IV, this volume). Variables targeted for study included population, resource supply, economic costs, social differentiation, and the technology of tools and facilities. Important for the discussion here is the contribution that geological studies can make in the effort to evaluate changes in resource supply through time. A decrease in resource supply can be brought about by climatic change or by human activities that deplete resources or alter habitats. Geological studies of the impact of human activities on the distribution of soils indicate a relatively minor effect of possibly plus or minus 5 percent on the total amount of arable soil (Petersen et al. 1985). The next topic to be considered is the effect of changing length of the killing frost-free period.

Rugged mesa and canyon topography can produce extreme temperature variations within a small geographic area. Temperature profiles were used by Petersen and Clay (1984) to quantify the differences in the growing season length between upland and canyon-bottom sites. A map was prepared that showed the modern distribution of growing season length for low-risk (>120 days), moderate-risk (90 to 120 days), and high-risk (60 to 90 days) areas. The map is based on a model developed to predict the frost-free season length for a particular site based on its location in relation to the local inversion layer and the local thermal belts (Petersen and Clay 1984).

A tree-ring-derived proxy of past periods of short growing seasons (Petersen 1984b; Petersen and Clay 1984) was used to reconstruct time periods when moderate-risk land became high-risk land and when low-risk land became moderate-risk land. Two maps showing the different distributions of high-risk land are presented in section 6, this chapter (figs. 4.22 and 4.23).

Because of the large area of fertile soils within the project area, the changing distribution of land with growing seasons adequate for corn may have been much more important to farming success during particular time periods. Refer to chapter 9, this volume, for a more concrete project-wide application of this expectation. Two local examples are discussed next.

SITE-SPECIFIC GEOLOGICAL STUDIES

Two studies that integrate many of the geologic studies presented above are the geoarchaeology reports on McPhee Village (Clay 1984) and Grass Mesa Village (Clay 1985c). Each will be discussed in turn.

In her McPhee Village geoarchaeology report, Clay (1984) summarizes the general geology and geography of the area. She outlines the geological resources, including rocks, landforms, soils, and water, and she describes the possible prehistoric uses of these immediately available resources. Dakota Sandstone, Mancos Shale, and Dolores River gravels provide locally available rock and clay materials for tool and container manufacture and building construction.

Clay (1984) notes the discrepancies in some of the landform maps discussed earlier, reproduces portions of 2 of them, and then produces a third map of the immediate environs of the McPhee that reconciles the discrepancies and identifies the distinct landforms and associated deposits near McPhee.

When dealing with agricultural potential, Clay (1984) compares the Ackmen and Witt loams and Leonhardy and Clay's (1985b:fig. 23) soils map to Darsie's (1983) distribution of class I and class II lands during the A.D. 800-880 period and to the land classified as excellent in figure 4.8 of this report. The similarities in these maps led Clay (1984) to conclude that the larger grid sampling and data recovery from topographic and soils maps accomplished by Darsie (1983) were relatively accurate when compared to ground recconnaissance for the same area.

Clay (1984) concluded that soils and their presumed agricultural potential are probably the most dynamic of the geological resources near McPhee Village. Results of her in-depth study of a number of soil monoliths from McPhee Village pitstructures (Petersen et al. 1985) suggest that continued erosion and deposition of soil profiles probably has altered at least some of the soil properties (depth, degree of weathering, and horizontation) since Anasazi times. Clay (1984) remarks that agricultural potential to grow and mature corn and other crops may have fluctuated more with climatic change than with soil changes or movement.

Clay's (1985c) geoarchaeology report for Grass Mesa provides another good demonstration of the integration of many lines of geological information to better understand the archaeological site setting. The location of Grass Mesa Village (Site 5MT23) is particularly favorable when considering access to and availability of geological resources. As she did in the McPhee report, Clay (1985c) examines all the maps that provide information on potential soils for prehistoric agriculture. She notes that good soils are located on the flood plain, on high terraces, and on the upland dip slope in the village vicinity, where fine textures, gentle slopes, and adequate soil depths are common.

Clay (1985c) notes that Darsie's (1983) maps indicate that areas of good agricultural potential existed in upland areas and canyon bottoms in the A.D. 600-800

and A.D. 800-880 periods, and that canyons and high uplands had poor agricultural potential in the A.D. 880-950 period. Uplands above Grass Mesa Village and directly across the river, however, had good agricultural potential in the A.D. 880-950 period. The good land classes in the river and stream valley were lost during the later years of the Anasazi occupation, while good land classes in the uplands adjacent to Grass Mesa Village remained adequate throughout the occupation.

Information presented in the musk ox study (Clay, Canaday, and Neusius 1985) and in the Grass Mesa report (Clay 1985c) indicates eolian deposits in the vicinity of Grass Mesa may be more than 5 m thick. As she did in the McPhee report (Clay 1984), Clay (1985c) concludes climate may have been a major contributing factor in the amount of land readily available for agriculture at any one time.

Darsie's (1983) exploratory study of reconstructed farming potential in the area of the McPhee and Grass Mesa Villages seems to be largely substantiated by Clay's (1984, 1985c) results reviewed here. In addition, the reader is encouraged to review chapter 9, this volume, and Orcutt (1984b, 1985a, 1985c). Orcutt used a finer time scale, more sampling points, a more updated soils map, and a more refined map of the distribution of killing frost-free periods, among other things, than did Darsie. This allowed for a more detailed evaluation of farming potential within the project area.

SUMMARY

Geological research in the project area has been guided primarily by the general research design (Kane et al. 1983). More specific questions have been generated by applying a geological perspective to all facets of DAP research. As a result, information has been generated about geomorphology and characteristics of site locations, stratigraphy of archaeological sites and pertinent resource areas, and delineation of potential resource areas on project-wide maps of modern bedrock, landforms, stream orders, and soils. Much of the data accumulated between 1978 and 1982 is summarized in *Dolores Archaeological Program: Studies in Environmental Archaeology* (Petersen et al. 1985). After 1982, geological studies concentrated more on the archaeological application of geological studies in the project area.

Keane and Clay (1984) found that when viewed on a per capita basis, exotic geological materials did not fluctuate through time. Wilson et al. (1985) found that just a few potential clay sources were probably being used. The radiocarbon-dating results of remains of an extinct musk ox (*Symbos*) (Clay, Canaday, and Neusius 1985) provided an extremely important key to unraveling the history of over 5 m of eolian loess deposited on Grass Mesa. Loess provides the matrix for the very fertile soils found within the project area.

Historically, locations of dry farms in southwestern Colorado and southeastern Utah have been determined largely by climatic limitations (in this case, precipitation) rather than by soil factors alone (Petersen 1985e). The geological studies completed since 1983 have determined that climatic limitations (in this case, length of growing season) were probably the most significant factors prehistorically.

Studies of the sedimentary and chemical characteristics of project soils and the distribution of soils within the project area received much more emphasis after 1982. Also examined was the distribution and archaeological implications of killing frost-free periods within the project area. The changing distribution of areas that were low risk, medium risk, and high risk possibly was the most critical factor in determining if a particular plot of ground could support corn and other crops to maturity during the Anasazi occupation.

Section 6

CLIMATIC RECONSTRUCTION FOR THE DOLORES PROJECT AREA

Kenneth Lee Petersen

Reconstruction of the prehistoric environment of the Dolores area was essential to answering many of the questions posed in the DAP general research design (Kane et al. 1983) and in the EAG midlevel research design (Petersen et al. 1984). The methods used in the climatic reconstruction and the resulting characterization of the environment are the subjects of this section.

Extensive research in the Colorado Plateau has indicated the Anasazi were well adapted to a varied and, at times, harsh environment. But more specific knowledge of environmental and cultural factors specific to the Escalante Sector was needed to understand and explain long-term cultural process in the Dolores River valley. For instance, more detailed evaluations of the past climate were needed to reconstruct the prehistoric resource base, the potential location and suitability of agricultural fields, and the possible effects of climatic change on the culture.

This last topic is of special interest because Euler et al. (1979) and Dean et al. (1985), using many lines of evidence, propose that many cultural changes in the Colorado Plateau (fig. 4.9) were contemporaneous with

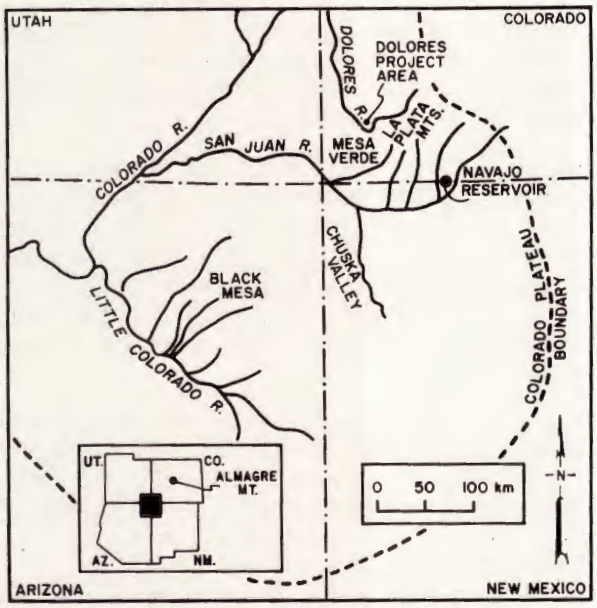

Figure 4.9 – Map showing the locations of the Dolores Project area and the paleoenvironmental sequences discussed in text.

environmental changes. Reported here is a summary of the findings of the DAP that provide an independent test for part of the Euler et al. (1979) and Dean et al. (1985) scheme and that introduce an additional climatic variable, summer warmth, not considered in their original presentations.

THE DATA BASE

Earlier studies (Petersen and Mehringer 1976; Burns 1983; Dean and Robinson 1977; Rose et al, 1982; Fritts et al. 1965; Petersen 1981) have shown the prehistoric environment of southwestern Colorado was both variable and occasionally marginal for corn horticulture (Shuster and Bye [1983, 1984]). Both cultural and environmental factors must be considered in any study of the processes that shaped Anasazi prehistory (Dolores Archaeological Program 1983, 1984).

For periods prior to weather instrumentation (which began in the late A.D. 1800's), climatic reconstruction for the Dolores Project area can be accomplished only by the use of proxy records. In addition to evidence from archaeological sites, these proxy records could include such things as pollen deposition in alluvium, caves, lakes, and bogs; accumulations of plant remains in packrat nests and middens; tree-ring growth; and cut-and-fill alluvial sequences. The DAP has sought paleoclimatic data from a number of different sources.

Tree-Ring Studies

Two studies (Petersen 1985f, 1985g) provide information on past variations in precipitation and on the occurrence of droughts in the project area. In these documents, Petersen reports on 2 other studies that have proven valuable for the project. The first is a report that uses tree rings to reconstruct inches of rainfall in southwestern Colorado (Rose et al. 1982); unfortunately, this study extends back to only A.D. 909. The second study (Burns 1983) uses tree rings to reconstruct the potential production of bushels of corn per acre in southwestern Colorado. Petersen (1985f) demonstrated the specific applicability of this report to the Dolores Project area.

In Petersen (1984b), a tree-ring record of high elevation bristlecone pine is used to reconstruct periods of short growing seasons that would have critically affected corn production in the project area. The elevation and physiographic setting of the project area is such that short growing seasons are a factor that must be considered when reconstructing past climates that might have been suitable for growing corn.

Packrat Midden Study

Van Devender (1985) reports on the results of analysis of the remains of porcupine and packrat middens recovered from Beaver Trap Shelter (Site 5MT4654). Radiocarbon dates were provided by the University of Texas Radiocarbon Dating Laboratory, Austin, for samples collected from 3 packrat middens (samples dating to approximately A.D. 500, 960, 1050, and 1370) and 1 porcupine midden (sample dating to approximately A.D. 1280). These data provide an inventory of local plants independent of that recorded for archaeological contexts.

Additional Pollen Studies

In addition to pollen samples from DAP archaeological contexts, pollen samples from the marsh in Sagehen Flats (1 km from McPhee Village and the packrat midden location) were processed and analyzed (Petersen 1985b). Pollen changes within a sequence of 3 peat deposits (dating approximately 5500 B.P., A.D. 625, and about A.D. 1730 to the present) complement the data from the packrat midden studies.

INTEGRATION OF CLIMATIC STUDIES

The preliminary report on the climatic reconstruction for the project area (Petersen 1985h) was based on pollen studies from the La Plata Mountains (Petersen 1981); since then, analysis has been done on close interval samples from the La Plata Mountains Beef Pasture pollen locality for the A.D. 500-1150 period (Petersen 1985i). This additional study of the La Plata Mountains pollen sequence has increased the resolution

for summer temperature and winter and summer precipitation reconstruction. It provides a comparative framework for the data from the Sagehen Marsh pollen and sediment sequences, the archaeological pollen samples, the modern pollen rain transect, the packrat midden analysis, and finally, the climatic reconstruction based on tree rings. The following is the most up-to-date climatic reconstruction for the project area.

DOLORES PROJECT AREA CLIMATIC RECONSTRUCTION

Reconstruction from Pollen

The Dolores Project area is located near the modern upper limits of the dry-farming belt (fig. 4.10). Stippling in figure 4.10 shows the distribution of the potential dry-farming belt. Based on where dry farming is successfully practiced today, only a narrow agricultural belt (2010 m [6600 ft] to 2380 m [7800 ft] elevation) is both wet enough (greater than about 360 mm [14 in] annually) and warm enough (greater than 110-day frost-free season) to allow routine dry farming of such crops as corn, beans, and grains (U.S. Department of Agriculture, Soil Conservation Service 1976). Changes in the elevation or width of this belt during prehistoric times would have affected Anasazi farm location just as it would were such changes to occur today.

Generally speaking, reconstruction of the prehistoric elevation and width of the dry-farming belt in the Four Corners region is aided by the knowledge that the climatic factors that can affect horticulture are the same factors that affect natural plant community composition and distribution.

Figure 4.11 is a portion of the Beef Pasture pollen record from the La Plata Mountains in southwestern Colorado. The pollen site is located 30 km east of the Dolores Project area (Petersen and Mehringer 1976; Petersen 1981, 1985i). At 3060 m (10 040 ft) elevation, Beef Pasture is above the ponderosa pine (*Pinus ponderosa*) and the still lower pinyon (*Pinus edulis*) zones, but is within the spruce (*Picea engelmannii*) forest, near the lower border of the forest. This pollen record is especially sensitive to past changes in winter precipitation manifested through changes in the elevation of the lower spruce forest border. Dating control is provided by tree-ring-corrected (Damon et al. 1974) radiocarbon dates. Increases and decreases in the spruce/pine pollen ratio (fig. 4.11) are interpreted as indicating long-term changes in winter precipitation. Because the lower elevational limit of the farming belt in the Four Corners region is in part determined by the amount of winter precipitation, the La Plata Mountains spruce/pine ratio can aid in reconstructing the relative elevation of the lower limit of the dry-farming belt (Petersen 1985j). Petersen (1985e) provides illustrations of the changing width of the farming belt in the project area during the Anasazi occupation.

Figure 4.11 also shows the number of pinyon pine pollen grains that originated in the lowlands surrounding the La Plata Mountains and that were subsequently deposited at the Beef Pasture on a 1-cm^2-surface area during a year's time (annual pollen influx). The influx values are proportional to the number of pinyon trees on the landscape in the lowlands adjacent to the La Plata Mountains (Petersen 1985i).

Natural pinyon pine tree distribution is dependent on summer precipitation (Fritts et al. 1965, Petersen 1981, 1985i; Wells 1979), which is mostly derived from the summer monsoon (Bryson and Lowry 1955; Huntington 1914; Mitchell 1976). Thus, a reconstruction of pinyon pine distribution may also be a reconstruction of the strength of the summer monsoon. Petersen (1985k, 1985i) treats this in more detail, but a summary is provided here. A weak monsoon arrives late in the Four Corners region, does not penetrate as far north in Colorado, leaves early, and produces relatively lower summer precipitation. A strong monsoon, on the other hand, arrives early, penetrates farther north, leaves later, and provides relatively higher levels of summer precipitation. Increased rates of pinyon pine pollen deposition (fig. 4.11) are interpreted as indicating a greater number of pinyon pine trees in southwestern Colorado resulting from higher summer monsoon rainfall. Of course, there is a lag between the establishment of pinyon seedlings and the growth of trees mature enough to produce pollen. In the project area, pinyon trees removed by chaining have been replaced by mature, pollen-producing trees within a couple of decades.

A Local Test of the Dating in Figure 4.11

A deposition curve derived from radiocarbon dates provides the basis for the age assignment of pollen samples in the Beef Pasture pollen core (Petersen 1981, 1985i). That these age assignments be substantiated is critical so the correlations based on the dates will be reliable. In the earlier pollen discussion (sect. 3), a test of the Beef Pasture reconstruction is outlined. It will be briefly reviewed here.

In the Beef Pasture spruce/pine pollen ratios, a ratio less than 0.60 represents winter precipitation less than that of today. During those time periods when ratios are less than 0.60, pollen spectra from archaeological sites that date to the same time period are expected to be characterized by more sagebrush pollen that can be found in pollen spectra from the modern ground surface. This is the case. Also, when paired archaeological

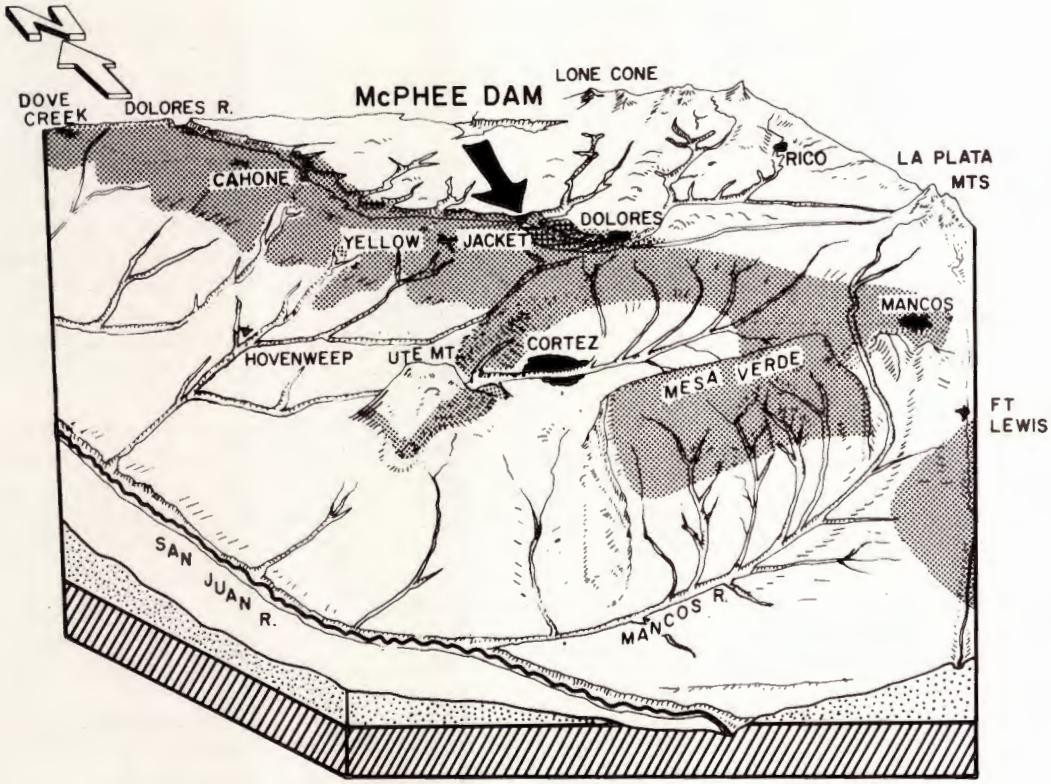

Figure 4.10 – Birds-eye view of modern potential dry-farming belt (stippled), southwestern Colorado. Dolores Project area shown by hatching. Source: Petersen (1985e).

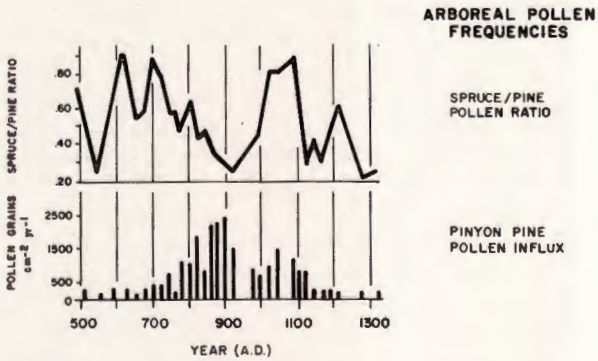

Figure 4.11 – Portion of the Beef Pasture pollen record, La Plata Mountains, southwestern Colorado (Petersen 1981, 1985i, 1985j).

samples have dates that coincide with time periods characterized by Beef Pasture spruce/pine pollen ratio values both greater than and less than 0.60, the direction of the vegetational change indicated by comparing the 2 archaeological pollen spectra is consistent with that predicted by the Beef Pasture climatic reconstruction. The timing of the changes also seems to be within approximately 25 years of that indicated by the Beef Pasture record. Timing on a finer scale is not possible because of the limits of the archaeological dates dependent on ceramics. However, it is reassuring when such dating agreement is demonstrated between the Beef Pasture reconstruction and the archaeological record.

Another independent test of the Beef Pasture chronology can be demonstrated using the pith dates of ponderosa pine (*Pinus ponderosa*) timbers used in construction in the project area. Ponderosa pine seedling establishment usually coincides with springs characterized by higher-than-average precipitation (Bates 1923:158; Schubert 1974:10-18; Minore 1979:10-12). During such springs, a number of seedlings will become established, giving rise to stands of trees very similar in age.

Germination of ponderosa seedlings is inhibited by dry springs. And even when springs may have been wetter than normal, if the winter that follows has less-than-normal snow cover so that deep soil freezing can occur, new seedlings are likely to be killed by frost heave or desiccation. Even older, shallow, rotted trees may be seriously damaged when moisture in their root zone is frozen.

Thus, pith dates for seedling establishment of ponderosa pine would be expected to coincide with times

when the Beef Pasture spruce/pine ratio is greater than 0.60. Figure 4.12 is a histogram plot of pith dates provided the DAP by the Laboratory of Tree-Ring Research, University of Arizona. As can be seen, primary ponderosa seedling establishment occurs coincident with times interpreted to have winter precipitation similar to that of the present. The lack of seedling establishment during drier times is pronounced. This suggests that the dating of the Beef Pasture spruce/pine pollen ratio for those time periods basically seems to be correct.

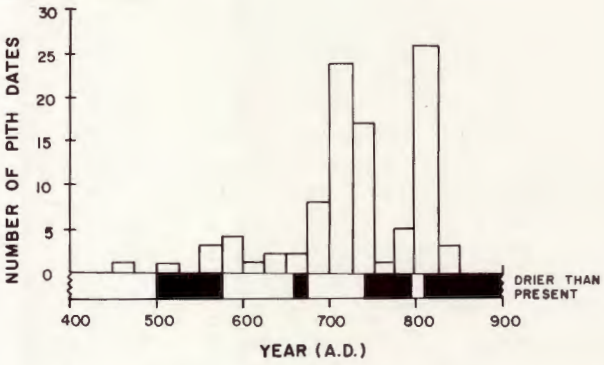

Figure 4.12 – Histogram (25-year groupings) of ponderosa pine pith dates supplied by the Laboratory of Tree-Ring Research, University of Arizona. Total n = 98; obvious duplicates from the same log have been excluded. Solid bars indicate spruce/pine ratios below 0.60 in figure 4.11, which is believed to indicate winter precipitation averaging below that of modern times.

A Regional Test of the Climatic Reconstruction in Figure 4.11

Comparison of the Beef Pasture, La Plata Mountains, reconstruction with the results of other regional pollen and climatic studies shows past changes in interpreted plant community distribution and hydrologic competence that appear to be in concert with one another (fig. 4.13). To allow further evaluation, each curve in figure 4.13 is discussed in turn; the curves are arbitrarily shown in the order originally published.

Comparison of modern pollen ratios and pollen spectra with those from dated alluvial and archaeological sites allowed Schoenwetter (Schoenwetter 1966, 1967, 1970; Schoenwetter and Eddy 1964) to reconstruct an effective moisture curve for the Navajo Reservoir and Chuska Valley areas of the Colorado Plateau (curves A and B, fig. 4.13). Higher arboreal (tree) pollen values are interpreted by Schoenwetter as indicating greater effective moisture.

Schoenwetter's reconstruction is largely mirrored by the hydrologic chronology (curve C, fig. 4.13) presented by Euler et al. (1979:fig. 4). The climatic reconstruction of Euler et al. (1979) is based partly on pollen, soils, and a cut-and-fill alluvial sequence from widely scattered stratigraphic sections at Black Mesa, Arizona. These sections were dated by archaeological markers and radiocarbon dating and were correlated to a tree-ring chronology. Finally, the hydrologic curve was smoothed to fit 2 apparently repeating cycles of different lengths.

Dean et al. (1985:fig. 1A) provide an updated version of figure 4.13, curve C, not reproduced here. The 2 figures are very similar. In the latest version, Dean et al. (1985) indicate the updated hydrologic curve represents fluctuations in alluvial ground water level. The new version also distinguishes between primary and secondary fluctuations; some of each are shown in figure 4.13, curve C.

Dean et al. (1985:fig. 1B) also present another curve that measures effective moisture based on pollen, and

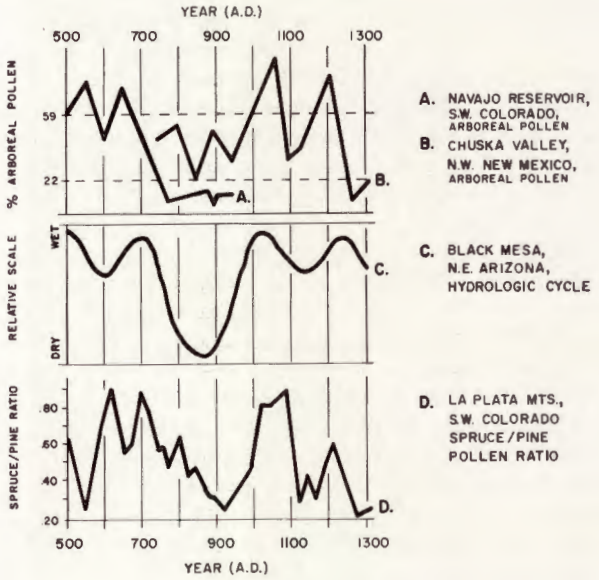

Figure 4.13 – Comparison of Four Corners region paleoenvironmental sequences, A.D. 500-1325.

again a distinction is made between primary and secondary fluctuations. The primary fluctuations in effected moisture based on pollen mirror the primary fluctuations in alluvial ground water level. Euler et al. (1979) and Dean et al. (1985) provide a more detailed discussion of this subject.

Navajo Reservoir, Chuska Valley, and Black Mesa have changes that appear to be synchronous with the Beef Pasture, La Plata Mountains (fig. 4.13). The fact that they were all dated independently adds support to the chronology for the general climatic reconstruction for

the Four Corners region illustrated in figure 4.13. Schoenwetter (1966) was the first to propose this chronology for winter dominant precipitation. He also suggested that the times of low winter precipitation were offset by increased summer precipitation. Support for this relationship is found in the La Plata Mountains record (fig. 4.11).

The History of the Dry-Farming Belt

The following climatic correlates for the DAP area are derived from figure 4.11. The A.D. 800-1000 and A.D. 1110-1325 periods are dry and are characterized by relatively low winter (jet-stream-derived) precipitation. (The A.D. 1110 date is based on tree-ring dating, which will be discussed below). The A.D. 575-800 and A.D. 1000-1110 periods are characterized by relatively higher winter precipitation, much like the present. The A.D. 750-900 period shows increasing summer (monsoon-derived) precipitation that compensates for the decrease in winter precipitation during the same time period. The A.D. 900-1000 period shows the reverse: decreasing summer rainfall that is offset by increasing winter precipitation. The A.D. 1000-1110 period shows increases in both summer and winter precipitation; and, the A.D. 1110-1325 period shows relatively lower precipitation for both summer and winter.

Radiocarbon-dated pollen spectra from marsh sediments in the Dolores Project area suggest the vegetation and climate of the A.D. 600's was similar to the early part of the 20th century prior to clearing of native vegetation for farming (Petersen 1985b). Based on that similarity, figure 4.14 was constructed to show the distribution of the potential dry-farming belt for the A.D. 575-800 period. Figure 4.15 shows the vegetation for the project area for the same time period. Figure 4.15 reconstructs Dolores area vegetation circa A.D. 1920, prior to the extensive clearing of natural vegetation for modern farming. Refer to Petersen (1984a, 1985a) for a more complete discussion of the development of this vegetation map.

As judged by figure 4.11, the A.D. 800's must have been relatively drier than both the A.D. 600's and the early part of this century. Therefore, the lower boundary of the dry-farming belt in the A.D. 800's was probably at a relatively greater elevation than at present. As evidenced by the estimated population levels in the project area during the A.D. 800's (Schlanger, chap. 8), the area was still located within the dry-farming belt. During the A.D. 800 to 1000 period, then, the dry-farming belt in southwestern Colorado and adjacent areas probably was narrower than either the preceding or succeeding periods. Figure 4.16 is the reconstructed distribution of the potential dry-farming belt during this time.

During the A.D. 800's, the Dolores Project area would have been relatively more attractive for dry farming than areas lower in elevation that had been farmed prior to the A.D. 800's but that had been left below the potential dry-farming belt with the drying conditions of the A.D. 800's.

Figure 4.17 is the reconstructed vegetation within the project area for the A.D. 800-1000 period under conditions relatively drier than those at present. Refer to Petersen (1985a) for a more complete discussion of the development of this figure and to section 3, this chapter, for an evaluation of that reconstruction. This reconstruction does not take into account the possible impact the Anasazi may have had on the landscape through clearing for farming. Refer to Petersen et al. (1985) for a more complete discussion of that factor.

Although the A.D. 800-1000 period is believed to have had lower winter precipitation than at present, this may have been offset by the high summer precipitation (fig. 4.11). In the Four Corners region, Petersen (1985k) has found that summer precipitation tends to be more concentrated within the dry-farming belt than in elevations below it. Thus, even during a time period when summer rainfall is high, only areas above certain elevations would be expected to benefit.

During the next period, A.D. 1000 to 1110, the Beef Pasture spruce/pine ratio (fig. 4.11) again reaches values similar to some reached prior to A.D. 800. Using the spruce/pine ratio alone, the farming belt would be expected to be as wide as the modern farming belt. However, summer rainfall is judged to be higher during the A.D. 1000-1110 period than during the period prior to A.D. 800. This should result in a higher annual total. Petersen (1985e) has shown that rather than being linear, the increase of precipitation with increasing elevation is actually curvilinear in southwestern Colorado. Weather stations between 1520 m (5000 ft) and 1980 m (6500 ft) all receive about 310 mm (12 in) of precipitation/year. If annual precipitation were to increase at all stations by 50 to 100 mm (2 to 4 in), a very large area that is too dry at present would become available for dry farming.

Archaeological pollen spectra from the project area that date between A.D. 900 and 1000 show increasing arboreal pollen percentages up to levels greater than the present, which suggests the farming belt also may have been becoming wider than the present during that time (sect. 3). Figure 4.18 illustrates the reconstructed dry-farming belt for the A.D. 1000-1110 period; it is much wider than at present.

With a widening dry-farming belt in the region beginning after A.D. 900, the project area would again occupy a more marginal position near the upper

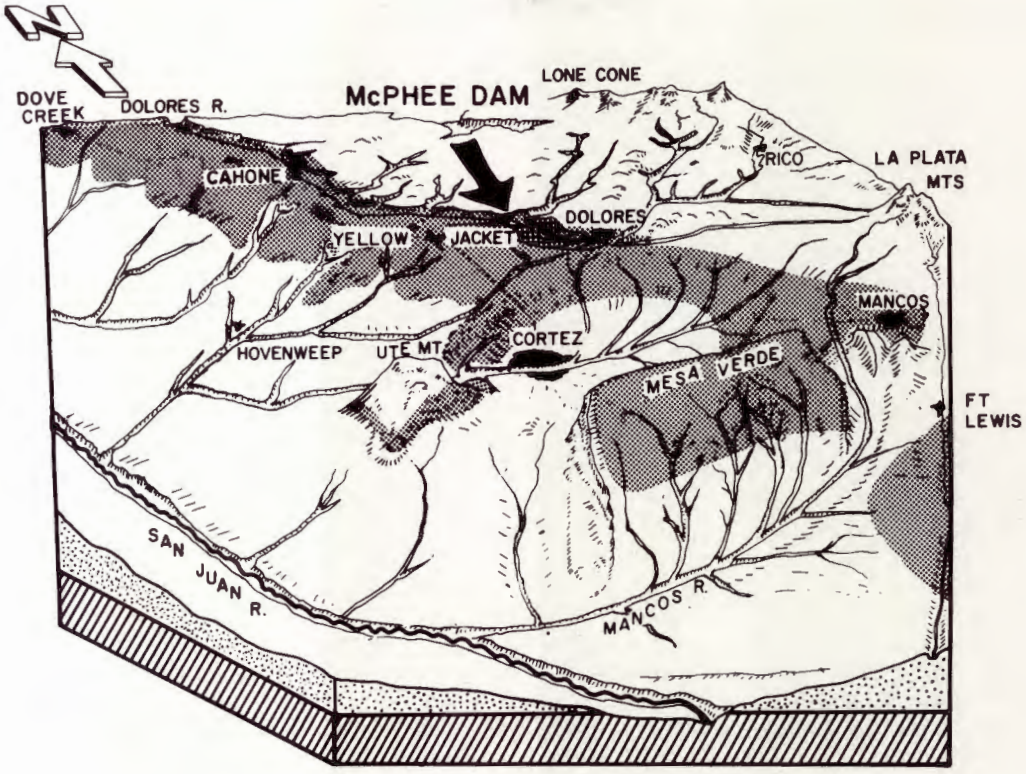

Figure 4.14 – Birds-eye view of the reconstructed potential dry-farming belt, A.D. 575-800, southwestern Colorado.

elevational limit of the potential dry-farming belt. Since the upper limit of the belt is determined by the length of the growing season, the project area may have been subject to more frequent occurrences of short growing season than lower elevation areas within the belt. Thus, the center of the potential dry-farming belt might have been relatively more attractive than either the upper or lower margins.

The A.D. 1110-1275 period is characterized as having relatively less winter and summer precipitation (fig. 4.11). However, it is unlike the prior 3 periods just discussed. Even though it has a spruce/pine ratio similar to that for the A.D. 800's, it does not have as much summer rainfall. Because of the relatively lower winter and summer precipitation, a narrower dry-farming belt is illustrated in figure 4.19. However, farming that was strictly dependent on summer rainfall within the dry-farming belt in the A.D. 1110-1275 period may have been relatively more risky than farming during the A.D. 800's.

To compensate for the greater risk associated with less dependable summer rains within a narrow dry-farming belt, farming practices might have become more diversified after A.D. 1100 than they were during the A.D. 800's. The relative attractiveness of the entire dry-farming belt in general and the project area in particular might not have been as high after A.D. 1100 as it had been during the A.D. 800's.

Climatic Reconstruction from Tree Rings

The changes in figure 4.11 are long-term, low-frequency fluctuations. They reflect effective moisture changes of a duration that allowed plant migration, establishment, and pollen production. However, short-term, higher-frequency changes on the order of individual years or decades are not evident in such a record, and such changes were probably more critical for prehistoric farmers growing corn and other crops. Tree rings have been used elsewhere to provide such short-term, high-frequency records (e.g., Euler et al. 1979; Dean and Robinson 1982; Dean et al. 1985; Rose et al. 1981).

Euler et al. (1979:1094) note that periodicities of greater than 100 years are not seen in archaeological tree-ring data because of the sampling limitations and because the mathematical transformations of ring widths and indices tend to suppress low-frequency variability. Recognizing the difference in their long- and short-term

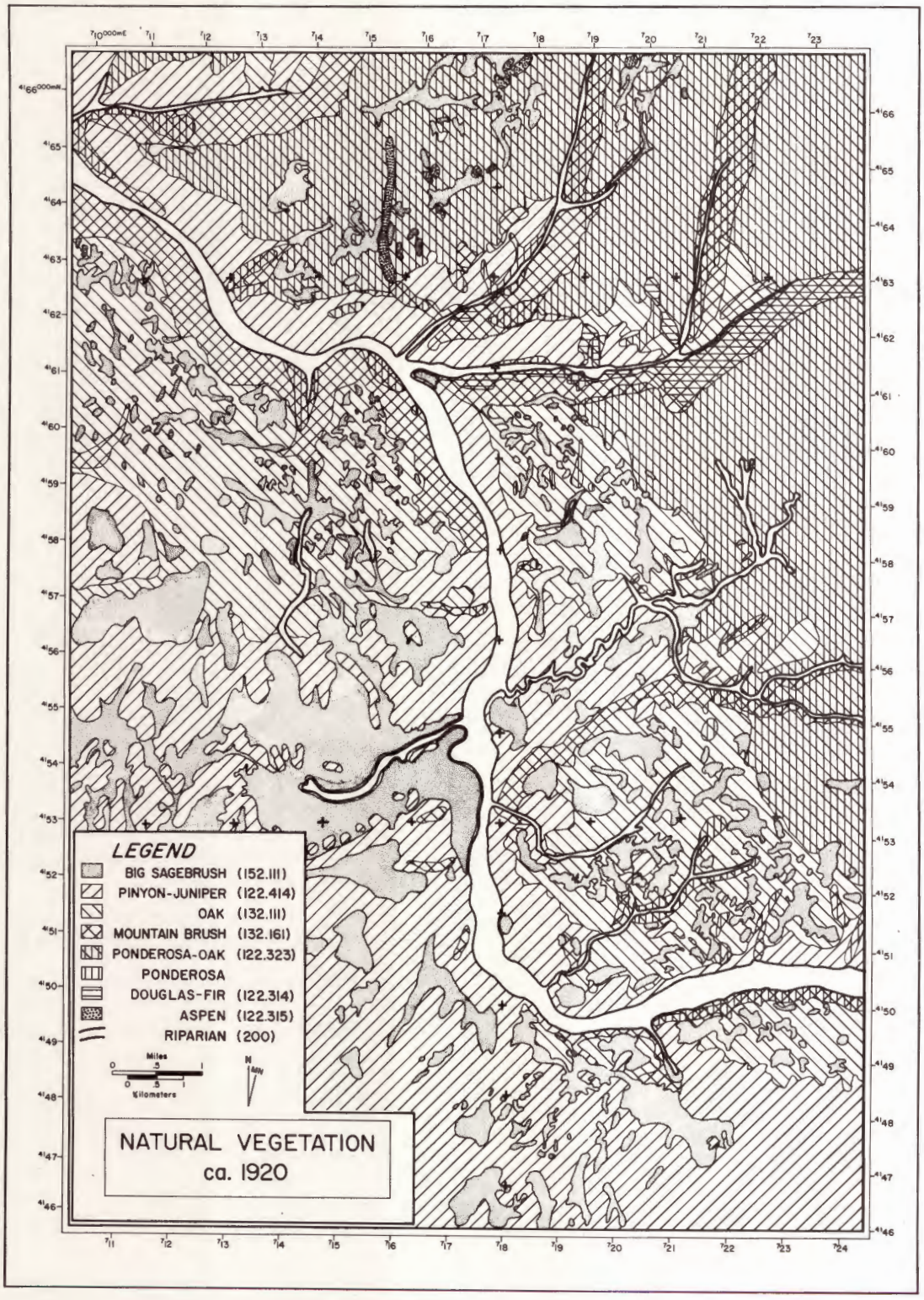

Figure 4.15 – Vegetation of the project area ca. A.D. 1920. Map is also believed to represent fairly well the vegetation in the project area for the A.D. 575-800 period. Source: Petersen (1985a:fig. 1). Refer also to Petersen (1984a). Numbers in parentheses refer to Brown's (1982) classification.

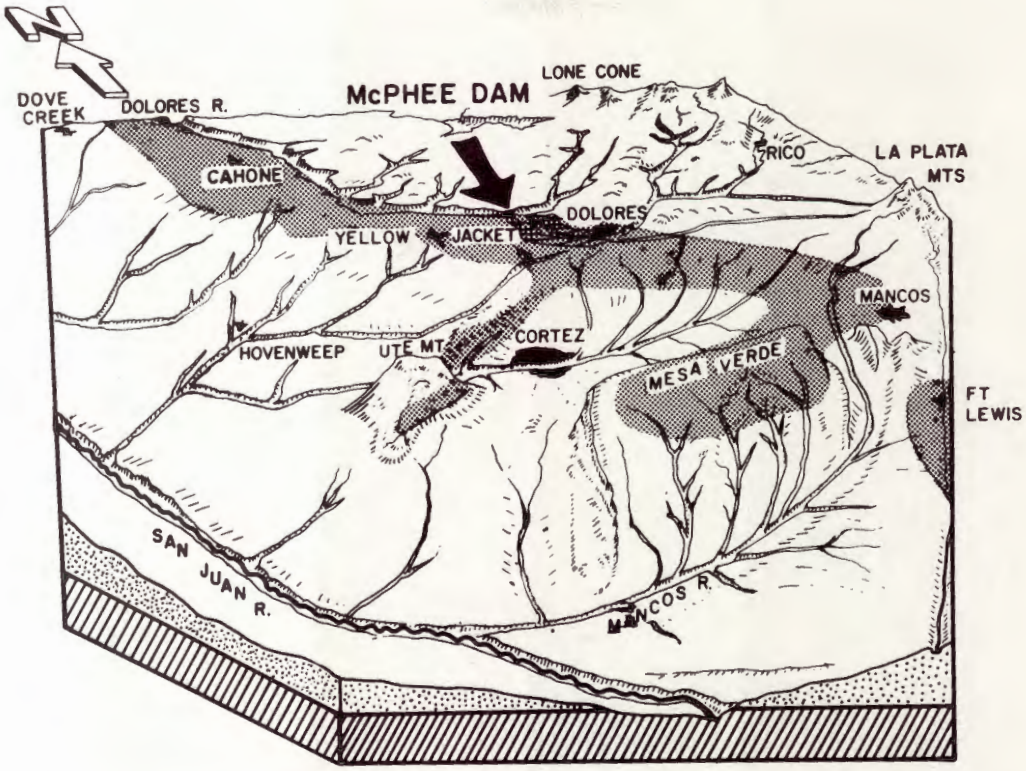

Figure 4.16 – Birds-eye view of the reconstructed potential dry-farming belt, A.D. 800-1000, southwestern Colorado.

records of variability at Black Mesa, Euler et al. (1979:fig. 5, column 1) superposed their 10-year tree-ring-departure sequence on their regional hydrological curve (fig. 4.13, curve C). In the Black Mesa report (Euler et al. 1979), tree-ring and pollen ratios were visually superposed; here, the records will simply be discussed. Dean et al. (1985) also chose not to superpose long- and short-term records.

The University of Arizona Laboratory of Tree-Ring Research provided the DAP with a tree-ring chronology from A.D. 371 to 1136 derived from mixed species analyzed from the archaeological samples obtained from the Dolores Project area (Petersen 1985f). An additional tree-ring record from high-elevation trees was also sought because LaMarche (1974) has demonstrated that in addition to a tree-ring chronology from the lower forest border used to reconstruct relative dry conditions, a tree-ring chronology from the upper treeline can be used to reconstruct a complementary record of relative summer warmth. The closest high-elevation record long enough to cover the time period of Anasazi occupation is from bristlecone pine (*Pinus aristata*) from Almagre Mountain, near Pikes Peak in central Colorado (fig. 4.9) (Drew 1974; LaMarche and Stockton 1974). The following reconstruction is based on this high elevation tree-ring record. Sample depth (number of tree-ring samples used for analysis) from this area for the time period that coincided with Anasazi occupation in the project area is not very great. In addition, rigorous calibration techniques developed by the Laboratory of Tree-Ring Research at the University of Arizona (Fritts 1976) were not used in this study. The reconstruction, therefore, remains a tentative one that needs to be tested further by comparison with future high-elevation bristlecone pine records and by comparison with other independently derived climatic reconstructions.

Historic killing-frost-free periods for the Dolores area (average 130 days) were calibrated to the Almagre Mountain record. Visual inspection of plots of the data from both areas suggests the correlation between the 2 areas is reasonably good (Petersen 1984b). Figure 4.20 plots the Almagre Mountain indices. All points are successive 10-year means plotted on the midpoints. A decade that averages less than an index of 0.90 in the Almagre Mountain sequence (solid line, fig. 4.20) had an average killing frost-free period in the Dolores area of less than 110 days (Petersen 1984b). A growing season of less than 110 days (solid bars, fig. 4.20) is too short to reliably grow mature aboriginal varieties of corn to maturity (Bradfield 1971: 6; Hack 1942:20, 23). Refer to Petersen and Clay (1984) for a more complete discussion.

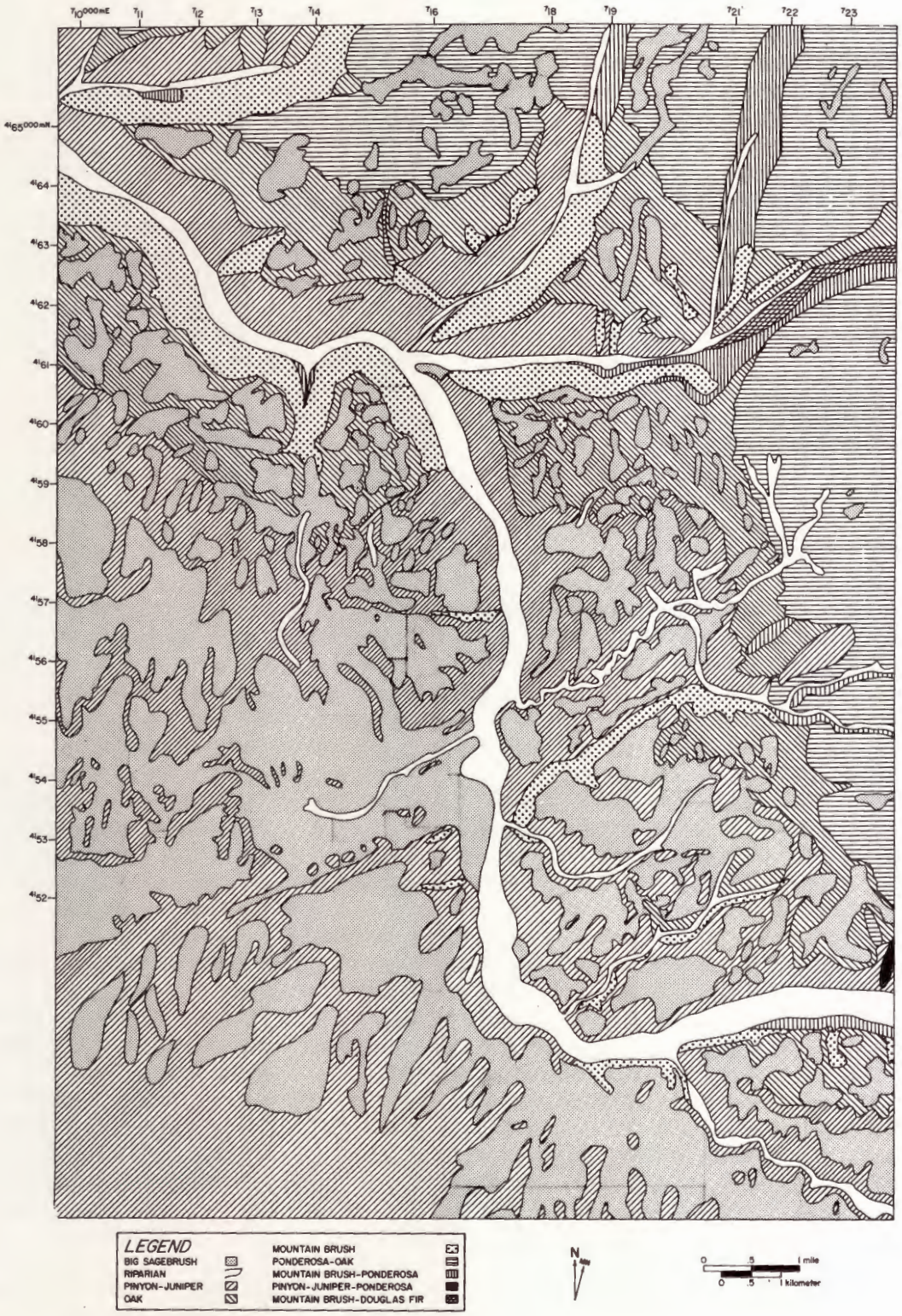

Figure 4.17 – Vegetation reconstruction for the Dolores project area, A.D. 800-1000. Source: Petersen (1985a:fig. 10). Note that the stippling and hatching conventions differ slightly from those used in figure 4.15.

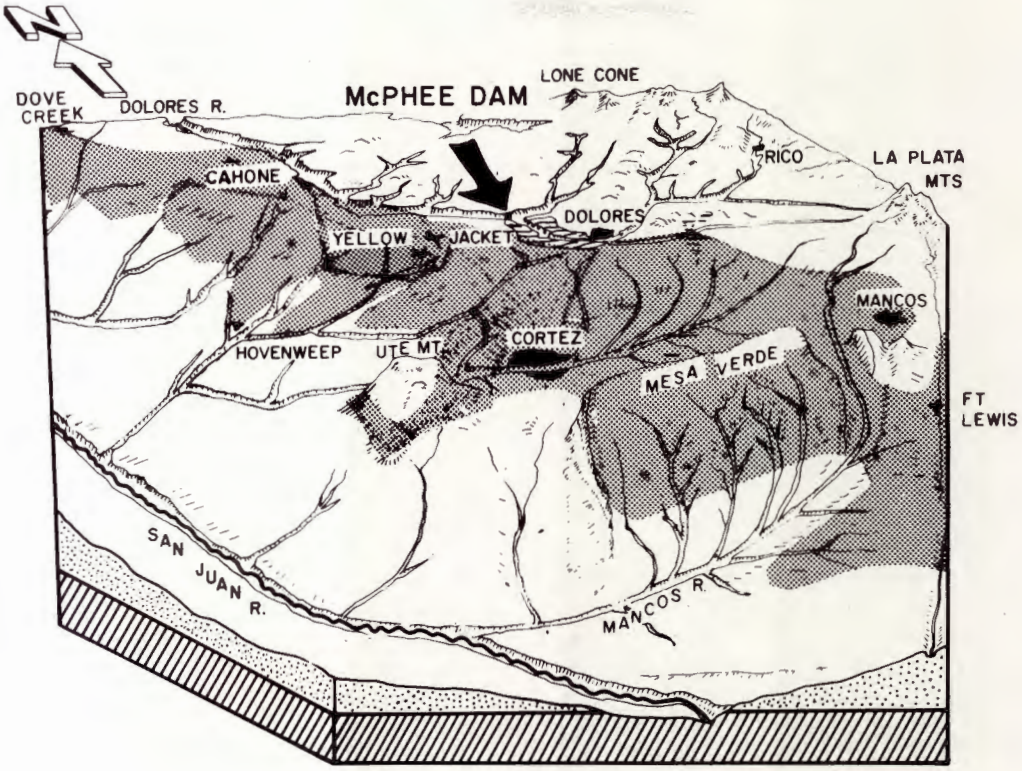

Figure 4.18 – Birds-eye view of the reconstructed potential dry-farming belt, A.D. 1000-1110, southwestern Colorado.

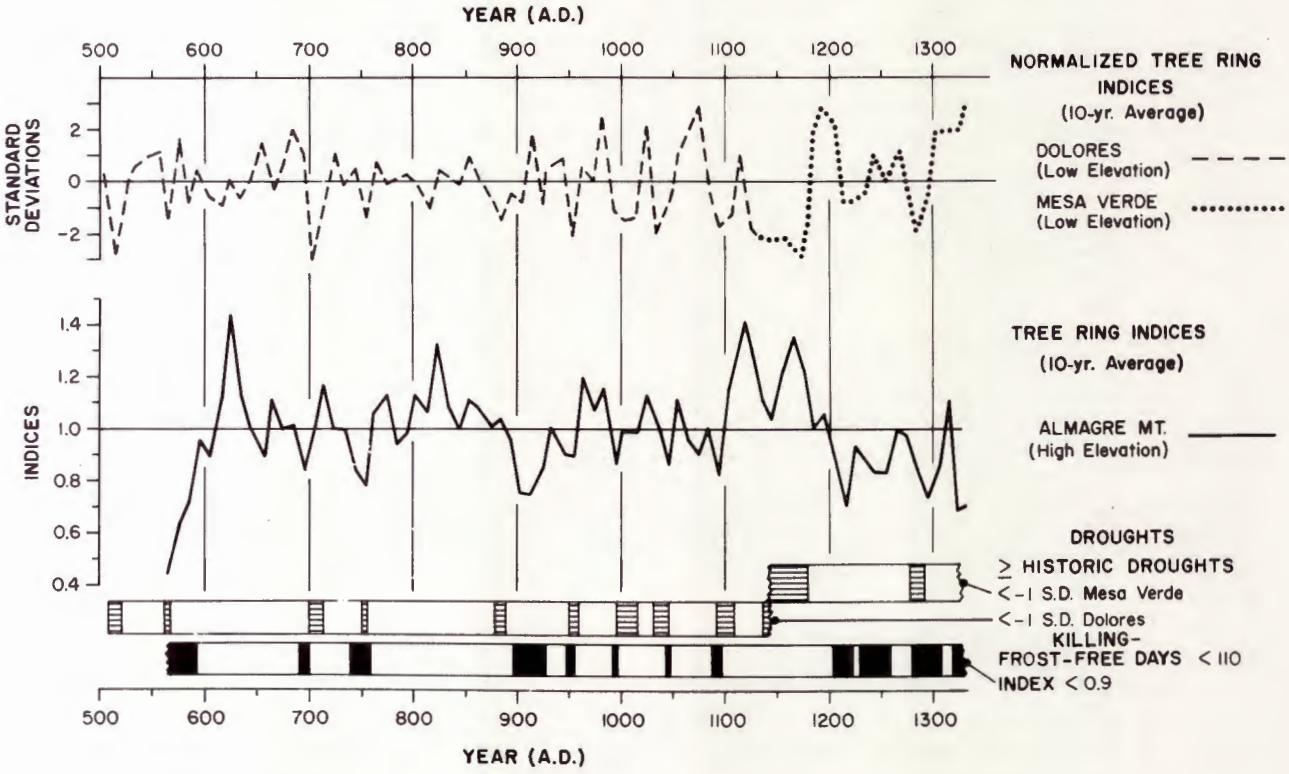

Figure 4.19 – Birds-eye view of the reconstructed potential dry-farming belt, A.D. 1110-1275, southwestern Colorado.

The Dolores tree-ring sequence is shown by a dashed line in figure 4.20. Normalization of the 10-year mean departures follows Dean and Robinson (1982). Each ring index was converted to a standard variate (mean equal to zero, and the standard deviation equal to 1). Because of the small sample size (n=10), the variates for the decade were multiplied by a constant [$10(n^{0.5})$] and the results summed algebraically and divided by 10n.

The Dolores chronology only extends up to A.D. 1136. However, the Dolores chronology correlates well with that of Mesa Verde (Robinson 1983). Therefore, the Mesa Verde chronology (dotted line, fig., 4.20), which contains samples collected from both archaeological and living Douglas-fir (*Pseudotsuga menziesii*) trees, was used to extend the record between A.D. 1140 and 1325 (Dean and Robinson 1977, 1978) and for modern calibration (Petersen 1985f). Decades that depart more than one negative standard deviation (lined bars, fig. 4.20) are decades that were as dry or drier than any of the historic droughts for the region (i.e., A.D. 1894-1904, A.D. 1924-1934, and A.D. 1946-1957 [Barry and Bradley 1976:fig. 10]).

Droughts and Short Growing Seasons in the Dolores Area

While figure 4.11 provides a way to reconstruct the relative low-frequency changes in the elevation of the lower boundary of the dry-farming belt (Petersen 1985e), the changes in figure 4.20 show high-frequency changes affecting potential corn production *within* the dry-farming belt. Reconstructed droughts would be most critical at the lower elevations within the dry-farming belt (Petersen 1985f, 1985g), whereas reconstructed shortened growing seasons would be most critical at higher elevations within the dry-farming belt and other areas subject to the affects of cold air drainage (Petersen 1984b; Petersen and Clay 1984).

Droughts in the project area occurred only once between A.D. 575 and about A.D. 875 (i.e., about A.D. 700), but numerous times between A.D. 875 and 1175 (fig. 4.20). Droughts would be expected to stress the Dolores Anasazi; however, due to the higher annual precipitation of the Dolores area (the result of its greater elevation and proximity to the La Plata and San Juan Mountains to the east and north), it would be relatively more attractive to people living in areas lower in elevation.

Between A.D. 550 and 600 (the most severe period shown in figure 4.20), the Dolores area had killing-frost-free periods too short for growing corn. The A.D. 600's, the late A.D. 700's through the A.D. 800's, and the A.D. 1100's were periods when all decades averaged growing seasons greater than 110 days.

During the late A.D. 700's through the A.D. 800's, when population was growing rapidly in the Dolores area (Dolores Archaeological Program 1984), there seems to have been a few constraints from either short growing seasons or lengthy droughts. A combination of drought followed by a period of short growing seasons beginning about A.D. 875 and ending approximately A.D. 950 is evident in figure 4.20. Droughts would possibly make the project area more attractive, while short growing seasons would tend to make it less attractive. The impact of short growing season within the project area will be examined in greater detail next.

To allow testing of a processual model of cultural change within the project area (Lipe 1984; also, chaps. 1 and 6, this volume), the Anasazi occupation was divided into a series of periods. These periods were established using tree-ring-dated ceramic assemblages (Blinman 1984; chap. 1). Figure 4.21 shows the Almagre tree-ring record for the span of time having the greatest amount of archaeological data from the project area. Also shown is the time covered by the various periods and subperiods. Decades that average killing-frost-free periods of less than 110 days are shown by black bars.

Figure 4.22 shows a map of frost-free periods within the project area under modern conditions (Petersen and Clay 1984:fig. 12). The canyon bottom and relatively level uplands above 2380 m (7800 ft) have growing seasons too short for growing corn. Shallow drainages are at times subject to inversion layers making farming more risky, but during years when the inversions are not deep or generally are infrequent, then corn could be successfully grown.

Figure 4.23 shows a map believed to represent the distribution of frost-free periods within the project area during the time periods represented by the black bars in figure 4.21. Under these conditions, the shallow drainages are believed to also have had growing seasons less than 90 days. The uplands are believed to have had growing seasons greater than 90 days, but at times they were risky for growing corn.

Comparison of figures 4.22 and 4.23 suggests a dramatic loss of land if growing seasons are shortened appreciably in the project area. The later parts of subperiods 1.2 and 2.1, all of 5.2, and the early portion of 6.2 are times of shortened growing seasons and possibly were subject to changes that could be detected in the archaeological record.

Relative Attractiveness and Abandonment of the Dolores Area

Figure 4.24 is a summary of the major factors that would have affected the attractiveness of the Dolores

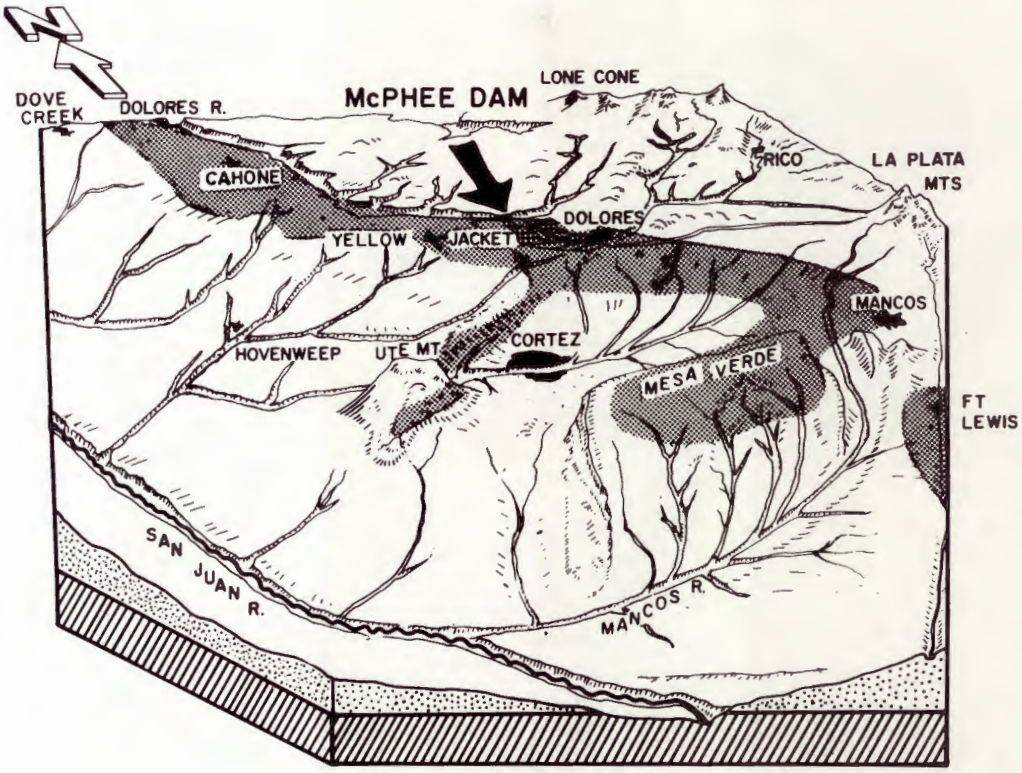

Figure 4.20 – Paleoenvironmental reconstruction for the Dolores Project area based on low- and high-elevation tree-ring records, A.D. 500-1325.

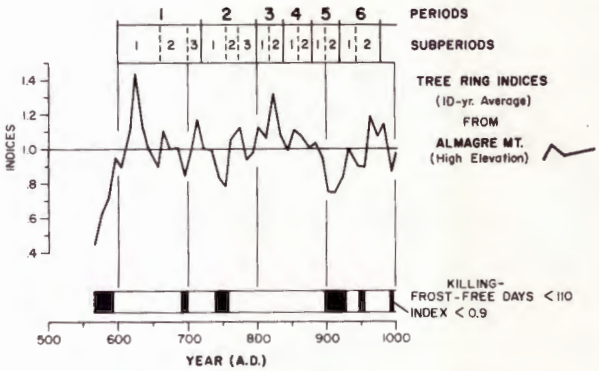

Figure 4.21 – Reconstructed killing-frost-free periods and Dolores Archaeological Program archaeological periods and subperiods for the project area up to A.D. 1000.

Project area relative to adjacent areas. Droughts would make the project area relatively more attractive to people living in lower areas. Because frosts are considered to have a greater impact in the project area, short growing seasons rather than droughts have been included in this evaluation. A plus and minus system is employed, with a plus indicating greater attractiveness, and a minus indicating lesser attractiveness. More detail is shown in the subperiod breakdown in table 4.43. Neutral (0) is applied to that portion of the record believed to be most like the present, based on the Sagehen Marsh pollen studies.

Coincident with the large population increase in the project area during the A.D. 800's, the project area is relatively most attractive. A combination of drought followed by a period of short growing seasons beginning about A.D. 875 and lasting until roughly A.D. 950 seems to have been too much for the inhabitants of the Dolores Project area (fig. 4.20). A large population decline occurred and the Dolores River valley was abandoned. Possibly the areas west and south of the project area were relatively more attractive because they were less affected by the occurrence of the short growing seasons common after A.D. 900.

Figure 4.24 indicates that about A.D. 1200 summer temperatures became cooler (growing seasons shorter) than those at present. During the A.D. 1275-1300 "great drought" (fig. 4.20), the potential dry-farming belt in the Four Corners region may well have been pinched out due to relatively less winter and summer precipitation affecting the bottom of the belt, and shorter growing season affecting the top (fig. 4.25). It was during and immediately after this "cold drought"

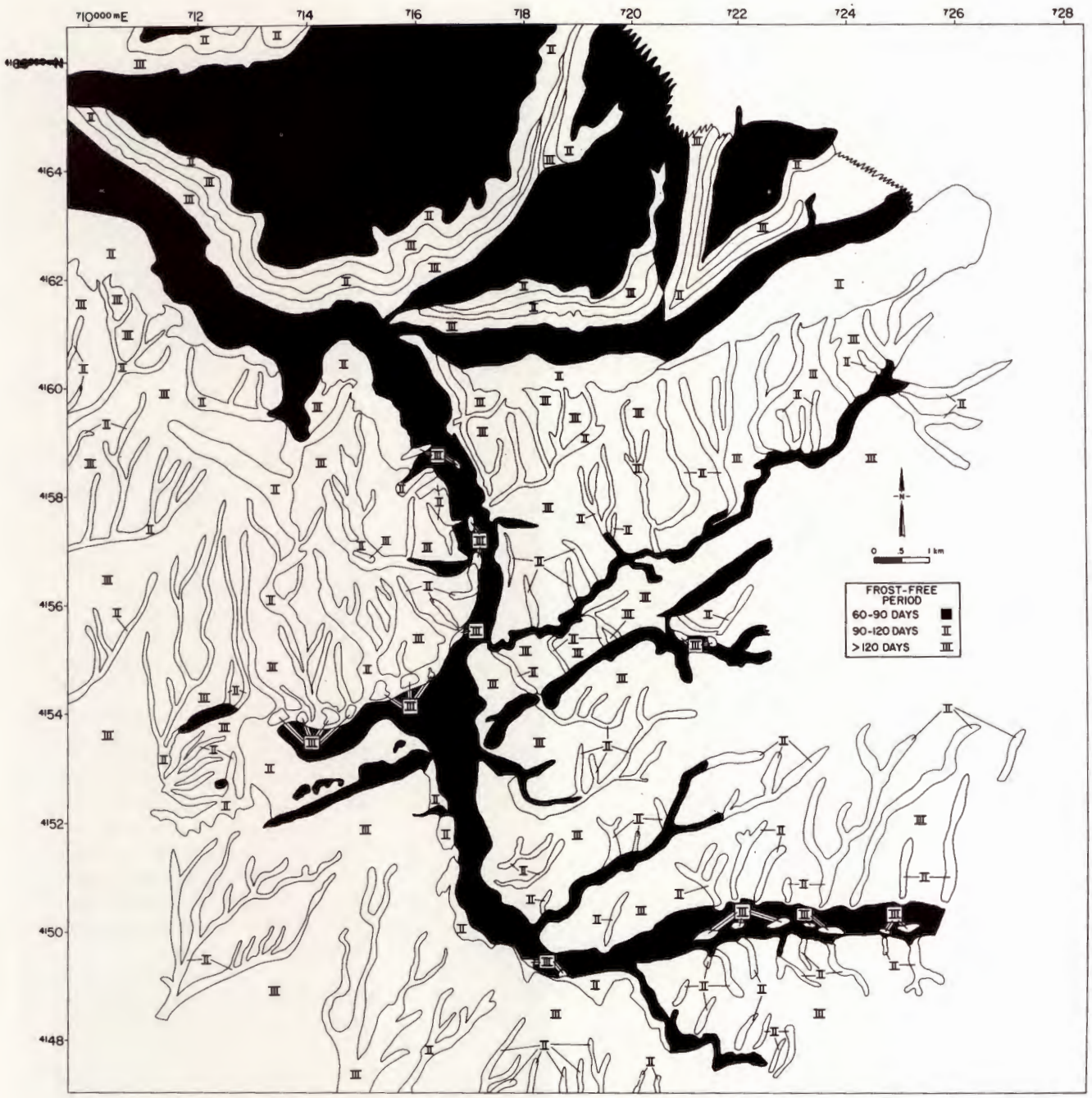

Figure 4.22 – Distribution map of killing-frost-free period length in the Dolores Project area under modern conditions and during times when growing seasons average more than 110 days in figure 4.21 (adapted from Petersen and Clay 1984:fig. 12).

that final regional abandonment seems to have occurred. The risk of farming failure during the early A.D. 900's and the late A.D. 1200's probably was further compounded by the reduction of summer rainfall during the early 10th century (fig. 4.24), and by the much-reduced level of summer rainfall during the late 13th century, as measured by pinyon pine pollen influx.

The factors that contributed to the 13th-century abandonment of a large portion of the Colorado Plateau have been the topic of considerable debate (Euler et al. [1979]). The results of the Dolores Project study suggest changes in the width of the dry-farming belt, the amount and dependability of summer rain, and the growing season length were critical in southwestern Col-

orado for cultures dependent upon corn and other crops for subsistence.

Section 7

OVERVIEW AND CONCLUSIONS

Kenneth Lee Petersen

MACROBOTANICAL DATA

Matthews (section 2) summarizes the macrobotanical data base as it applies to Problem Domain 1 (Economy and Adaptation) and Problem Domain 5 (Cultural Process) of the general research design. These 2 topics are addressed in terms of potential availability of botanical resources, the actual resource mix used, and the changes in mix through time. Available resources are assessed by using information collected during a modern vegetation reconnaissance. Evidence for the mix of botanical resources used is provided by macrobotanical remains recovered from excavated sites. Matthews notes, however, that an accurate reconstruction of the resource mix cannot be ascertained, because factors such as preservation and sampling bias have altered the archaeological record and the representation of macrobotanical remains. Change in the resource mix is evaluated through expectations generated by a model of agricultural intensification.

Four groups of botanical resources are discussed: cultigens and pioneer, wild, and woody plants. Except for the occurrence of domesticated plants and modern contaminants, all other plants identified in the macrobotanical assemblage could have been indigenous to the DAP area, although not all of them were documented in the present-day vegetation communities of the project area. The predominance of an agricultural subsistence base is believed to have been influential in altering the natural environment of the project area and in directing the composition of the resource mix. Therefore, change in the agricultural system would have had an impact on the resource mix, and consequently, change in the mix should be reflected in the compositions of the different plant categories.

Zea mays is both ubiquitous and the most abundant domesticate represented. *Phaselous vulgaris*, the only species of bean represented in the assemblage, is also ubiquitous but not as consistently abundant. Remains of *Cucurbita* sp., *C. pepo*, and *Lagenaria siceraria* occur sporadically and only in low quantities. The genera within the cucurbit family probably were more important than their minimal presence in the macrobotanical assemblage tends to indicate, although Matthews also suggests that the deteriorating climatic conditions reconstructed by Petersen (sect. 6) would have had deleterious effects on the reproductive success of cucurbits. The intensive analyses of *Zea mays* cobs indicates 12-row maize was the most abundantly represented type of maize in all time periods. However, analytical methods are not considered sophisticated enough to allow definition of distinct varieties or races of maize within the assemblage.

Matthews believes that changing representation of pioneer plant remains in the macrobotanical assemblage is the result of an agricultural intensification strategy being pursued during Periods 4 and 5 (A.D. 840-920). Based on a subsample of the assemblage, the data indicate that pioneer plant procurement also intensifies. Matthews argues that part of the intensification process could entail a multiple-cropping system, intercropping domesticates, and selection of particular genera of pioneer plants. Ubiquity measures support the argument that seven genera of pioneer plants were preferred resources.

The evidence of change in wild plant resources is ambiguous. Although abundance, diversity, and ubiquity measures do fluctuate to varing degrees over time, bias introduced by differential preservation, collection techniques, and small sample size hinders accurate assessment of the role played by wild plant resources throughout the Dolores Anasazi sequence.

The category of woody remains has not been given adequate attention, and data interpretation suffers from biases incurred through field methods. Earlier reports (Kohler et al. 1984; Kohler and Matthews 1984) suggested a model of wood resource depletion that does find some support in the macrobotanical data but needs to be more vigorously tested. The present study shows a correlation between site location and the taxa of wood used for construction posts.

The macrobotanical assemblage in general reflects a certain amount of diachronic consistency in the resource mix. This is the result of an agricultural subsistence base being maintained throughout all the time periods under investigation. The most noticeable change in the resource mix is evident for corn and pioneer plant resources, which not only reflect increased disturbance to the environment as the result of agricultural practices, but also indicate a change in procurement strategy, possibly as a result of agricultural intensification.

POLLEN DATA

Pollen samples were collected to obtain information concerning potential economic resources that could

Figure 4.23 – Distribution map of killing-frost-free period length in the Dolores Project area during times when growing seasons average less than 110 days in figure 4.21 (adapted from Petersen and Clay 1984:fig. 12).

have been used by the Dolores Anasazi and to gain information on the prehistoric environment. Because archaeological pollen samples often can be dated to within 25 years of the deposition of the pollen due to their archaeological associations, they provide a relatively precise chronological tool for reconstructing past changes in the local environment. Distinguishing changes due to the influence of humans versus that caused by climate has been particularly difficult, but DAP pollen analysis has made some progress in this area.

Petersen (sect. 3) lists pollen taxa or types identified in the analyzed DAP samples. Pollen types representing plants that potentially could have been used for food also are indicated. Although pollen grains originally are

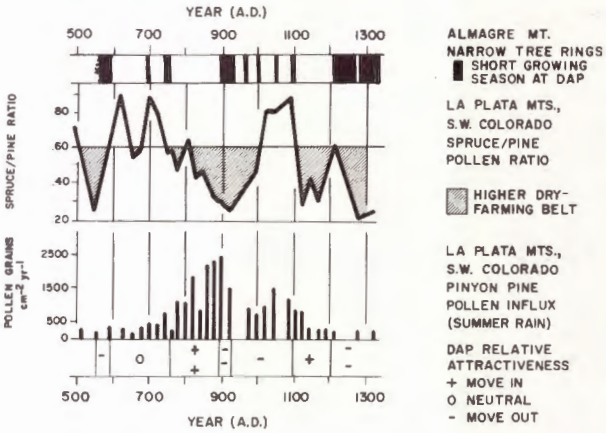

Figure 4.24 – Summary figure showing the combined records used to reconstruct the relative attractiveness of the Dolores Project area to areas lower in elevation.

derived from plants, the deposition may or may not be related to the plant being present at the archaeological site. Macrobotanical remains provide complementary and more specific evidence for plant use by the Anasazi.

Some coprolites collected from Singing Shelter (Site 5MT4683) were analyzed for pollen. The pollen analysis complemented the macrobotanical analysis but added little additional about dietary components.

Pollen analysis of closely spaced samples from both floor and above-floor sediments of Pitstructure 1 and from floor sediments of Pitstructure 2 at Windy Wheat Hamlet (Site 5MT4644) gave clear evidence that the distribution of pollen was patterned. The macrobotanical remains also showed patterning and some corroboration for the pollen patterns. A table is presented that shows the ubiquity of certain economic pollen types in the Windy Wheat Hamlet samples that had sufficient pollen for analysis. Petersen concludes much can be said if rare economic pollen types are identified (especially in large frequencies), but the fact that such types are not tallied may only be a function of small sample size. A large sample size increases the chance of identifying the rarer economic pollen types. On the other hand, many samples from a single floor should be averaged together to obtain a representative picture of the regional pollen rain. Such averaging tends to reduce the bias of economic pollen types.

Zea and *Cleome* pollen can be identified easily and their presence in an archaeological site can be attributed to the fact that the plants were also there. The same argument is made at Windy Wheat Hamlet for Umbelliferae pollen because of the ubiquity of this pollen type. Although Umbelliferae pollen occasionally occurs in natural pollen rain, *Cleome* almost never does, and the high ubiquity of both suggests that these plants, while in flower, might have been stored hanging from the rafters of the pitstructures at Windy Wheat Hamlet in a fashion similar to that observed at modern pueblos.

Table 4.43 – Relative attractiveness of the Dolores area, by modeling period and subperiod

Dolores Archaeological Program modeling periods	Relative attractiveness
Period 1 – A.D. 600-720	0
1.1 – A.D. 600-660	0
1.2 – A.D. 660-700	-
1.3 – A.D. 700-720	0
Period 2 – A.D. 720-800	+
2.1 – A.D. 720-760	-
2.2 – A.D. 760-780	++
2.3 – A.D. 780-800	++
Period 3 – A.D. 800-840	++
3.1 – A.D. 800-820	++
3.2 – A.D. 820-840	++
Period 4 – A.D. 840-880	++
4.1 – A.D. 840-860	++
4.2 – A.D. 860-880	++
Period 5 – A.D. 880-920	0
5.1 – A.D. 880-900	++
5.2 – A.D. 900-920	--
Period 6 – A.D. 920-980	0
6.1 – A.D. 920-940	+
6.2 – A.D. 940-980	-
Period 7 – A.D. 980-1250	-
7.1 – A.D. 980-1025	-
7.2 – A.D. 1025-1100	-
7.3 – A.D. 1100-1175	+
7.4 – A.D. 1175-1250	--

0 – Average attractiveness similar to today.
\+ – Greater attractiveness.
\- – Lesser attractiveness.

The ubiquity of *Zea* and *Cleome* pollen was examined through time to see if any changes could be detected. *Zea* occurred in about 45 percent of the 501 samples examined, while *Cleome* occurred in roughly 84 percent. A significant decrease in the ubiquity of *Zea* was noted between the Grass Mesa and Cline Subphases; the decrease in *Zea* ubiquity coincides with a time in the A.D. 900's when Petersen (sect. 6) reconstructs that corn farming was more risky in the project area. Because there was not a similar decrease in *Cleome* ubiquity, this suggests that the decrease in the ubiquity of *Zea* pollen is real and not just an artifact of sampling.

Two pollen projects were undertaken specifically to attempt reconstruction of the climate within the project. The first was pollen analysis of the marsh in Sagehen Flats. The pollen record proved discontinuous, and only some marsh sediments that radiocarbon dated to the

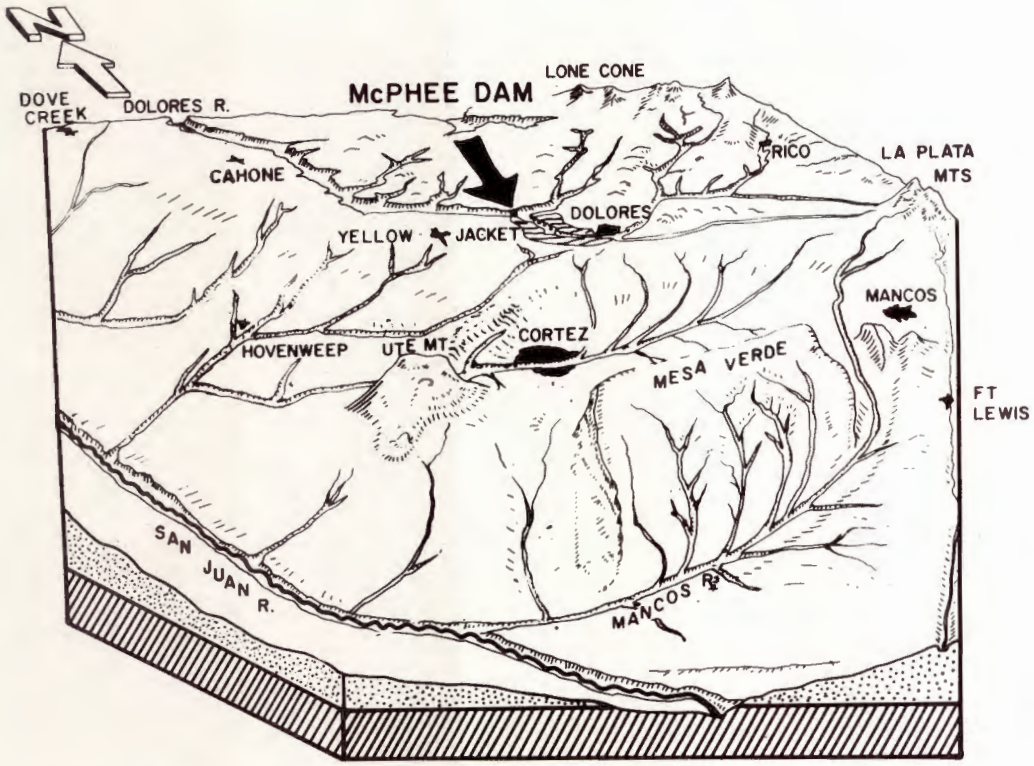

Figure 4.25 – Birds-eye view of the project area, A.D. 1275-1300. No potential dry-farming belt is believed to be present in southwestern Colorado.

A.D. 600's could be analyzed to give information on climate during a portion of the Anasazi occupation. The second study was the analysis of pollen samples from Singing Shelter (Site 5MT4683). This record proved to be less than satisfactory because of the difficulty of assigning ages to the individual pollen samples, and because the changing rates of deposition made comparisons between pollen samples problematical. However, when used in conjunction with other studies, these 2 pollen studies help complete the overall picture of changing climate and vegetation in the project area.

The pollen data from the archaeological sites in the project area provide an independent and more satisfactory test of the climatic scheme developed by Petersen (sect. 6). Petersen, using a pollen record from the La Plata Mountains, reconstructs a sequence of climatic conditions that fluctuate between those similar to and those drier than the present; the climatic fluctuations resulted in corresponding vegetation changes in the project area. Because of the tight dating control for the DAP archaeological pollen samples, these samples could be used to see if the direction and magnitude of change reconstructed by Petersen from the La Plata Mountains record could be seen in the archaeological record.

To overcome possible bias in the archaeological pollen record due to the effects of humans on the local pollen rain preserved in an archaeological site, all samples of a similar age were averaged together, and then only the pollen of the 4 major cover plants (i.e., sagebrush, juniper, pine, and oak) were examined. The results suggest that the chronology and direction of climatic change presented by Petersen (sect. 6) is basically correct.

The initial goal of obtaining information on the potential economic resources that could have been used by the Dolores Anasazi and that of obtaining information on the prehistoric environment have largely been reached. In addition, a large number of pollen samples have been collected and are being curated, which may aid future pollen research directed toward more specific problems.

FAUNAL DATA

The DAP devoted much effort toward establishing a quality data base from which could be derived information on potential resource availability and the probable resource mix used by the Dolores Anasazi. For instance, Neusius (1985b) and Neusius and Gould (1985) examined the correlation between taxonomic and bone element composition of the faunal assemblage and the collection mode under which it was recoverded. Only a weak correlation was found between collection

mode and assemblage composition, which suggests the collection is fairly free of bias introduced by the manner in which the bone was recovered. However, in the present report, Neusius does note faunal assemblages recovered through troweling may not be as representative as was assumed when the excavation manual was written (Kane and Robinson 1984).

Earlier, Neusius (1985a) presented a discussion on the potential availability of fauna both historically and prehistorically. In section 4 of this chapter, she uses the data presented in that earlier document to determine the relative faunal biomass within the project area and to assess the probability that a particular species might be included in the Dolores Anasazi diet. Those species with the highest relative biomass generally could be expected to be the ones most likely to have been exploited and included. As the relative biomass decreased, it would be expected the probability of inclusion in the diet would also decrease.

Several rankings of mammalian resources were generated and compared with the archaeological data. The results indicate seasonal variation seems to be less important than habitat distribution. Several habitats have 25 species that could have been exploited, while others have fewer than 25. Two habitats are noticeably less productive than the others in terms of mammals: aquatic habitats and Douglas-fir forest. Sagebrush has 20 species, and because of the extent of sagebrush habitat reconstructed for the project area during the height of Anasazi occupation in the A.D. 800's (sect. 3), the project area might have been less productive in terms of mammals than if it and all pinyon-juniper woodland or scrub oak/mountain brush, each of which has 25 species. This assessment does not take into account the effect of clearing for farms or the effects of climatic change on habitat redistribution.

Roughly 90 percent of the remains in the macrofaunal assemblage are those of mammals. and of these, cottontails are the most common taxa. Most cottontails in the DAP macrofaunal assemblage are identified only to genus; however, most of these specimens likely represent the desert cottontail or the Nuttall's cottontail. Because these 2 species have different and distinct habitat preferences, their remains could provide information about the prehistoric environment.

A more detailed treatment of the issue of cottontail species and habitat type than was presented in section 4 of this chapter was provided in an earlier DAP report by Flint and Neusius (1985). In the latter study, it was anticipated the majority of the cottontails identified would be Nuttall's, because of the elevation and wooded vegetation cover of the project area. The project area today is near the upper elevational range limit of the desert cottontail, which has a preference for more open and less wooded habitat than the Nuttal's cottontail. Therefore, it was surprising to find the most common cottontail that could be identified to species in the Dolores faunal assemblage is the desert cottontail. The high occurrence of this species could mean the open habitat provided by the cleared fields tended to draw the desert cottontail into the project area. Alternatively, during the A.D. 800's, the time of highest Anasazi population in the project area, Petersen (1985a) suggests a shift upslope of the major vegetation zones in the project area. If the range of the desert cottontail also shifted upslope, this might account for the observed trend in the DAP faunal assemblage.

Flint and Neusius (1985) found a close correspondence between the amount of sagebrush in the reconstructed vegetation catchment of an archaeological site and the proportion of desert cottontail mandibles to total cottontail mandibles collected from the site. This suggests the reconstruction of sagebrush habitat by Petersen may be realistic. Also, since sagebrush most likely was the first vegetation cleared for fields, the proportion of desert cottontail mandibles may be related to a combination of sagebrush and cleared fields.

The final point of the study conducted by Flint and Neusius (1985) is that cottontail hunting appears to have been a very localized activity, based on the makeup of the reconstructed catchment and on the correlation between cottontail species type and vegetation type. Neusius also suggests land clearing would have had a generally positive effect on animal biomass for a number of species because it would have increased the area of edge and the availability of food (greens, seeds, insects).

In section 4, Neusius presents an annotated list of faunal taxa recovered during DAP excavations. She notes that Lagamorphs and artiodactyls are the most commonly occurring taxa in the identifiable assemblages. However, these hardly dominate the assemblage entirely. Many types of mammals and quite a few birds are represented. Dogs were recovered and are considered to have been domesticated; no clear evidence for domestication was established for turkey.

The Dolores faunal assemblage is very diverse. This may be due to the proximity of the Dolores area to the highlands to the north and east or to the large size of the Dolores faunal assemblage, which would tend to increase the probability of more rare items occurring.

Neusius concludes in section 4 that game seems to have been an important part of Anasazi economics throughout the Dolores sequence. Two game procurement strategies probably were used. The first can be characterized

as opportunistic garden hunting, where game is procured in the course of other activities. Such hunting might have been embedded in crop planting, maintenance, and harvesting, and possibly even in wild plant collecting. The second strategy is winter large-game procurement. The 2 different strategies should result in different characteristic fauna in the resource mix. The evidence for temporal changes in faunal resource mix is discussed in greater depth in chapter 7.

GEOLOGICAL DATA

Geological studies undertaken in conjunction with archaeological excavation in the Dolores Project area have generated a number of reports that cover a wide range of subjects, including geomorphology and characteristics of site location, stratigraphy of archaeological sites and pertinent resource areas, and delineation of potential resource areas on project-wide maps of modern bedrock, landforms, stream order, and soils. Regional maps delineate possible source areas for exotic rocks and minerals. Two project-wide maps showing the distribution of growing season length under 2 different climatic regimes have proven valuable in evaluating the capability of a particular plot of ground to mature corn and other crops. A number of studies have focused on the changes of the distribution of arable land through time.

Section 5 of this chapter provides an overview of DAP geology reports. In early site reports, geological information was included in appendixes; in later reports, discussions were integrated into the reports themselves. The environmental archaeology volume (Petersen et al. 1985) also contains a number of reports that describe bedrock geology, landforms, geomorphology, and modern stream order. In addition, the volume contains a report on the marsh in Sagehen Flats; in this report, an attempt is made to ascertain when the marsh might have existed in the past and therefore when it might have been available for exploitation by the Anasazi.

Later DAP geology reports focused primarily on questions derived from both the general research design (Kane et al. 1983) and the modeling effort (Lipe 1984, part IV, this volume). Problem Domain 4 in the general research design deals with extraregional relationships. Keane and Clay (1984) found that a variety of rocks and minerals recovered from DAP sites do not occur naturally in the project area. Maps of possible sources were produced to allow assessment of potential extraregional relationships. Keane and Clay (1984) conclude that when exotic materials are considered on a per capita basis, the frequencies are essentially constant through time.

Problem Domain 1 focuses on the resources used by the Dolores Anasazi. Wilson et al. (1985) found that, although many of the geological formations could supply suitable clay for ceramics, a smaller subset of the most desirable seems to be what was used.

Problem Domain 1 allows the formulation of questions dealing with the distribution of arable land in the project area. In the Four Corners region, loess provides the most ideal dry-farming soil, and an examination of Anasazi site locations in the Four Corners area shows that the sites are largely confined to loessal soils. The recovery, identification, and subsequent radiocarbon dating of the partial skeleton of an extinct genus of musk ox at Grass Mesa Village allowed a more precise date assignment (i.e., within the last 16,000 years B.P.) for the most recent episode of loess deposition.

A series of reports dealing with the agricultural potential in the project area (Petersen and Orcutt 1985, comps.) points out that arable soil distribution and the length of the frost-free season may have had much to do with the occupation, rapid population growth, and abandonment of the project area during the A.D. 600-950 period. After abandonment, the project area did not sustain another long-term sedentary farming population again until the 19th century. Maps show that the amount of arable soil probably was not the limiting factor, but that during years of short growing seasons, a good portion of the arable soil could not be successfully farmed because of the effect of cold air pooling in low-lying areas within the project area.

Another aspect examined was the impact that a large Anasazi population would have had on the environment. Petersen et al. (1985) concluded that, in most instances, the impact was not negative to the point it would have led to permanent abandonment. To develop a well-documented case study of the possible affects of Anasazi-caused erosion, a modern pit-filling experiment was undertaken in which climate and sediment deposition were monitored and the findings compared with soil monoliths recovered from McPhee Village pitstructures. Clay (in Petersen et al. 1985) concludes that project pitstructures probably filled within 100 years of exposure in areas that had landscapes largely denuded by clearing for fields. However, this erosion probably was not severe enough to have led to abandonment of the area.

PALEOCLIMATIC DATA

In section 6 of this chapter, Petersen draws together a number of lines of evidence to reconstruct the climate in the project area. Contemporaneous change reflected

in DAP archaeological data and in palynological, radiocarbon, geological, and dendrochronological data from the northern American Southwest supports the interpretation that Anasazi population dislocations in the Dolores River valley were triggered by environmental fluctuations. Critical changes in growing season length, and in summer and winter precipitation during the A.D. 550-1325 period resulted in changes in the elevation and width of the potential dry-farming belt in southwestern Colorado and adjacent southeastern Utah. The changes, in turn, affected where the Anasazi located their habitations and agricultural fields.

The environmental data set used in the climatic reconstruction included data from tree-ring analyses, a packrat midden study, the Sagehen Flats marsh pollen study, and an ongoing pollen study of vegetational history in the La Plata Mountains, which began in 1972 (Petersen and Mehringer 1976; Petersen 1981). The chronology, direction, and magnitude of climatic change derived from the La Plata Mountain study seem to be substantiated by the pollen results from the project area and by a test that uses a histogram of the pith dates of ponderosa pine beams recovered within the project area. Even the short climatic reversal from dry to wet conditions dated to about the A.D. 800's from the La Plata Mountain chronology seems to be clearly indicated in the clustering of pith dates.

Vegetation distribution maps of the project area have been compiled for different time periods. The distributions shown on these maps seem to be substantiated by the results of DAP pollen analysis from archaeological sites and by the findings of the cottontail study (Flint and Neusius 1985; Neusius and Flint 1985).

The importance of past changes in the distribution of land available for farming is dramatically illustrated by maps showing changes in growing season length. The time periods characterized by short growing seasons were reconstructed using a remote high-elevation tree-ring record of Bristlecone pine from central Colorado. Although the correlation between local killing-frost-free season length and the tree-ring record has not been subjected to the vigorous testing and confirmation routines developed at the University of Arizona Laboratory of Tree-Ring Research (Fritts 1976), the results shown in this study and in the other supporting studies (Petersen 1984b; Petersen and Clay 1984) are compelling.

Petersen reconstructs an index of relative attractiveness of the DAP in relation to the areas to the south and west and at lower elevations. Based on relative attractiveness, population movements might be accounted for, and this measure might prove useful in explaining some of the other changes evident in the DAP archaeological record. Refer to part IV for further discussion.

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General Layout and Structure Populations

Habitation sites seem to conform to 1 of 2 general patterns: large aggregated villages consisting of several to more than 15 roomblock units (fig. 5.17), and isolated single-roomblock settlements (termed "outlying settlements" by the DAP), which are assumed to be socially related to specific aggregated villages. The roomblock units within the large villages exhibit the "right-tailed" total size distribution common in DAP data (fig. 5.18). The ranked size distribution does exhibit a small secondary peak at 80 to 90 m, which suggests that Periman Subphase roomblocks might be categorized as "small" (less than 10 to approximately 60 m in length) or "large" (more than 60 m in length). With the exception of Roomblock Unit 39 at Grass Mesa Village, all of the "large" roomblocks are situated at the 3 largest project area villages (McPhee Village, Windy Ruin, and Cline Crest Ruin [Site 5MT2663]). This relationship is further discussed in the social organization chapter (chap. 14). The "small" roomblock units generally consist of 8 to 20 individual rooms and 1 to 3 pitstructures, while the "large" units consist of 30 or more individual rooms and 5 or more pitstructures. The small roomblocks appear to be spatially patterned according to the locations of the more centralized large units, and the intravillage spatial arrangements are believed to reflect social affinities. Also, the presence of the small roomblocks might be partially explained by population growth; they may reflect late immigrations into the area or "budding" from established roomblock units.

Internal roomblock configurations conform to the general pattern described for the preceeding Dos Casas

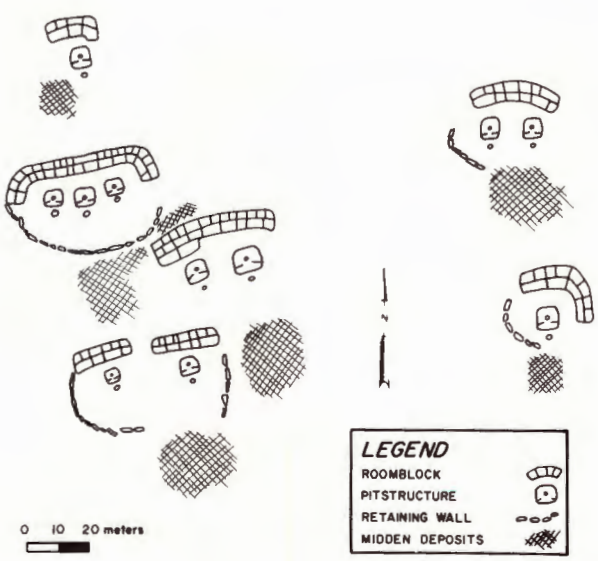

Figure 5.17 – Periman Subphase habitation site layout (adapted from Wilshusen [comp. 1985:fig. 2]).

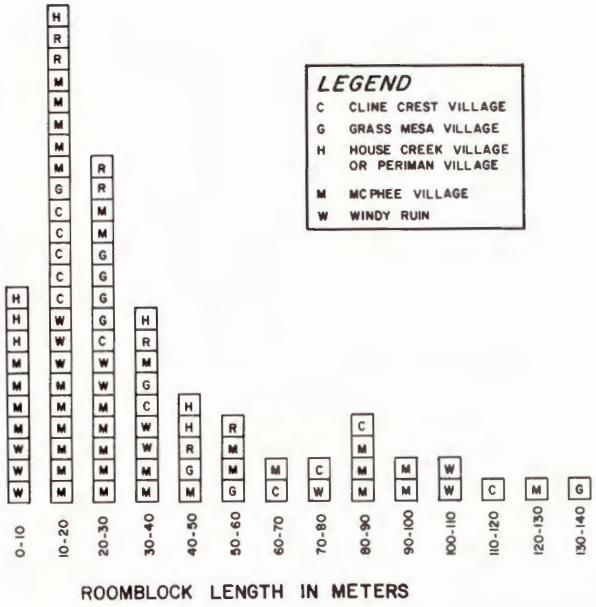

Figure 5.18 – Ranked display of Periman Subphase roomblock lengths.

Subphase: a roomblock, usually cresent shaped or possibly horseshoe shaped; a plaza area south of the roomblock containing pitstructures and extramural work areas; and a midden or possibly 2 to 3 separate refuse mounds south of the living complex. Small roomblock units range from 0.1 to 0.2 ha in area, while the large roomblock units usually cover between 0.2 to 0.4 ha. Village areas may be several to up to 10 ha in area.

Besides roomblocks and pitstructures at habitation sites, Periman Subphase architecture also includes agricultural field houses. Such sites usually are located a few kilometers away from the large aggregated multiple roomblock settlements and consist of 1 or a few surface rooms and outdoor activity areas. The field house rooms are relatively small and appear to have functioned as storage facilities; a larger room with a hearth was investigated at Little House (Site 5MT2191 [Hewitt 1983d]). Periman field houses exhibit less investment in materials and labor and less substantial construction than surface rooms at habitation sites. These field houses were not included in the data set used for the Periman surface room discussion. Field house architecture is discussed further in pertinent DAP site reports (Little House [Site 5MT2191; Hewitt 1983d], Moonlight House [Site 5MT2205; Kleidon 1982], and Hamlet de la Olla [Site 5MT2181, Etzkorn 1983]).

Surface Structures – Back Rooms

Periman Subphase back rooms are in many ways morphologically similar to their Dos Casas predecessors. The back rooms are arranged linearly within the contiguous roomblock, and 1 or 2 back rooms are found

per 1 front room; a Periman Subphase roomsuite consisting of 2 back rooms and a front room is depicted in figure 5.19. Specific architectural characteristics are as follows.

1. Shape. Without exception, the structures appear to be rectangular or square in plan.

2. Size. The distribution of room sizes approximates a normal curve. The mean size (floor area) is approximately 5.5 or 6.0 m² (Wolf 1985a:table 2; Wilshusen 1985c:table 3), which is substantially larger than the mean size of Dos Casas back rooms (3.5 m²); this may indicate increased investment in and reliance on storage facilities (Wolf 1985a; Gross chap. 13). Some exceptions to the normal distribution have been observed; for example, Room 18 at Pueblo de las Golondrinas (Site 5MT5107 [Brisbin 1984c:136]) is more than 10 m² in area. This may represent a modification of the original architectural pattern to meet functional needs.

3. Wall construction. A variety of wall construction types are observed for Periman Subphase back rooms. Most back room walls were of composite construction; the lower portion (0.5 to 1.0 m) was masonry, and the upper portion was daub or jacal. Wall foundations were of daub, horizontally laid sandstone slabs, or vertically placed sandstone slabs; subfloor trenches were often prepared to accommodate the foundation materials. Vertical-slab foundations in Periman Subphase back rooms may represent retention of original wall bases dating to the previous Dos Casas Subphase. Variability in wall construction for the late Pueblo I period (A.D. 800-900) has also been described by Brew (1946:218-219) in a synthesis of early Anasazi architecture. The increased investment in materials and labor necessary to build partial masonry walls for back rooms may reflect increased dependence on storage and the need for a secure storage environment. Access to back rooms apparently was by means of a small door or hatch in the south wall. Field observations suggest that the hatch was above the floor level and may have been reached by means of a step in the front room.

4. Roof construction. Most back rooms have 4 postholes near the 4 corners, which suggests that the standard four-post roof-support pattern was employed. The roof itself apparently consisted of primary beams, secondary beams, and several layers of closing materials. Postholes in back rooms are deeper, and they more consistently incorporate bracing and footing materials than do postholes in front rooms, perhaps indicative of more substantial roof construction.

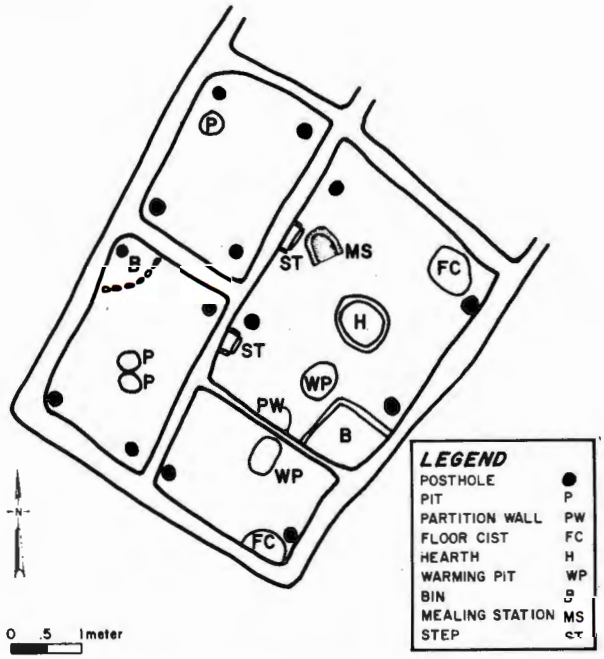

Figure 5.19 – Plan of Periman Subphase three-room apartment (adapted from Kleidon [1984a:figs. 16, 18, 26]).

5. Floor. Floors in back rooms usually consist of the use-compacted excavated ground surface, perhaps with a veneer of dried mud. They usually are located 10 to 20 cm below prehistoric ground surface and are level or basin shaped.

6. Domestic and economic activity areas. Pueblo I back rooms usually are assumed to have functioned primarily as storage facilites (Brew 1946:190-191; Hayes and Lancaster 1975:182-183). The DAP data mostly support this assumption, with some exceptions (Wolf 1985a:53). Periman Subphase back rooms apparently were multipurpose, based on their contents. They functioned as granaries (for storage of cultivated foodstuffs such as corn and beans), as storerooms (for storage of domestic tools and agricultural implements, of wild or ruderal plant foods such as amaranth and chenopods, and perhaps of firewood or construction materials), and infrequently as locations for processing activities. The occasional presence of mealing tools in Periman Subphase back rooms (Wolf 1985a:62) suggests that preparation of cornmeal or other milled foodstuffs might have taken place on occasion. Rectangular bins and subfloor bell-shaped cists have also been recorded in Periman subphase back rooms; this suggests that activities in these rooms included compartmentalized storage, perhaps for items in bulk.

Architectural characteristics and functions of Periman Subphase back rooms appear similar to those of the

preceding Dos Casas Subphase. Periman Subphase back rooms are larger, incorporate more substantial construction, and were used for a greater variety of activities, although produce storage remained the primary function.

Surface Structures – Front Rooms

The sizes and feature populations of Periman Subphase front rooms have bimodal distributions. Large (greater than 10 m^2 floor area) front rooms usually have feature populations consistent with definition of the structures as habitation or domestic rooms, while small (less than 10 m^2 floor area) front rooms may have functioned as habitation rooms or as processing facilities. The similarity in form and content between Periman and Dos Casas front rooms suggests that the original functional patterns established in the late A.D. 700's remained basically unchanged into the late A.D. 800's. Remodeling and other modifications that resulted in departures from the normal pattern apparently were more frequent during the Periman Subphase. Examples of this phenomenon include use of small front rooms as living rooms and division of large front rooms into 2 smaller units. Specific architectural characteristics of Periman Subphase front rooms are as follows:

1. Shape. Periman front rooms are rectangular or subrectangular in plan. The south corners may be rounded, which results in a "scalloped" appearance along the roomblock outline. Shape distributions are similar to those of the previous Dos Casas Subphase.

2. Size. Room sizes for Periman front rooms range from about 7 m^2 to 25 m^2. The distribution has 2 peaks and closely resembles the distribution for Dos Casas front rooms. The mean floor area for large rooms is about 17 m^2, which is slightly more than that for large Dos Casas rooms, while the mean for small rooms (approximately 8 m^2) is about the same as that for small Dos Casas Subphase rooms.

3. Wall construction. Periman front room walls are similar in form and construction to Dos Casas front room walls. With the exception of the north wall, Periman front rooms incorporate less substantial materials than do back rooms; most construction is probably of daub turtlebacks or jacal. Foundations and some lower wall portions are of vertical sandstone slabs or of horizontally positioned stone blocks or cobbles.

4. Roof construction. Periman front room roofs probably were similar to Dos Casas front room roofs. The standard Anasazi four-post support system was common, although sometimes 2 or even 4 additional support posts were used near the center of large rooms. In such cases, the additional posts probably were used to support additional construction members in rooms with relatively long east-west dimensions.

5. Floors and associated features. Floor construction and feature complements in Periman front rooms are similar to those described for comparable Dos Casas structures; refer to the Dos Casas description for details.

Pitstructures

Periman Subphase pitstructures exhibit greater variability in form and function when compared to earlier pitstructures. Between 2 and 8 pitstructures per roomblock unit is characteristic of Periman Subphase habitation sites, and more than 40 pitstructures may have been in simultaneous use at some of the larger villages. Periman pitstructures appear to be consistently located in the plaza area south of the roomblock. Size, feature complement, and function are interrelated. Based on size rankings (chap. 14, fig. 14.2), Periman Subphase pitstructures are characterized as "small," "oversized," or "great kivas." Most "small" pitstructures contain a preponderence of domestic and processing features with some contents or features believed to have had ritual functions; these structures probably are "protokivas." Figure 5.20 depicts the plan of a Periman Subphase "small" pitstructure. "Oversized" (greater than 30 m^2) Periman pitstructures generally contain both domestic and ritual features and items, although the population of ritual features is more complex when compared to "small" pitstructures. The 2 largest recorded "oversized" pitstructures (Pitstructure 9 at Pueblo de las Golondrinas [Site 5MT5107] and Pitstructure 3 at McPhee Pueblo [Site 5MT4475]) are associated with horseshoe-shaped roomblocks and are thought to represent locations of suprahousehold organizations and managerial power (chap. 14). These 2 structures lack artifacts and features indicative of domestic activities; rather, the feature and artifact content (rectangular central pits, floor vaults, paho marks, ornaments) appears to entirely reflect ritual and ceremony. A plan of an oversized pitstructure is illustrated in figure 5.21.

A possible Periman Subphase great kiva was investigated at Singing Shelter (Site 5MT4683 [Nelson and Kane 1985]); the "possible" qualification is necessary because use of the structure could only be assigned an A.D. 800-900 bracket date based on stratigraphic relationships and associated ceramics. This structure is very large (approximately 800 m^2 of floor space), even when compared to other described Pueblo I great kivas. The structure contains a circumferential bench and may have been enclosed by a row of rooms on the south and

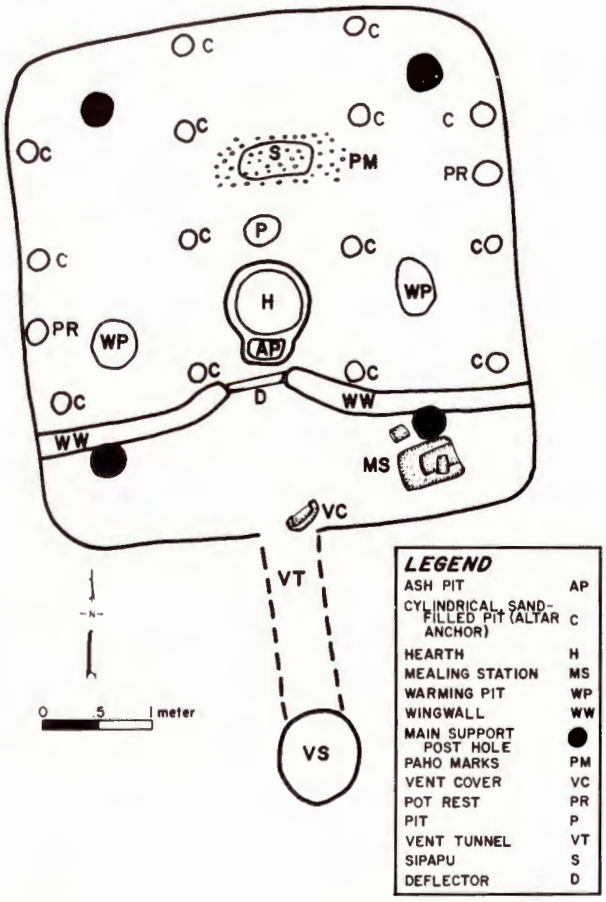

Figure 5.20 – Plan of a Periman Subphase "small" pitstructure (adapted from Kleidon [1984a:fig. 33]).

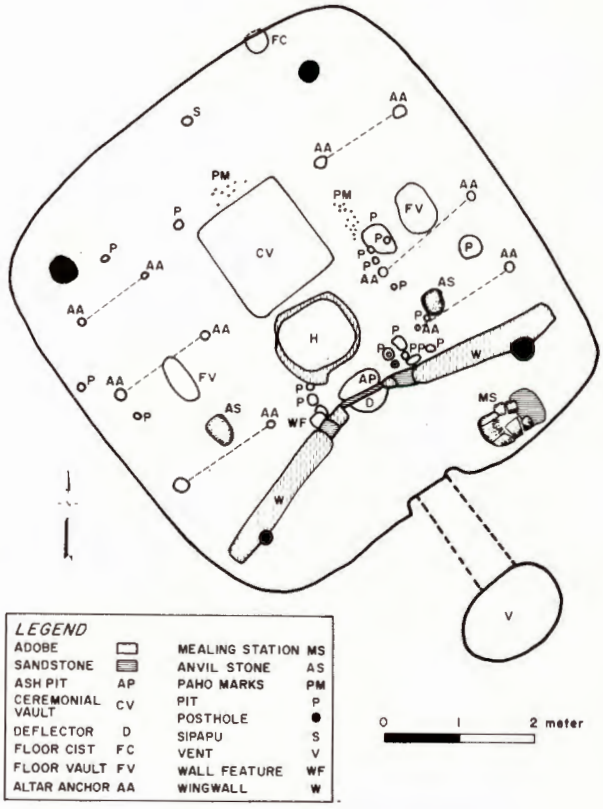

Figure 5.21 – Plan of a Periman Subphase oversized pitstructure (adapted from Kuckelman [1984a:fig. 20]).

west sides. It apparently was not roofed, although the natural shelter setting would have provided partial protection for the north and east portions. The true nature of associated artifact and feature populations could not be accurately estimated because only small parts of the floor were preserved; however, a possible reconstruction of the floor plan of this structure is offered in figure 5.22. This reconstruction represents the author's concept of what the floor of such a structure might look like; evidence for specific features and other architectural details shown in figure 5.22 was not necessarily encountered during excavation of the Singing Shelter great kiva. Refer to Nelson and Kane (1985:fig. 21) for the actual floor plan of this structure, as mapped during excavation.

Specific characteristics of Periman pitstructures are as follows. This discussion does not take into consideration the Singing Shelter great kiva.

1. Shape. Periman pitstructures are rectangular with rounded corners; the mean squareness index is 0.934, very close to the value for Dos Casas pitstructures (0.937 [Hewitt et al. 1983:135]).

2. Size. The size distribution of Periman pitstructures conforms to a right-tailed curve, reflecting a diverse size and functional population (chap. 14, fig. 14.2). Small pitstructures have a mean floor area of 17 to 18 m². Oversized pitstructures have a mean floor area of about 40 m². The 2 pitstructures at McPhee Village associated with horseshoe-shaped roomblocks have floor areas of 63 m² and 50 m².

3. Depth. The mean depth for the smaller pitstructures is about 1.6m; for the larger structures, it is about 2.0 m. Periman pitstructures are somewhat deeper than Dos Casas pitstructures. Pitstructure 3 at McPhee Pueblo is anomalous, with a depth of over 3 m.

4. Roof construction. Roof patterns are similar to those for Dos Casas Subphase pitstructures. Four main support postholes are present; these are located in the northeast and northwest corners and in the wingwall; auxiliary posts may be present. Leaner posts apparently were footed on a ground-level shelf around the margin of the structure, as benches are absent in Periman pitstructures.

5. Bench. Benches are almost invariably absent in Periman pitstructures. The only recorded Periman

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PART III

Chapter 5

PREHISTORY OF THE DOLORES RIVER VALLEY

Allen E. Kane

INTRODUCTION[1]

Field and laboratory research conducted by the DAP from 1978 through 1985 focused on the reconstruction of lifeways and the explanation of cultural process for the prehistoric Anasazi population of the Dolores River valley. In this chapter, the intent is to present an overview, or "culture history," that integrates the data presented in the analytical contributions (chaps. 2 through 4) and some of the results of the DAP modeling effort (chaps. 6 through 16).

This chapter is divided into 3 major sections. The first presents the DAP site typology, the spatial series, and the temporal scheme, which together constitute the body of common archaeological conventions and terminology used by the DAP to describe spatial and temporal variability in the Dolores data. Collectively, these tools for examining the archaeological data are referred to as "program systematics."

DAP systematics were based on ethnographic and archaeological analogies, inferences from pertinent project excavation and survey data, and logical derivations regarding the "fit" between project data and the more general analogies. As the project data base expanded, perceptions of Dolores Anasazi culture process were modified accordingly, and the systematics framework came to be regarded as a flexible tool for describing and quantifying the patterns observed in the archaeological record. Thus, DAP systematics have undergone numerous refinements since their initial presentation in the first DAP volume (Kane 1983b) and their subsequent update in the second volume (Kane 1984a). In this chapter, the final version of DAP program systematics is presented; the presentation is a convenient reference when specialized DAP terminology is encountered in the other chapters.

The second major section provides a summary of the culture history of the project area. The presentation is limited mainly to the Anasazi Tradition and contains a comprehensive discussion for each phase and subphase defined for the Anasazi occupation at Dolores. Anyone interested in particular aspects of Dolores Anasazi culture history should refer to the analytical and modeling chapters (chaps. 2 through 4, and 6 through 16) for more detailed treatments.

The final section of this chapter presents a summary of architectural styles and forms characteristic of habitation sites assigned to particular subphases. Specifically, characteristics of and changes in structure population, general site layout, surface room construction, and pitstructure construction are charted throughout the Dolores Anasazi sequence. Significant departures from the norm are also noted, and ample citations to specific DAP site reports are provided for those interested in pursuing specific topics.

DOLORES ARCHAEOLOGICAL PROGRAM SYSTEMATICS

This section summarizes DAP systematics, or the sets of archaeological units developed to provide a common frame of reference for the project analytical and field staffs. DAP systematics consist of 3 separate but complementary sets of units. The organization of each set is hierarchical; that is, smaller units in each set can be combined to form larger categories. The 3 sets consist of a site typology, a spatial series, and a temporal (or formal) series.

The site typology was used by the DAP to classify sites recorded during survey. The proportions of different site types were then used as a basis for estimating the composition of the archaeological resource.

The spatial series provides a means of describing and interpreting units of space recognized during field investigations. The units were defined according to the concept of social space, which appeared to provide a

[1]Portions of this chapter first appeared in an earlier Dolores Archaeological Program report entitled *Fieldwork and Systematics* (Kane 1983a). Many of the topics discussed in this chapter, and in the report from which it has been excerpted, are based on concepts originally presented by Kane in *Dolores Archaeological Program: Field Investigations and Analysis – 1978* (Kane 1983b).

more appropriate interpretive framework than archaeological units of space such as "site" or "grid square."

The third systematics set, the temporal series, consists of several types of units (basic, synthetic, and integrative) used to describe temporal patterning in the DAP data. Included in the temporal systematics is the DAP phase scheme, which was used by the analytical staff and site report writers as a common frame of reference. Because the specific units defined for the phase scheme (phases and subphases) were based on organization and settlement pattern variability that in some cases overlapped, a separate temporal classification using modeling periods, which were based solely on increments of time, was used for the modeling effort (part IV of this volume).

Dolores Archaeological Program Site Typology

The development and implementation of a site classification system based on formal site attributes and content was prerequisite to describing settlement patterns and designing field sampling plans. The DAP site typology is based on a simple model of the relationship between the settlement behavior of prehistoric groups and the formal attributes of "sites" reflective of that behavior. The frequency of site use and the duration of each use can be viewed as a continuum, from constant, continuous use at one extreme, to sporadic, temporary use at the other. Frequency and duration of use are related to the number of different activities performed at a site; sites occupied continuously usually served as bases for a wide range of activities, while those used only sporadically and for short periods often were used for a narrower range of activities. This range of use intensity and diversity is reflected in the archaeological record and usually can be recognized from surface evidence. In developing the project typology, the hypothetical continuum of use intensity and activity diversity was divided into 3 segments, which formed the basic units of the system:

1. Habitations. Habitations were continuously occupied sites where a wide range of activities was performed. They are equivalent to the habitation units discussed in the section on spatial systematics. For the Anasazi Tradition, habitations usually consist of 1 or more household clusters earlier in the sequence and 1 or more interhousehold clusters later in the sequence. For other traditions, habitations might consist of base camps used for periods of several months rather than continuously. Refer to the discussion of the DAP spatial series for an explanation of the terms "household cluster," "interhousehold cluster," and "habitation."

2. Seasonal loci. Seasonal loci were occupied on a short-term basis, usually by household or interhousehold groups. "Seasonal" suggests that use of these sites might have been related to domestic or economic seasons (e.g., harvest season or spring planting season). Seasonal sites were established for specific purposes, and most activities performed at these sites reflect these purposes. Seasonal sites might have been used for a few days to several weeks; use of these sites was periodic (e.g., they were used annually or perhaps several times a year).

3. Limited activity loci. Limited activity loci were occupied for only a short period by individuals or small groups. Activities performed at limited activity loci were limited in number and reflected a specific purpose; the sites probably were used for only a very brief period – a few hours to a few days – though perhaps repeatedly. Limited activity sites tend to yield artifact and feature assemblages consistent with the interpretation of short-term use and a narrow range of activities.

Subcategories of the 3 basic site types are defined according to function; these subcategories are discussed by Kane (1983b:19-23) and are listed in table 5.1

Dolores Archaeological Program Spatial Series

The DAP spatial series consists of hierarchical units at the intra-community and intercommunity levels. Definitions of units are based on **social space**, the space and facilities used by human groups for domestic, economic, and integrative activities. The definitions of some intracommunity units recognized by the DAP have changed as new data have become available. Initially, these units were based on the use of space model developed by Flannery (ed. 1976) in a study of Formative communities in Mesoamerica. Subsequently, as new data revealed evidence of spatial and social organization not adequately explained by the initial model, selected definitions were revised and expanded to incorporate concepts introduced by Wilk (1981) and Wilk and Netting (1981), based on modern ethnographic studies. The intracommunity units at the household and interhousehold levels reflect the concepts of Flannery (1976a, 1976b) and Wilk and Netting (1981), selectively applied to different portions of the Dolores Anasazi sequence.

The definitions of intercommunity units were based on results of earlier efforts to devise regional spatial systematics for southwestern Colorado (cf. Bullard 1962; Lehmer 1971; Gillespie 1976). Because modeling prehistoric organization and use of space at an intercommunity level is difficult, intercommunity units are

Table 5.1 – Dolores Archaeological Program site typology *

I. Habitations
   A. Base camps
   B. Hamlets (1 to 3 dwelling units or household clusters)
   C. Large hamlets (usually 4 to 8 dwelling units and several pitstructures arranged in 2 to 4 interhousehold clusters)
   D. Villages (usually more than 20 dwelling units in 5 or more roomblock clusters)
   E. Function-specific habitations

II. Seasonal loci
   A. Economic or technical
      1. Towers
      2. Forts
      3. Isolated kivas or great kivas
   C. Communications

III. Limited activity loci
   A. Economic or technical
      1. Procurement loci: specific types include quarries, kill sites, gathering stations, agricultural sites (garden plots), water control sites
      2. Primary processing loci: specific types include butchering and timber reduction stations
      3. Secondary processing (manufacturing) loci: specific types include kilns, chipping stations
      4. Maintenance loci
      5. Storage loci
      6. Consumption loci
      7. Discard loci
   B. Social or ceremonial loci: specific types include shrines, petroglyph and pictograph panels, cemeteries
   C. Communications loci: individual types include trails and roads, signal fire locations

* Adapted from Kane (1983b:19-23).

administrative divisions defined on the basis of environmental characteristics rather than on models of prehistoric behavior.

Intracommunity Units

Intracommunity units can be characterized as those pertaining to the household level of organization and its spatial correlate, the household cluster, and those pertaining to community organization above the household level. Intracommunity spatial units at the household level are depicted in figure 5.1; units above the household level are depicted in figure 5.2. The latter figure also illustrates the changes in dwelling units, household clusters, and interhousehold clusters through time.

Activity area. – An activity area is a location where an activity or series of activities was performed (Kane 1983b:12). It is often a location where an individual household member carried out a task, but it is possible that an intrahousehold task group composed of several individuals, or individuals representing several different households, used the activity area.

Use area. – A use area is defined as a space used by individuals and task groups for multiple activities (Kane 1983b:12). Use areas consist of several or even numerous activity areas, and often are either artifact scatters or enclosed spaces defined by the limits of surfaces. Activities performed in use areas usually are functionally related and reflect the general purpose of the group in using that space (for example, storage, processing of animal and plant materials, domestic tasks, refuse discard, or group integration). Use areas are not limited to domestic architecture or space; spaces reserved for specific activities can be identified in shared or public areas as well. Houses usually consist of several use areas where domestic activities were conducted; this is a modification of the original concept of use area as defined by Kane (1983b:12).

Dwelling unit. – This term refers to the architectural component of a household cluster (in the original DAP system, the specific terms "roomsuite" or "pithouse" usually were used to describe such components). The dwelling unit represents the primary architectural facility used by a family unit or household. In the Dolores Project area, the types of dwelling units used by the Anasazi changed through time (fig. 5.2). During the early part of the Dolores Anasazi sequence (Tres Bobos and Sagehill Subphases [A.D. 600-780]), and perhaps during the Grass Mesa Subphase (A.D. 870-910), dwelling units were equivalent to pithouses. (Refer to discussion of DAP temporal systematics for an explanation of phases and subphases). During the middle portion of the sequence (Dos Casas and Periman

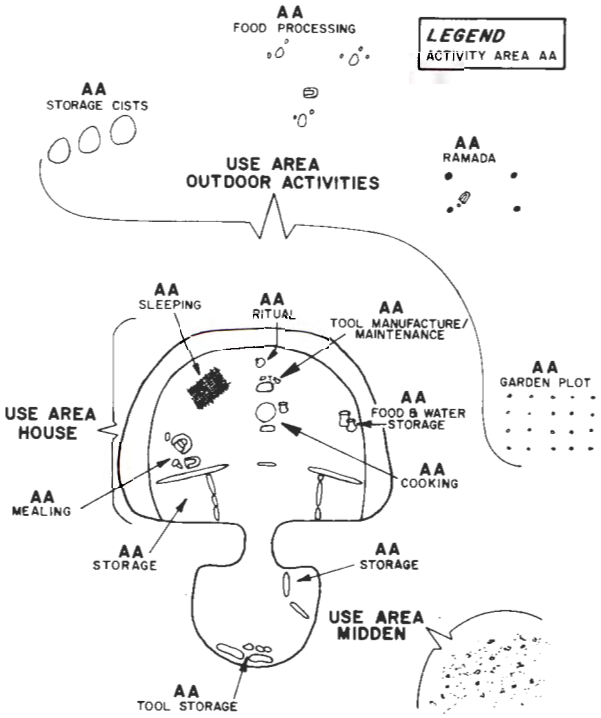

Figure 5.1 – Relationships of intracommunity spatial units at the household cluster level. Not to scale.

Subphases [A.D. 760-910]), dwelling units consisted of roomsuites (1 front living room and 1 or 2 rear storage rooms) in surface pueblos. Overlap periods (A.D. 760-780 and A.D. 870-910) occurred during which both forms were present.

Dwelling units were characterized by comparatively greater variability in later periods at Dolores (the Grass Mesa and Cline Subphases [A.D. 870-1000] of the McPhee Phase, and the Marshview [A.D. 1000-1200] and Escalante [A.D. 1120-1180] Subphases of the Sundial Phase). Grass Mesa Subphase dwelling units were roomsuites or small, architecturally simple pithouses. The Cline Subphase (A.D. 920-1000) was characterized by greater complexity and specialization in architectural forms; roomsuite dwelling units are identifiable, although their configurations are more complex than those of the earlier Dos Casas and Periman analogs. Sundial Phase (A.D. 1000-1200) dwelling units are usually small pithouses consistent with the nonintensive, seasonal use of most of the project area during the late period. Exceptions are found at the Escalante and Reservoir complexes on the southern fringe of the project area, where dwelling units consisted of roomsuites in roomblock units.

Dwelling units incorporate sets of use areas and activity areas that reflect domestic activities. These include facilities and space used for raw material processing, pottery manufacture, stone and bone tool manufacture and maintenance, food preparation, cooking, eating, heating and ventilation, sleeping, and temporary and permanent storage of tools and foodstuffs. Although spatial patterning of these activities within dwelling units is noted, some temporal and spatial variation is observed as well. For example, rear rooms in Dos Casas and Periman Subphase roomsuite dwelling units were used primarily for storage, but perhaps occasionally served as tool maintenance and mealing areas as well (Wolf 1985a).

Household cluster and interhousehold cluster. – As originally defined by the DAP (Kane 1983b:12-13), a household cluster referred to all space and facilities used by a household. This definition was based on a similar concept presented by Flannery (1976c) and Winter (1976:25-31) in their study of Formative Mesoamerican village life. As originally presented by Kane (1983b:13), an interhousehold cluster consisted of a "spatially or otherwise related grouping of household clusters." The DAP interhousehold was conceived as being similar in content and organization to what Flannery (1976b:75) termed the "courtyard group," or "groups of 3 to 4 households, all sharing the same courtyard or open work space." The original DAP concepts have since been re-evaluated in light of recent studies by Wilk and Rathje (1982), Wilk (1981), and Wilk and Netting (1981). These researchers strongly advise that the household be regarded as a functional rather than a biological unit, with an emphasis on the basic economic functions necessary for survival. The DAP household, however, more closely represents the nuclear family biological unit.

The Mesoamerican households analyzed by Flannery and his coworkers (Flannery ed. 1976) are probably equivalent to "independent households" as described by Wilk (1981:9) for the Kekchi Maya. "Independent households" generally consist of a nuclear family (a married couple and their children), although an odd relative, perhaps a widowed grandparent, might be absorbed into the group as well. The members of this nuclear family household cooperate in performing the tasks necessary for meeting the basic survival needs of the group; little cooperation with other nuclear families is shown in satisfying these needs. Wilk and Rathje (1982:621-631) suggest that the basic functions of a household are subsistence-related production and distribution, reproduction, and transmission of social values, knowledge, and property to the succeeding generation. Wilk (1981:9-11) also describes "household clusters," although his use of the term refers to a social unit rather than to a unit of space as employed by Flannery and the DAP. Wilk's "household clusters" consist of several nuclear family units that usually are related through one of the parents (e.g., a married man and his

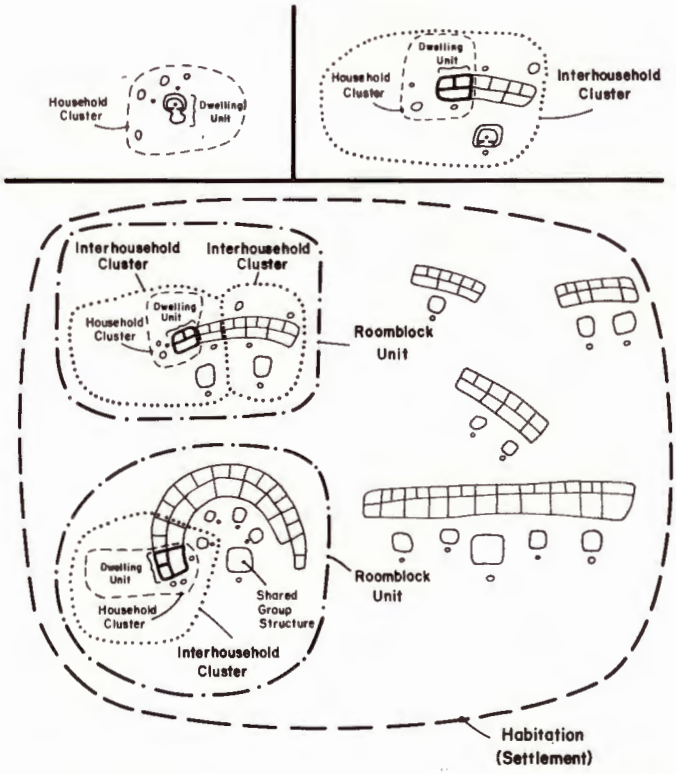

Figure 5.2 – Relationships of intracommunity spatial units above the household cluster level. Top left: Tres Bobos or Sagehill Subphase settlement containing 1 dwelling unit and 1 household cluster. Top right: Dos Casas Subphase settlement containing 1 roomblock unit and 1 interhousehold cluster with several dwelling units. Bottom: Periman Subphase settlement with multiple roomblock units containing numerous interhousehold clusters and dwelling units. Not to scale.

married sons, 2 sisters and their husbands); each family occupies a separate dwelling unit, but basic household tasks are shared by the participating family units.

The DAP term "household cluster" refers to space representing the nuclear family unit. During the Tres Bobos, Sagehill, Grass Mesa, and Marshview Subphases (A.D. 600-780, A.D. 870-910, A.D. 1000-1200), this is equivalent to the space used by an independent single nuclear family household, but represents only part of the space used by a multiple-family household later in the record. The DAP "interhousehold cluster" is appropriate when referring to the space used by the multiple-family household during the middle and late portions of the Anasazi occupation at Dolores (Dos Casas, Periman, and Cline Subphases [A.D. 760-910, A.D. 920-1000]). A more detailed description of Dolores Anasazi household organization is provided by Wilshusen (1985a).

Household cluster. In DAP site reports, "household cluster" is synonymous with the space used by a nuclear family household or a nuclear family component of a multiple-family household; it includes a dwelling unit and surrounding outside use space (fig. 5.2). During the Tres Bobos, Sagehill, Grass Mesa, and Marshview Subphases, a household cluster represents the space used by an independent nuclear family; it consists of a pithouse dwelling unit, outdoor work areas, small storage rooms or cists, and a refuse area. During the Dos Casas, Periman, and Cline Subphases, household clusters consist of roomsuite dwelling units and extramural work areas representing a nuclear family cooperating in a larger group (Wilk's "household cluster").

Interhousehold cluster. This unit represents the space used by a multiple-family household (fig. 5.2). The space may include 1 or several dwelling units, processing rooms and extrahousehold storage rooms, a plaza area, a shared pitstructure (termed a "protokiva"), peripheral extramural work areas, and a midden.

Roomblock unit or roomblock cluster. – A roomblock unit or cluster refers to aggregated groups of interhousehold clusters (fig. 5.2). During the Dos Casas, Periman, and Cline Subphases, these units typically consist

of from 2 to 25 nuclear family dwelling units arranged linearly in a single roomblock, and 2 to 8 pitstructures located in front of the roomblock. These roomblock units can be classified as small (2 to 5 dwelling units and 1 or 2 pitstructures, which together constitute 1 to 2 interhousehold clusters) or large (8 or more dwelling units and 3 or more pitstructures, which together constitute 3 to more than 10 interhousehold clusters). At McPhee Village, large roomblock clusters include oversized pitstructures with ritual feature complexes (e.g., Brisbin et al. 1985); small roomblock clusters at McPhee lack these ritually specialized structures (e.g., Kleidon 1984a). This pattern is not consistent in the project area as a whole, however. For example, at Grass Mesa Village (Lipe et al. 1985:18.140, 18.147), oversized pitstructures with ritual features were identified at both large and small roomblocks. Roomblock clusters may represent the locations of suprahousehold organizations, operating above the household and interhousehold levels. These organizations and interhousehold groups may be similar to the "corporate groups" described by Hayden and Cannon (1982). Corporate groups consist of co-residential nuclear families that might have cooperated in some subsistence activities (e.g., field clearing, harvesting, and organized hunts) and might have performed some managerial functions (e.g., land tenure, scheduling of coordinated activities, and responsibility for integrative ritual and ceremony). The appearance of large roomblock clusters in the archaeological record at Dolores after A.D. 780 may be related to increasing competition for agricultural land or the appearance of ranked leadership groups (chap. 14).

Habitation. – The definition of habitation provided here is similar to the initial concept developed in 1978: habitations (or "settlements"; these terms are used interchangeably in this chapter) are the residential centers of the community and contain the dwellings (household and interhousehold clusters), integrative structures, and other facilities and spaces integral to the community cluster (Kane 1983b:13).

Early Dolores Anasazi communities (those assigned to the Tres Bobos, Sagehill, and Dos Casas Subphases [A.D. 600-840]) generally are characterized by a habitation "zone" or core settlement area in which household clusters or interhousehold clusters are dispersed across the landscape. Each individual household or interhousehold cluster can be considered a habitation. During the Periman and Cline Subphases (roughly A.D. 840-1000), Dolores settlements are aggregated or nucleated. Such settlements usually consist of a large central habitation (or "village") with multiple roomblock clusters and specialized structures used for ritual and ceremony ("oversized" pitstructures) and an outlying network of smaller "satellite" habitations consisting of 1 or 2 roomblock units.

Community cluster. – The definition of community cluster has remained essentially the same since its introduction: a community cluster is the "space, facilities, and architecture normally used by a community" (Kane 1983b:13). Three distinct types of community clusters have been recognized in the DAP archaeological record: dispersed, dispersed/aggregated, and aggregated.

A dispersed community cluster, or "neighborhood" (Kane 1983b:13-14), consists of about 4 to 8 habitations, separated by approximately 100 to 150 m, and a complement of seasonal and limited activity sites. The constituent habitations exhibit little or no tendency toward aggregation; each habitation consists of 1 household cluster (or occasionally 2) with domestic facilities only. Special sites that served to integrate the various constituent sites within the dispersed community cluster probably existed but have not been documented in the Dolores area. Dispersed community clusters are characteristic of the A.D. 600-780 period (Tres Bobos and Sagehill Subphases and the Sagehen Phase).

In a dispersed/aggregated community cluster, also called a "neighborhood," household clusters are aggregated, but interhousehold clusters usually are not. Habitations consist of 1 roomblock unit with 2 to 6 nuclear family dwelling units and 1 to 2 pitstructures. These dwelling units and their shared pitstructures usually constitute 1, sometimes 2, interhousehold clusters. Dispersed/aggregated community clusters also contain a complementary set of seasonal and limited activity sites. Dispersed/aggregated community clusters have been documented in the Dolores Project area at sites that date to A.D. 760-820 (early Dos Casas Subphase). For example, Dos Casas Hamlet (Site 5MT2193 [Brisbin et al. 1982]) and Windy Wheat Hamlet (Site 5MT4644 [Brisbin 1984a]) are constituent settlements of dispersed/aggregated communities.

After A.D. 820, DAP community clusters can be described as aggregated or nucleated. These community clusters include central habitations, consisting of 5 to 20 roomblock units, and smaller sites located at some distance from the central habitation. The distant sites include 1 or 2 roomblock unit habitations, seasonal sites (including agricultural field houses), and limited activity loci. Apparently, aggregated community clusters developed as the result of internal growth and the influx of foreign groups (cf. Kane 1985a).

Intercommunity Units

Intercommunity units (localities, sectors, and districts) form a nested hierarchical series above the level of community. These units are administrative divisions based on topographic features; they do not reflect prehistoric use of the project area. However, some of the locality

boundaries may reflect approximate catchment limits of McPhee Phase (A.D. 840-1000) community clusters, at least for the community area containing habitation sites and adjacent agriculture plots. Sectors are spatial units intermediate between locality and district and may reflect social ties or ethnic identity above the community level. Because recognizing the presence or absence of intercommunity social units in Anasazi culture is very difficult, assigned sectors in the Dolores Project area represent spatially contiguous groups of localities.

The district is the largest unit in the DAP spatial series; this concept originally was developed by Morris (1939) and Bullard (1962) and later was modified by Gillespie (1976). Districts were established to correspond approximately to recognizable general differences in cultural patterns or to define areas in which archaeological work had been concentrated. To remove this ambiguity, Eddy et al. (1983) have suggested the term "drainage unit" be used to approximate general cultural similarities, and "district" be used to describe administrative archaeological areas. Using the scheme developed by Eddy et al. (1983), most of the Dolores Project area is contained in the Dolores Drainage Unit, with some portions in the adjacent McElmo and Monument Drainage Units. DAP site reports written from 1978 through 1982 incorporate the broader district concept; in this scheme, most DAP sites are located in the Yellowjacket District. A detailed discussion of DAP spatial units above the community level is provided by Kane (1983b:14-19); table 5.2 summarizes defined DAP intercommunity units.

Dolores Archaeological Program Temporal or Formal Series

The DAP formal series was originally presented by Kane (1983b), and the phase system was further discussed in the DAP interim synthetic report (Kane 1984a). The DAP formal series consists of 3 sets of units: basic units (episode and element), synthetic units (phase, subphase, and tradition), and integrative units (component, local sequence, and sector sequence).

The episode and element concepts are the building blocks upon which the remainder of the system rests, and they represent discrete intervals of site use. An episode is the smallest unit of time recognizable in the archaeological record. It represents brief (a few hours to a week or two), transitory use of a site by an individual or small task group for a specific purpose, often economic in nature. In contrast to an element, an episode is not associated with construction and use of major architectural facilities; however, architectural facilities abandoned by their original users during an element may be used during subsequent episodes. Episode assignments generally have been made for occupations at limited activity sites (in which case, the episode may reflect multiple periods of short-term use). Episodes also have been assigned to more specific instances of short-term use, such as intrusive burials in postabandonment deposits at sites processing substantial architecture, temporary structures and living surfaces in structure fills, and ceramic assemblages from postabandonment fills or from surfaces that represent later use.

The second building block in the system, the element, is also a discrete time interval, but it represents a period during which a structure or related group of structures was built and used. This unit was developed in part because of its applicability to the archaeological record in the Dolores area, where most of the excavation data can be provenienced by structure. Elements usually reflect the social groups that used architectural spaces; these groups are assumed to be the same groups – i.e., households or interhouseholds – responsible for economic production. Because the element is linked to architecture, assignment of these units is limited to habitation sites and to seasonal sites with structures.

The duration of an element corresponds to the uselife of its constituent structures: this is estimated to range between 10 and 30 years, and probably reflects the durability of the roof of a structure (Kane 1984a:37). Roofing material consists of timber, other perishable vegetal matter, and earth; most of these materials apparently will deteriorate beyond repair after about 30 years, necessitating replacement (McGuire and Schiffer 1983:291). Refurbishing may extend the uselife of certain structures to 50 or 60 years, and extensive remodeling or modification of a structure is usually justification for the assignment of a new element.

The definitions of the synthetic units (phase, subphase, and tradition) have not changed significantly since the original development of the formal series. The DAP phases and subphases are defined on the basis of broad similarities in cultural patterns (economic practices, architectural styles and layouts, and social organization) among communities; in terms of the DAP spatial series, phases usually include community clusters within a sector or across sectors. Phases and subphases are defined by archaeological content and hence are not strictly units of time, although all defined phases and subphases have a distribution in time. The time spans of some phases and subphases overlap.

Traditions are also defined as cultural units (Kane 1983b:26) and are similar to "full cultural traditions" or "cultures" as described by Willey and Phillips (1958:47-78) and Willey (1966:4). Traditions are defined on the basis of general similarities in adaptations, social patterns, and lifeways, and they are assumed to

Table 5.2 – Dolores Archaeological Program intercommunity units

Drainage unit	Sectors	Localities
Dolores	Escalante	Willow Draw, Salter Canyon, Yellowjacket Crest, Hoppe Point, Grass Mesa, Trimble Point, Beaver Point, Cline Crest, Periman, Sagehen Flats, House Creek, Escalante, Dolores, May Canyon, Reservoir, and Windy Ruin
	Haycamp	Haycamp Mesa, Carver, and Grouse Point
	House Creek	Hatchery, Stump, Tucker, Bean Canyon, Railroad, and Carlyle Point
	Narraguinnep	Hinchman, Summers, Long Park, Ferris, Ormiston, Lost Park, and Narraguinnep Canyon
	Doe Canyon	Five Pine and Clydia
	Bradfield	Cabin Canyon, Lone Dome, Ryman, and Williams Draw
McElmo	Totten	Ritter Draw, Simon Draw, Lakeview, Sunset, Cash Canyon, Camp Ditch, East Lakeview, and Kernan Canyon
	Hartman	Mildred, Corkscrew, Cedar Grove, Leavell, and Lebanon
	Yellowjacket	Lone Pine, Brumley, Koskie, Wilson, Lanier, Ives, Suraouro, Emmanuel, Gai, and Dove Roost
	Sandstone	Pipeline and Sandstone
Monument	None assigned	None assigned

represent ethnic groups; hence, they are not strictly temporal in nature.

Integrative units (component, local sequence, sector sequence) have also retained their original meanings. The term "integrative units" refers to combinations of basic units that can be used for spatial or temporal comparison. For example, temporal trends in local areas can be examined by comparing local sequences (sequences of components at specific community clusters), while more regional trends can be investigated through comparison of sector sequences (sequences of phases within a sector). The component is a key concept; it refers to the manifestation of a phase or subphase at a community cluster. A component consists of a set of elements and episodes assigned to sites used by a community. Single components ideally represent broadly similar behavioral patterns over a community "life span" or over a period of social and political integrity (Kane and Phagan 1981). Community clusters that demonstrate marked occupational discontinuities or major architectural remodeling (e.g., evidence of razing of roomblock units, rebuilding) are assigned several components depending on the number of these events. The component concept in its present form is an expansion of the original definition presented by Kane (1983b:25).

Phases, subphases, and traditions are combined hierarchically to form the DAP phase system. This system was originally reported by Kane (1983b:27-32), and later was expanded in the 1981 interim synthetic report (Kane 1984a:25-33). The phase scheme is used to organized the following discussion of Dolores area prehistory.

THE PREHISTORY OF THE DOLORES PROJECT AREA

This section presents a summary of the prehistory of the Dolores Project area organized according to the DAP phase system. The individual description of the phase system units presented are the final interpretations of the project data base; consequently, some changes from the original descriptions (Kane 1983b:27-32) and from those presented in the interim synthetic report (Kane 1984a:25-33) have occurred. A new phase

representing Basketmaker II occupation in the Dolores area has been added (the Cougar Springs Phase), and the date ranges for some phases and subphases have been refined. The individual discussions are basically inferential and hence are to some degree subjective. An effort was made to base the inferences on project data and on pertinent ethnographic and archaeological analogies. However, such sources are subject to varying interpretations based on the individual's own perceptions and experiences. Thus, the interpretations offered here reflect the author's viewpoint and not necessarily the views of other members of the DAP staff. The basic sources for the presentations are the analytic and modeling chapters (chaps. 2 through 4, and 6 through 16), supplemented by data from other DAP reports.

Paleo-Indian Tradition (Prior to 5000 B.C.?)

Prehistoric use of the Dolores area by Paleo-Indian peoples is suspected, but not convincingly demonstrated. One fragment of a parallel-flaked projectile point was recovered by a DAP survey crew in 1979; however, curation of this particular item by later groups cannot be ruled out. Possible Paleo-Indian occupations at site locations in the high plateau area north of the project have been reported by various authors (Bradley and King 1983:70; Hibbetts and Wharton 1980; York 1981), and a summary discussion is presented by Webster (1985:3-6). The hypothetical Paleo-Indian occupations are based on the recovery of diagnostic artifacts (Hell Gap, Concave Base A type, and Jimmy Allen projectile points, and lanceolate parallel-oblique flaked blades) from designated sites or from isolated locations. Because of the equivocal nature of the available evidence, no DAP phases have been assigned to the Paleo-Indian Tradition.

Archaic Tradition (5000 B.C. – A.D. 500)

Early Archaic occupation of the project area is undocumented, and no phase or subphase designations have been made for the early part of this tradition. More substantial evidence exists for use of the project area by prehistoric groups beginning about 2000 B.C. The late Archaic use of the project area is termed the Great Cut Phase.

Great Cut Phase (2000 B.C. – A.D. 500)

Archaeological deposits believed to be Archaic were identified at 11 intensively excavated or tested sites in the project area (chap. 1, table 1.13). The Archaic assignments were based on radiocarbon dates when available; the presence of "diagnostic" artifacts; and "lithic profiles," or characteristics of the lithic assemblages from suspected Archaic contexts (Phagan 1984 and chap. 3; Greenwald 1981). The archaeological contents of the identified Great Cut occupations suggest seasonal and nonintensive use of the project area. The pertinent contexts generally, though not always, consist of ephemeral use surfaces and a few associated pit features including small, basined, cobble-lined hearths. Artifacts recovered from the deposits are almost exclusively of stone and consist of flaked lithic tools (utilized flakes, bifaces, unifaces, choppers, and projectile points), flaked lithic debitage, nonflaked lithic tools (basin metates, one-hand manos, hammerstones), and burned igneous cobbles and sandstone fragments.

A more permanent and intensive Great Cut use of the project area was documented at Casa de Nada (Site 5MT2731; Kane et al. 1985). The remains of what might have been a small brush and daub structure and an associated outdoor work area were discovered. The occupation was dated to 1200 B.C., plus or minus a few hundred years, based on 3 radiocarbon dates. The authors (Kane et al. 1985:74-75) suggest this site might have functioned as a seasonal base camp analogous to the base camps described for the late Archaic settlement systems of northwestern New Mexico (Irwin-Williams 1973:8-10). They also suggest that other project-area Archaic occupations (e.g., at Beaver Trap Shelter [Site 5MT4654] and Singing Shelter [Site 5MT4683]) may be contemporaneous with Casa de Nada (Kane et al. 1985:69-70). Thus, use of the project area during the Great Cut Phase may have been limited to seasonal use by highly mobile groups relying on a hunting and gathering subsistence strategy. Casa de Nada might have served as a base camp from which small task groups regularly canvassed the river valley and adjacent highlands for exploitable resources.

A major problem in investigating possible Great Cut occupations is distinguishing them from nonceramic Anasazi and late prehistoric occupations. The cultural affiliation of aceramic site deposits has been one focus of DAP research; results of some of this research are presented elsewhere (Phagan 1984 and chap. 3, this volume; Dolores Archaeological Program 1985).

Anasazi Tradition (A.D. 1-1200)

Anasazi groups apparently began using the Dolores area soon after the beginning of the first millenium. Early use probably was seasonal and transitory, with permanent settlement of the river valley and the adjacent highlands occurring in the A.D. 600's. The transition from Archaic to Anasazi is thought to have occurred via colonization rather than via direct transition. Anasazi population densities reached maximum levels in the late A.D. 800's, and permanent settlement of most of the area ceased soon after A.D. 900. The river valley

and northern highlands were used as seasonal resource procurement zones by Anasazi groups settled near the southern fringe of the project area and perhaps by groups residing to the west during the A.D. 1000's and 1100's.

Cougar Springs Phase (A.D. 1-600)

The Cougar Springs Phase was established to represent use of the project area during the Basketmaker II period. Basketmaker II deposits have been encountered at only 1 DAP site (Cougar Springs Cave [Site 5MT4797]; Gross [1984a]); hence, generalizations regarding the extent of the Cougar Springs occupation, group organization, and subsistence practices are difficult to make. As only 1 Cougar Springs occupation was identified in the project area, population levels during the phase were probably low and occupations probably were seasonal or transitory.

Although no structures were identified at the cave, a fairly sizable material culture complement was recovered from Cougar Springs Cave, so some speculations regarding the cultural practices of the Basketmaker II group or groups using this particular site are possible. Investigated features included several hearths and pits; deposits of organic material, which may represent refuse cleaned from hearths; and a linear arrangement of basin-shaped bedrock pits across the front of the shelter, which may have been the foundation for a post-supported wall or a windbreak. Radiocarbon dates obtained from shelter deposits and the similarity of the shelter materials to those associated with other Basketmaker II sites in southwestern Colorado (cf. Talus Village [Morris and Burgh 1954] near Durango and Valentine Village [Eddy 1961:67-72] in the Pine River drainage) suggest the Cougar Springs group or groups occupied the shelter between A.D. 1 and 600. Gross (1984a:95) suggests the occupation dates to the late portion of the Basketmaker II period, or A.D. 375-620.

Based on the archaeological data recovered from the shelter and on archaeological analogs, Gross (1984a:96-101) postulates that the shelter was used on a seasonal basis by a small group or groups engaged in economic pursuits. Based on the relatively small size of the shelter and low feature density, the occupation was probably by 1 or 2 families or task groups (perhaps 5 to 10 individuals). Activities performed by these small groups during their stay at the shelter evidently included stone tool manufacture, milling of vegetable foodstuffs (perhaps including maize), and meal preparation and consumption.

Several classes of material items were recovered from the shelter, including flaked lithic tools, debitage, nonflaked lithic tools, raw clay, worked bone items, unworked bone refuse, and botanical remains (including uncultivated seeds and fruits, maize cobs and kernels, and charcoal from consumed firewood). The characteristics of the flaked lithic tool assemblage appear to be distinctive from DAP aceramic (mixed Archaic and Anasazi deposits) and Anasazi comparative collections. The Cougar Springs assemblage contains higher proportions of utilized flakes and lower proportions of cores, used cores and cobble tools, unifacial and bifacial tools, and projectile points than the ground aceramic assemblage. When compared to grouped Anasazi lithic assemblages, the Cougar Springs collection has more utilized flakes, bifaces, and projectile points, but fewer cores, used cores and cobble tools, and unifaces (Gross 1984a:72). Gross suggests 2 factors may be responsible for the observed variation: first, differences in lithic manufacture and use technologies among the 3 groups; and second, the emphasis on tool manufacture as a major activity based at the shelter (Gross 1984a:73). Nonflaked lithic tools present in the Cougar Springs collection include one-hand manos, a two-hand mano, basin and trough metates, hammerstones, and miscellaneous or indeterminant items. The metate fragment classified as a trough metate did not exhibit the usual trough pattern associated with Anasazi trough metates (Gross and Howes 1984:115).

Among the other materials classified as tools or modified items were 13 worked bone objects, including an awl fragment, a pointed piece, 8 gaming pieces, and several edged fragments. Also, a lump of unfired clay was recovered. This item may have functioned as a basket liner, similar to those noted by Guernsey and Kidder (1921:98) during their explorations of Basketmaker II occupations in several shelters in northeastern Arizona. Gross notes the morphological similarities between the items in the Cougar Springs collections and those from the Basketmaker II deposits at Talus Village and Valentine Village. In particular, projectile points, manos, and metates seem to be very similar morphologically (Gross 1984a:74-75).

Unworked bone refuse from the shelter included a high proportion of cottontail (*Sylvilagus* spp.) remains, and lesser proportions of bones from other animals, including squirrel (Sciuridae), beaver (*Castor canadensis*), porcupine (*Erethizon dorsatum*) and mule deer (*Odocoileus hemionus*). Wild plant remains included seeds or fruits from pigweed (*Amaranthus*), goosefoot (*Chenopodium*), pinyon pine (*Pinus edulis*), and chokecherry (*Prunus virginiana*), and charred wood fragments from pine (*Pinus* spp.), juniper (*Juniperus* spp.), scrub oak (*Quercus gambelii*), and willow (*Salicaceae*). Gross suggests (1984a:59, 97) the animal and plant remains represent local hunting and gathering forays and hunting probably was opportunistic rather than targeted at a few

species. The corn remains include inflorescences and charred kernels and cob fragments; these were recovered in proximity to hearths. Gross speculates (1984a:97) that the corn was brought with the Cougar Springs groups when they moved to the shelter; equally likely, however, the shelter occupants might have maintained small corn plots near the shelter.

In summary, Basketmaker II groups were uncommon in the Dolores area. Sampling error in the field may have resulted in an underestimation of the Basketmaker II (Cougar Springs Phase) occupation. DAP excavations in the river canyon itself were numerous and included several other shelters in addition to Cougar Springs Cave, locations that might have been preferred by Basketmaker II groups. However, except for Cougar Springs Cave, no Basketmaker II deposits were identified in the Dolores Project area. Early Anasazi use of the Dolores valley, at least in the project area, was not as intensive as that documented for other river valleys to the south and east. Basketmaker II villages with fairly substantial populations have been documented in the LaPlata, Animas, and Pine River drainages (Foster 1983; Morris and Burgh 1954; Eddy 1961:64-72). Dolores may have been a fringe area to the north and west of the main locations of Basketmaker II settlements.

Sagehen Phase (A.D. 600-840)

The Sagehen Phase was a period of large-scale immigration and population growth by the Anasazi. Settlements were dispersed, and locations with good farming soils were favored. Economic and demographic strategies usually were based on small-group organization. Most settlements were occupied by 1 or 2 households that, for the most part, probably functioned independently.

Tres Bobos Subphase (A.D. 600-700). – The Tres Bobos Subphase was the period of initial Anasazi colonization and use of the Dolores area as a permanent settlement zone. The movement of Tres Bobos groups into the project area probably was initiated in the first half of the seventh century A.D., based on the apparent settlement of Tres Bobos Hamlet (Site 5MT4545) during this period (Brisbin and Varien 1981:124-126). However, the major part of the immigration probably was delayed until the last half of the seventh century, based on tree-ring dating of other Tres Bobos occupations. For example, Pitstructure 2 at Rusty Ridge Hamlet (Site 5MT2848 [Hewitt 1983a:96-151]) apparently was constructed in the late A.D. 680's, Pitstructure 1 at Chindi Hamlet (Site 5MT4684 [Tucker 1983]) was constructed in the A.D. 670's, and Pitstructure 1 at Lone Pine Hamlet (Site 5MT2162 [Hewitt 1983b:71-95]) was built in the A.D. 690's (app. A). The seventh century movement of Anasazi groups into the Dolores area may have been part of a larger scale Basketmaker III "spread" to the north and east from a core area farther south. This speculation is supported by tree-ring construction dates in the late A.D. 600's from Basketmaker III structures investigated to the north and west of Dolores (Lux-Harriman 1982a:6.39; Gerwitz 1982:6.107; Adams 1982:6.163).

Population levels for the Tres Bobos Subphase apparently were very low when compared to other subphases. Schlanger (chap. 8, fig. 8.4) estimates a momentary household population of only 3 (about 13 individuals) for the length of the entire subphase. Of course, population levels may have been lower before A.D. 650 and higher for the A.D. 650-700 period. Most Tres Bobos settlements consisted of single household dwellings; this is in contrast with later subphases (chap. 8, fig. 8.5) and is consistent with the colonization interpretation.

Tres Bobos settlements were dispersed and apparently contained independent households; household organization appears to have been based on the nuclear family. Habitation sites may have been affiliated with other small adjacent settlements; together, these sites constitute dispersed communities or "neighborhoods" in the DAP system.

Architectural styles conform to regional Basketmaker III patterns (Hayes and Lancaster 1975; Birkedal 1976). Pitstructures are relatively shallow and D-shaped, and have an antechamber to the south. They incorporate a bench and a vertical slab wingwall with storage bins built into the southern corners. These pitstructures apparently served as the living quarters for the domestic household and hence can be termed "pithouses."

The pithouse is accompanied by a complement of surface facilities arranged in an arc west and north of the pithouse. These facilities include ramadas, extramural activity areas, and small round or oval rooms that might have had dome or "beehive" roofs. The beehive rooms might have been used for storage, although they would have provided a poorly controlled storage environment, and as locations for some auxiliary household activities. Corner hearths are present in some of these rooms (cf. Brisbin 1985b:fig. 15). Tres Bobos structures appear to exhibit less investment in materials and labor than do their 8th, 9th, and 10th century counterparts; this may reflect nuclear-family versus multiple-family household organization and subsistence strategies that incorporate a relatively great degree of mobility. Tres Bobos material culture includes ceramic vessels (gray ware jars and bowls and Chapin Black-on-white bowls), basketry and matting, flaked lithic and nonflaked lithic implements (the nonflaked lithic tool inventory includes trough metates, one-hand manos and lapstones), bone tools, and shell and bone ornaments.

To provide a comparative framework for the subphase discussions of lithic tool assemblages, some tentative correlations between social organization and lithic technologies have been postulated (table 5.3). These correlations were suggested by patterns in the lithic data sets described by Phagan (chap. 3, figs. 3.4 and 3.6; chap. 11, fig. 11.1). While Phagan does not discuss these possible relationships, some fairly consistent correlations exist between household task organization and some characteristics of the lithic data. The characteristics of the Tres Bobos lithic assemblages seem to be consistent with the expectations for societies with simply organized (nuclear family) households. The Tres Bobos flaked lithic assemblage contains low proportions of utilized flakes and high proportions of used cores and cobble tools, thin unifaces, and projectile points; the associated diversity-equitability measures are comparatively high (chap 3, fig. 3.4). The nonflaked lithic tool assemblages contain high proportions of one-hand manos and miscellaneous tools and low proportions of two-hand manos and ornaments; the associated diversity-equitability measures are comparatively low (chap. 3, fig. 3.6). The flaked-nonflaked lithic tool ratio is low when compared to those of the Dos Casas, Periman, and Marshview Subphases. In the ceramic container inventory, gray ware seed jars are in relatively high proportions compared to later subphases (chap. 2). This suggests Tres Bobos groups had a poorly developed storage facility technology and relied to a relatively large extent on vessel storage rather than on bulk storage in rooms.

Cultigens represented in Tres Bobos habitation site assemblages include corn, beans, squash, and gourd. Sagebrush, willow, pinyon and ponderosa pine, juniper, oak, and cottonwood were used in construction or for firewood. A resource mix study aimed at determining plant use diversity and relative reliance on corn (app. D) suggests the range of plant species used by Period 1 (approximately the Tres Bobos Subphase) groups was probably greater than during later subphases and reliance on corn was probably less. The validity of these interpretations could not be demonstrated statistically. Beans were recovered from a late seventh century Tres Bobos site (Chindi Hamlet, Site 5MT4684) but were absent from an early seventh century settlement (Tres Bobos Hamlet, Site 5MT4545). Perhaps beans were introduced to the area after A.D. 650.

Tres Bobos Subphase sites investigated by the DAP include Tres Bobos Hamlet (Brisbin and Varien 1981), Chindi Hamlet (Tucker 1983), Apricot Hamlet (Site 5MT2858 [Montgomery 1982]), and Poco Tiempo Hamlet (Site 5MT2378 [Brisbin 1984b]).

Sagehill Subphase (A.D. 700-780). – During this subphase, the area continued to be used by small, mobile, horticultural groups. Population levels probably remained steady or increased at low rates during most of the subphase; Petersen indicates that the Dolores area had "neutral" attractiveness for potential immigrants during the first half of the eighth century A.D. (chap. 4, sect. 6, fig. 4.25). However, after A.D. 750 or 760, the area became highly attractive, and immigration increased. Thus, while Schlanger (chap. 8, tables 8.5 and 8.9) estimates the momentary population level during Period 2 (Sagehill and early Dos Casas Subphases) at 37 households, and suggests a relatively high growth rate between Period 1 (Tres Bobos Subphase) and Period 2 (0.0266 percent/annum), these figures probably reflect increased rates of immigration after A.D. 750. Also, Schlanger's figures include early Dos Casas resident groups (cooperating family household organization) as well as Sagehill groups. Prior to A.D. 750, the Sagehill population probably was very sparse, with momentary population levels averaging less than 20 households. Sagehill settlements (single family farmsteads or "hamlets") have been recorded in the Sagehen Flats area (for example, Sagehill Hamlet [Site 5MT2198] and Prairie Dog Hamlet [Site 5MT4614]; Hewitt [1983c] and Yarnell [1982a], respectively) and through the length of the river valley proper (for example, Sagehill occupations have been recorded at LeMoc Shelter (Site 5MT2151 [Hogan 1983]), Grass Mesa Village (Site 5MT23 [Lipe et al.. 1985:18.8-18.16]), and Pozo Hamlet (Site 5MT4613 [Nelson 1984]). Thus, the general distribution of Sagehill settlements may have been more widespread in the project area when compared to the previous Tres Bobos Subphase; Tres Bobos settlements seem to be absent from the northern part of the project area.

The Sagehill occupation at Grass Mesa consisted of 12 pithouses (dwellings) and a larger pitstructure possibly serving as an integrative facility (Pitstructure 93). Additional Sagehill structures might have been present, but, if so, were not discovered by the field crews (Lipe et al. suggest that momentary household levels at the site were between 22 and 35 [1985:18.74]). Again, population levels were probably lower during the first part of the subphase and higher later.

The basic economic, demographic, and organizational strategies practiced by Sagehill groups remained unchanged from the Tres Bobos Subphase (nuclear-family household organization, dispersed settlements with single household clusters, and loose ties at the community level). Architectural styles, however, underwent several major changes: pitstructures were deeper, subrectangular rather than D-shaped, and lacked benches. The Basketmaker antechamber was replaced with a ventilator system. Surface structures include rectangular rooms with four-post roof-support systems and Tres

Bobos-style "beehive" rooms; these rooms are noncontiguous and are arranged in an arc west and north of the pithouse.

Other material culture apparently was similar to the preceding Tres Bobos Subphase. Lithic assemblages in general exhibit characteristics indicative of simple organization (table 5.3), although there were a few exceptions. The flaked lithic toolkit has relatively high proportions of used cores and cobble tools, thin unifaces, and thick bifaces, and low proportions of utilized flakes (chap. 3, fig. 3.4); proportions of projectile points are lower than anticipated. The diversity and equitability measurements are relatively high (chap. 3, fig. 3.4) and thus are consistent with the expectations in table 5.3. The nonflaked lithic assemblages (chap. 3, fig. 3.6) have low proportions of two-hand manos, hafted items, and ornaments, and high proportions of one-hand manos, which is consistent with organizational expectations; proportions of miscellaneous items were unexpectedly low, however. The nonflaked lithic diversity-equitability measures and flaked/nonflaked lithic tool ratio are low, which is compatible with expectations. Red ware vessels probably were introduced into the ceramic inventory during the Sagehill Subphase. Also, the proportions of seed jars in ceramic collections decreases, perhaps reflecting a shift in storage practices from vessel storage to bulk storage in surface rooms (chap. 2).

Subsistence resources exhibit little change during the Sagehill Subphase; cottontail, jackrabbit, and other small mammal remains are common in Sagehill deposits, while the large mammal fraction is dominated by mule deer. The results of the resource mix study presented in appendix D suggest that diversity in utilized plant species perhaps was lower during the Sagehill Subphase than during the Tres Bobos Subphase and perhaps was on a par with later subphases. Also, dependence on corn probably was less than during later subphases. However, the validity of these interpretations could not be demonstrated through application of statistical tests, so they must be regarded as speculation only.

Sagehill Subphase sites excavated by the DAP include LeMoc Shelter, the earliest well-documented occupation (Site 5MT2151 [Hogan 1983]), Prairie Dog Hamlet (Site 5MT4614 [Yarnell 1982a]), Sagehill Hamlet (Site 5MT2198 [Hewitt 1983c]), and Pozo Hamlet (Site 5MT4613 [Nelson 1984]). Grass Mesa Village (Site 5MT23) also contained a substantial Sagehill Subphase component (Lipe et al. 1985:18.8-18.13). The Sagehill manifestation at this particular site is noteworthy because of the aggregation of household clusters (the earliest recorded aggregation of population in the project area) and the presence of large integrative pitstructures.

Dos Casas Subphase (A.D. 760-840). – This period is marked by sweeping changes in architecture, settlement patterns, and social organization. The Tres Bobos-Sagehill pattern of nuclear family household organization is replaced by a more complex unit consisting of several cooperating nuclear families. Settlements originally were dispersed, although several of the large villages (McPhee [multiple site numbers], Rio Vista [Site 5MT2182], and House Creek [Site 5MT2320]) recorded in the project area apparently were founded during this period and may have contained quite substantial resident populations. Also, a large early Dos Casas occupation, including a great kiva, was at Grass Mesa; however, population levels declined after A.D. 825 (Lipe et al. 1985:18.16-18.20). A project-wide trend of movement of most dispersed groups to the large central villages is evident late in the period. Settlements characteristically contain 1 or 2 roomblocks, each containing 1 to 2 interhousehold clusters and 2 to 6 nuclear family dwelling units. Whether this shift in basic social organization was a transition by indigenous groups or whether the shift reflects a second wave of migrants already possessing complex household organization is not possible to say with certainty. The evidence seems to strongly favor the latter alternative. Very few, if any, sites might be considered "transitional," and regional climatic patterns during the period favor migration into the Dolores Project area (Schlanger 1985 and chap. 8, this vol.).

The generally favorable climate during the subphase (chap. 4, sect. 6) probably was conducive to internal growth as well as to immigration. The figures supplied by Schlanger (chap. 8, table 8.5) suggest that momentary population levels in the project area were over 50 percent higher during Period 3 (A.D. 800-840, late Dos Casas Subphase) than during Period 2 (A.D. 720-800, Sagehill and early Dos Casas Subphases). Two of the largest settlements, Grass Mesa Village (Site 5MT23) and Rio Vista Village (Site 5MT2182), both in the northern part of the project area, were either established or exhibited rapid population expansion during the first half of the subphase (before A.D. 800), based on tree-ring dates from structural timbers. However, these 2 villages apparently suffered an unexplained (by lack of documented climatic stress or agricultural production shortfalls) population decline in the late part of the subphase (after A.D. 825). McPhee Village and House Creek Village, both in the central part of the project area, may have been established in the A.D. 820's or 830's. The population from Grass Mesa and Rio Vista may have moved to the new village locations. Much of the early Dos Casas project population resided in small farmstead "hamlets," such as Dos Casas Hamlet (Site 5MT2193 [Brisbin et al. 1982]) and Windy Wheat Hamlet (Site 5MT4644 [Brisbin 1984a]). Settlement longevity apparently increased during the Dos

Table 5.3 – Household organization – lithic assemblage correlations

	Simple organization (nuclear family households)	Complex organization (cooperating nuclear family households)	Intrahousehold task group organization (seasonal agricultural occupations)
Flaked lithic tool proportions	High proportions of specialized tools (used cores/cobble tools, unifaces, projectile points); low proportions of expedient tools (utilized flakes)	Low proportions of specialized tools (used cores/cobble tools, unifaces, projectile points); high proportions of expedient tools (utilized flakes)	High proportions of expedient tools (utilized flakes)
Flaked lithic tool diversity, equitability	High	Low	Very low
Nonflaked lithic tool proportions	Low proportions of agriculturally and architecturally specialized tools (two-hand manos, hafted items) and ornaments; high proportions of general-purpose tools (miscellaneous tools, one-hand manos	High proportions of agriculturally and architecturally specialized tools (two-hand manos, hafted items) and ornaments; lower proportions of general-purpose tools (miscellaneous tools, one-hand manos)	High proportions of task-specialized tools
Nonflaked lithic tool diversity, equitability	Low	High	Very low
Flaked lithic/nonflaked lithic tool ratio	Low	High (reflects high proportion of expedient flaked-lithic tools (utilized flakes))	Low (reflects high proportions of specialized nonflaked lithic tools)

Casas Subphase. While Tres Bobos and Sagehill structures generally exhibit only slight evidence of refurbishing, ample evidence is present for renovation of Dos Casas structures, including wingwall reconstruction and replacement of vertical support posts (cf. Brisbin 1984a:fig. 29). Also, the stratigraphic relationships between some superimposed Dos Casas pitstructures indicate the newer ones were built soon after abandonment of the older ones. Some Dos Casas settlements were probably inhabited for 2 to 3 generations (30 to 50 years) rather than for 1 to 2 generations, as was the case for the Tres Bobos and Sagehill Subphases.

Domestic architecture exhibits several major changes in construction techniques, form, and function during the Dos Casas Subphase. Habitation sites consist of a double-row surface roomblock containing several spatially distinct but contiguous roomsuite apartments (usually 2 smaller rear, or northern, rooms serving as crop storage facilities and auxiliary work areas, and a larger, southern room functioning as a habitation or living room), 1 or more pitstructures shared by the interhousehold unit for domestic and integrative ritual functions, a shared plaza area, and a refuse midden to the south of the architectural complex. Construction costs associated with Dos Casas and Periman Subphase dwellings are greater than those associated with their Tres Bobos and Sagehill analogs (see discussion in architecture section). Wilshusen (1984) believes pitstructure and roomblock construction of these interhousehold units are very closely linked, with the earth excavated from the pitstructure serving as construction material for room walls. Much greater investment in storage technology is evident during this and subsequent periods, compared to Tres Bobos and Sagehill storage facilities (Gross and Wolf 1984; Gross, chap. 13, this volume). This greater attention to storage facilities is manifested in the adoption of rectangular, corner-post-supported storage rooms as standard architectural facilities in place of the beehive form common during the Tres Bobos and Sagehill Subphases, and the attachment of these rooms to the rear (north) of

habitation rooms, which provided better security, easier access, and a more controlled storage environment. Also, Dos Casas storage rooms exhibited more sturdy construction in the form of a foundation course of slabs or horizontal stone masonry, or, in some cases, the lower portion of the walls was of stone masonry, while the upper portion was of jacal or daub.

Changes in the functions of various types of structures can be summarized as follows: Surface rooms and other surface structures during the Dos Casas Subphase were primary locations for nuclear family activities, including food storage, rather than incipient storage and auxiliary activity locations, as they were during earlier periods. Dos Casas Subphase pitstructures served as foci of interhousehold domestic and ritual activities, rather than as dwellings for nuclear family households. "Oversized" pitstructures (greater than 30 m^2 in floor area) containing ritually oriented features probably first appeared near the end of the period (chap. 14). These particular structures are though to have functioned as interhousehold facilities and as managerial-ritual locations for roomblock "corporate group" organizations above the household level. That the Dos Casas groups possessed sophisticated engineering skills and were capable of impressive building achievements is demonstrated by the great kiva at Grass Mesa village (Lightfoot 1984; Lightfoot et al. 1985:7.51-7.112). This tremendous structure (for the times) was built at approximately A.D. 800; it had over 400 m^2 of roofed area and was roofed through a complex system of vertical and horizontal supports. It was probably used for community or intercommunity integrative group ceremonies.

Material culture and subsistence practices also appear to exhibit some major changes. In ceramics, the proportion of large seed jars decreases significantly, probably reflecting increased reliance on bulk storage of corn and other produce in the back rooms in the surface pueblos (chap. 13). Neckbanded cooking and storage jars appear for the first time as well as Piedra Black-on-white vessels. Flaked and nonflaked lithic toolkits remain mostly unchanged as far as individual tools represented in the kits are concerned, but proportions of various tools do show some directional changes (chap. 3, figs. 3.4 and 3.6). In the flaked lithic tool assemblages, used cores and cobble tools decrease in frequency during the Dos Casas Subphase, and frequencies remain comparatively low during succeeding periods, while utilized flakes increase in frequency. This seems to be consistent with a trend toward a more "expedient" approach to flaked lithic technologies during the later periods. Both the diversity and equitability of flaked lithic toolkits decrease during the Dos Casas Subphase (chap. 3, fig. 3.4); this is interpreted as reflecting a lesser emphasis on flaked lithic tools and probably the activities they represent (chiefly animal procurement and animal product processing).

The other subphases characterized by complex household organization (Periman and Cline) also exhibit comparatively low diversity and equitability indices. The nonflaked lithic toolkit also exhibits some changes during and after the Dos Casas Subphase. Proportions of large hafted tools and ornaments increase, possibly reflecting the increased importance of wood preparation for construction and the greater complexity of social relationships during the later periods. Nonflaked lithic toolkit diversity and equitability exhibit trends opposite those recorded for flaked lithic tools (chap. 3, fig. 3.6). These indices are higher for the organizationally complex Dos Casas and Periman Subphases than for the Tres Bobos and Sagehill Subphases.

This trend probably reflects more of an emphasis on nonflaked lithic tool technologies, and on the activities such technologies reflect (preparation of plant products, especially cultivated grains), during the later periods. These shifts in stone tool technologies may be correlated with changes in basic economic organization; that is, the shifting technological emphasis from flaked to nonflaked lithic tools may be associated with the change from nuclear family household organization to multiple family household organization noted during the Dos Casas Subphase. This hypothesis is supported by the comparison of the measurements for the Grass Mesa Subphase flaked and nonflaked lithic tool assemblages versus those for the other periods. The Grass Mesa Subphase is a later period characterized by nuclear family household organization (see Grass Mesa Subphase discussion); the relevant measurements are more similar to the organizationally simple Tres Bobos and Sagehill patterns than to the organizationally complex Dos Casas, Cline, and Periman Subphases (compare chap. 3, figs. 3.4 and 3.5). Thus, the household organizational changes described for the Dos Casas Subphase probably are associated with lithic toolkit and subsistence change as well. The direction of the change is probably from a subsistence strategy based on exploitation of multiple food sources to one emphasizing production of agricultural produce, especially corn.

The botanical data also exhibit some changes consistent with those noted for architecture and tools. In chapter 7, it is concluded that greater use of cultigens began during Modeling Period 2 (see chap. 1 for an explanation of modeling periods) and continued into the later periods (except Period 7) based on the comparative ubiquity of cultigen remains in fire-related features. The Period 2 data base consists of both Sagehill and Dos Casas Subphase contexts but is probably biased toward the latter because of the inclusion of materials

from comparatively large sites such as Dos Casas Hamlet (Site 5MT2193) and Windy Wheat Hamlet (site 5MT4644). New varieties of corn may also have been introduced during the Dos Casas Subphase. This speculation is based on the possibility that 14- and 16-row corn appear during Periods 2 and 3, probably during the Dos Casas Subphase (chap. 4, sect. 2, table 4.10). The sample for Period 1 is too small to permit a definite statement. The evidence for pioneer plants generally parallels the cultigen group, although there is a lower ubiquity index for Period 2 (chap. 7). Pioneer plants may have been deliberately encouraged by agricultural groups as a supplement to crop produce. Thus, an increase in the use of pioneer plants (again measured as ubiquity in fire-related features) is interpreted as indicating increased reliance on agricultural subsistence strategies (chap. 7), However, a separate resource mix study (app. D) suggests no significant changes in plant use occurred during this time and that noncultural factors might have been largely responsible for the variability in this data set. Analysis of the animal bone data did not reveal any significant changes in faunal procurement practices during the modeling periods that coincide with the Dos Casas Subphase as compared to earlier periods (chap. 7).

The DAP investigated numerous sites with Dos Casas Subphase occupations. Among the more noteworthy in terms of subsistence report coverage are the second recorded occupation at LeMoc Shelter (Site 5MT2151 [Hogan 1983]), a major occupation at Grass Mesa Village (Site 5MT23 [Lipe et al., comps. 1985]), Periman Hamlet (Site 5MT4671 [Wilshusen 1983]), Dos Casas Hamlet (Site 5MT2193 [Brisbin et al. 1982]), Windy Wheat Hamlet (Site 5MT4644 [Brisbin 1984a]), Pheasant View Hamlet (Site 5MT2192 [Yarnell 1982b]), Cascade House (Site 5MT4512 [Wilshusen 1982a]), and the second occupation at Aldea Sierritas (Site 5MT2854 [Kuckelman 1983]).

McPhee Phase (A.D. 840-1000)

The McPhee Phase was the period during which the growth/aggregation trends initiated during the previous Sagehen Phase culminated. The population in the project area peaked in the middle to late A.D. 800's and then swiftly declined in the last 20 years of the 9th century and in the early decades of the 10th century. By A.D. 1000, the river valley itself and the plateau areas to the east and west were abandoned as settlement zones; only the Reservoir and Escalante Village areas on the southern fringe of the project area remained permanently inhabited into the 11th and 12th centuries. McPhee Phase communities were aggregated or nucleated, with most of the population based in large, central villages consisting of multiple roomblock units. The villages were fairly evenly distributed along the flood plain of the river valley and on the mesas to the east and west.

Periman Subphase (A.D. 840-910). – Climate continued to be generally favorable during the first half of the Periman Subphase; indigenous population levels continued to rise as a result of both internal growth and immigration (chap. 8).

Population probably reached a peak in the 20 years between A.D. 860 and 880. Schlanger estimates that as many as 1250 people were present in the "Dolores area" (the project takeline) at any time during the late 9th century (chap. 8, table 8.5). This estimate is based on rubble mound measurements, the conversion of rubble area to number of dwelling units, and the uselives of the structures that make up the dwelling units. Intuitively, this estimate seems low given the total amount of architecture evident in the villages of the period and climatic reconstructions (chap. 4, sect. 6) that indicate little subsistence stress on the indigenous population during this period.

An alternative approach based on roomblock length measurements and a different set of assumptions is presented in chapter 14. This alternative calculations suggest a momentary population of 3000 to 4000 individuals in the "Dolores area" during the A.D. 860-880 period. The alternative estimate appears more reasonable in terms of predicted subsistence stress. Schlanger (chap. 8, table 8.4) suggests a potential peak population of about 6500 individuals, based on estimated yields of the prehistoric agricultural system and assuming reliance on corn as a dominant crop and a 50-percent fallow cycle. More likely, stress would have occurred if population levels were 50 or 60 percent of maximum potential numbers rather than the 20 percent estimated by Schlanger.

Increasingly unfavorable and unpredictable climatic conditions, the result of consecutive years of drought and crop failures due to killing frosts, prevailed in the last part of the ninth century (chap. 4, sect. 6). Assuming the population estimates based on roomblock length are reasonably accurate, then the local villages would have been faced with a series of worsening production shortfalls beginning in the late A.D. 860's and continuing into the first decade of the 10th century (Wolf 1985b). The latest tree-ring dates representing the nucleated village occupation in the project area are in the A.D. 880's, which suggests abandonment began in that decade.

Other supporting evidence (ceramic dates, archaeomagnetic dates, architectural and depositional stratigraphy) suggest that, without exception, the Periman Subphase villages were totally abandoned by A.D. 910

or 920 (refer to, for example, Kane [1985a]). Thus, the abandonment is viewed as a gradual and drawn out event rather than a sudden, hasty exodus. The temporal correlation between the advent of unfavorable and unpredictable climate and the abandonment of the Dolores area has been interpreted as cause and effect by the Dolores staff (chap. 16).

During the Periman Subphase, the "interhousehold" (a cooperating group of several nuclear families linked by co-residence in the same architectural complex and probably by kin ties as well) continues to be the unit responsible for most domestic and economic tasks. The architectural manifestations of the interhousehold are similar to their Dos Casas Subphase analogs: the interhousehold cluster consists of several nuclear family apartments in a contiguous roomblock, and a shared plaza area, pitstructure, and midden. The surface roomblock exhibits more substantial construction; more stone masonry was incorporated into the exterior and interior walls. This is most evident in storage room construction, where the walls often are of hybrid construction – the lower meter or so consists of horizontally laid sandstone slab masonry, while the upper portions consist of jacal construction (Morris 1984:36, fig. 18).

Interhousehold clusters are incorporated into larger roomblock units; the latter vary greatly in size and contain from 2 to more than 20 nuclear family dwelling units. This aggregation of household architecture into larger complexes suggests social organization above the household level was a prominent force within Periman Subphase communities. Such suprahousehold organization might be equivalent to corporate groups as described by Hayden and Cannon (1982). Their probable presence at Dolores implies that unencumbered land in the local area was becoming scarce and competition for croplands probably occurred.

In addition to the control and transmission of land holdings, Hayden and Cannon (1982:147) cite education, worship, sacrifice, and economic affairs as potential responsibilities of corporate groups. Suprahousehold groups also control specialized structures within the residential area to conduct group-oriented activities. At Dolores, such specialized architecture is thought to consist of oversized pitstructures containing ritual features (Wilshusen 1985b; Kane 1985b; and chap. 14). Horseshoe-shaped roomblocks may also be activity centers for suprahousehold organizations within Periman Subphase communities (chap. 14). The presence of corporate groups may imply status categories within the late ninth century Dolores villages. Although the evidence for ranking and stratification within Dolores communities is equivocal, Kane (chap. 14) suggests a correlation between proximity to corporate group facilities and economic well-being (measured as the relative sizes of household structures); however, examination of individual household clusters did not suggest any great variations in material wealth based on feature and artifact content (chap. 14).

In addition to large aggregated villages, which probably functioned as the centers of management and commerce as well as the primary residences for most of the populace, Periman Subphase communities also included smaller satellite settlements and agricultural field houses removed from the central village. Each community probably had a territory centered on the large village settlement; the Thiessen polygon territories developed and analyzed by Orcutt (1985) are an archaeological approximation of these community areas. The Periman Subphase settlement pattern reflects a logistically organized system in which resources and goods move to central consumer locations (cf. Binford 1980:10-12). It is probably a more extreme variant of such a system than those of earlier subphases, which incorporated greater degrees of mobility. Kane (chap. 14) suggests competition between village centers for population and resources was based on the spacing between centers and the ranked size distribution of settlements. The Dolores-area Periman villages may have shared an intercommunity ritual-integrative facility – the Singing Shelter great kiva (Nelson and Kane [1985]). The presence of this structure suggests the local villages may have participated collectively in certain rites and ceremonies. Blinman (chap. 15) suggests the Singing Shelter great kiva may have replaced the Dos Casas Subphase great kiva at Grass Mesa Village. Thus, the local center of intercommunity interaction may have shifted from the northern villages to the central portion of the river valley. This shift is consistent with the speculation regarding the possible movement of population from the Grass Mesa and Rio Vista areas to the McPhee and House Creek areas during the late Dos Casas Subphase (refer to the Dos Casas Subphase discussion).

The Dolores-area Periman villages exhibit a high degree of homogeneity in architectural and ceramic styles. This homogeneity suggests the local communities may have participated in an "alliance"; strong political and economic ties may have existed among the higher status groups of the larger settlements (cf. Plog 1983:310-311).

Material culture and subsistence practices generally seem to conform to those of the preceding Dos Casas Subphase, although evidence indicates some "intensification" in subsistence activities and organization. In ceramics, new types introduced during the period include Mancos Gray and sherd-tempered red wares. Proportions of individual tool types in the flaked and nonflaked lithic tool assemblages are similar to those during the Dos Casas Subphase, except for a significant

increase in the proportion of two-hand manos (chap. 3, fig. 3.6). The diversity and equitability measurements for the Periman flaked and nonflaked lithic assemblages are very similar to those for the preceding Dos Casas Subphase, perhaps indicating a general similarity in lithic tool technologies and applications (chap. 3, figs. 3.4 and 3.6). Compared to the other subphases, the diversity and equitability measurements for these 2 periods are relatively low for the flaked tool lithic assemblages and high for nonflaked lithic tools. Thus, the characteristics of the Periman Subphase lithic assemblages generally conform to the expectations for complex organization (table 5.3).

The faunal and botanical data for the Periman Subphase (chap. 4, sect. 4; chap. 4, sect. 2; chap. 7) do not readily lend themselves to interpretation in terms of possible trends in subsistence practices. Part of the difficulty is due to incompatibility of the temporal units used for the analyses. The analysts employed modeling periods rather than subphases as temporal increments to provide compatibility with the modeling effort. In converting modeling period to subphase, Period 4 (A.D. 840-880) is roughly equivalent to the earlier 2/3 of the Periman Subphase, but Period 5 combines the last 1/3 of the Periman Subphase and the Grass Mesa Subphase. The resource mix study presented in appendix D suggests no significant changes in plant use occurred during the Periman Subphase but that use of corn apparently was greatest during the Dos Casas and Periman Subphases.

The Periman Subphase represents the climax period of trends in population, organization, and subsistence practices initiated in the previous periods. Indigenous population levels probably reached their peak in the 2 decades between A.D. 860 and 880, fueled by successful internal reproduction and by continued immigration from outside the Dolores area; peak population for prehistoric Dolores is estimated to have been between 3000 and 4000 individuals. Domestic (household) organization remained stable and consisted of several cooperating nuclear families constituting an "interhousehold." Organization above the household level increased in importance and complexity due to the increasingly aggregated population distribution. The appearance of nucleated village centers necessitated more complex managerial organizations and special facilities to carry out leadership and integrative functions. Subsistence practices and resource mix during the early part of the period appear similar to the previous Dos Casas Subphase, except there may have been additional agricultural intensification. After A.D. 880, dramatic changes occurred in all aspects of local culture, perhaps in response to worsening climate (in terms of agricultural potential). Population levels declined drastically between A.D. 880 and 910, probably reflecting immigration to other areas, chiefly to the west and south of the project area. Remnant groups apparently retained the traditional interhousehold domestic structure in the southern portion of the project area, but groups at Grass Mesa (Site 5MT23) and Rio Vista (Site 5MT2182) Villages seem to have reverted to a simple nuclear family organization. This shift in organizational strategies has been termed the Grass Mesa Subphase (see following discussion). Subsistence strategies during the late part of the Periman Subphase might have featured a higher proportion of wild plant and animal food sources, a greater reliance on pioneer plants, and less emphasis on corn agriculture. Such strategies might have been necessary to buffer or supplement the increasingly unreliable agricultural base.

The DAP invested the greatest proportion of field labor in investigating Periman Subphase archaeological contexts. Most efforts were spent at 2 of the large village sites, Grass Mesa Village (5MT23) and McPhee Village (multiple site numbers), but substantial excavations were conducted at other Periman Subphase sites as well. Investigations at Grass Mesa and McPhee Villages are reported in 2 separate DAP volumes (Lipe et al., comps. 1985; Kane and Robinson 1985a). Investigations at 2 smaller villages (Rio Vista and House Creek; Sites 5MT2182 and 5MT2320, respectively) and at the Singing Shelter Periman Subphase great kiva are described in a separate volume (Kane and Robinson 1985b). Excavations at smaller, outlying Periman Subphase settlements and at affiliated field houses were conducted at LeMoc Shelter (Site 5MT2151 [Hogan 1983]), Prince Hamlet (Site 5MT2161 [Sebastian 1983]), Hanging Rock Hamlet (Site 5MT4650 [Gross 1984b]), Hamlet de la Olla (Site 5MT2181 [Etzkorn 1983]), Dovetail Hamlet (Site 5MT2226 [Nelson 1985]), Kin Tl'iish (Site 5MT2336 [Dohm and Gould 1985]), Little House (Site 5MT2191 [Hewitt 1983d]), and Hawk House (Site 5MT4681 [Brown 1981]).

Grass Mesa Subphase (A.D. 870-910). – Worsening climate in the last decades of the 9th century and in the first portion of the 10th century (chap. 4, sect. 6) led to some sweeping lifestyle changes within the Dolores Anasazi communities. While some members of the Dolores staff (e.g., Orcutt chap. 10; Matthews chap. 4, sect. 2) have presented a case for continued organizational and subsistence intensification, an alternative case can be made for simplification ("deintensification"), diversification, and out-migration as the responses in some areas. The Grass Mesa Subphase is viewed as one cultural response in this period of stress and can be characterized as a "shift to a lower-overhead, lower-investment, higher-mobility adaptation" (Lipe et al. 1985:18.100). Based on the limited data from excavated sites, the Grass Mesa Subphase expression may have been confined to the northern half of the project area.

Excavated Grass Mesa contexts are confined to the Rio Vista Village (5MT2182) and Grass Mesa Village (5MT23) areas and to a few seasonal sites. It appears that coeval prehistoric groups in the southern portion of the project area chose to maintain traditional forms of organization and subsistence (their manifestation is classified as Periman Subphase), while most of the northern residents chose to simplify organization and diversify subsistence (Lipe et al. 1985:18.108-18.112).

Apparently, both the northern and southern portions of the project area lost population at a rapid rate after A.D. 880 (Kane [1985a] and Wilshusen [comp. 1985;596]). An exception was the Grass Mesa site itself, which may have gained population during the A.D. 880's (Lipe et al. 1985:18.78). The population gain at Grass Mesa Village may represent a coalescence of northern groups at this site. By employing calculations based on estimated pitstructure lifespans and total number of pitstructures, Lipe and his associates arrived at high (about 250) and low (about 150) momentary total household estimates for the Grass Mesa Subphase occupation at the Grass Mesa site (1985:18.82-18.83). Based on ceramic deposition rates (Kohler 1985), the lower range of the estimates presented by Lipe et al. is more realistic. Given an estimated average of 150 households per year during the Grass Mesa Subphase, the deposition rate of sherds per household would be less than 1/3 of what it was during the preceding Periman Subphase, based on the figures supplied by Kohler (1985:fig. 3.6). A number of possible explanations would account for this phenomenon, including differential breakage rates, a shift in behavior associated with ceramic artifacts, a shift in settlement patterns, or overestimation of the average number of households. Kohler (1985:3.32-3.34) cites a shift in subsistence patterns and a related greater emphasis on offsite activities as a possible alternative explanation. However, the rate of household sherd deposition for Period 2 (A.D. 720-800) (628 sherds/household/year), when households are thought to have been relatively highly mobile and therefore comparable to Grass Mesa households, is more than twice that of the Grass Mesa Subphase. This suggests that overestimation of the average number of households may be a better explanation; it may have been that the average number of Grass Mesa households during the early part of the period (A.D. 880-890) approximated the lower estimate presented by Lipe and his associates (for instance, 125 to 150 households), and that population rapidly declined after A.D. 890.

The extent of the Grass Mesa Subphase occupation outside the Grass Mesa site was not well investigated. Wilshusen (comp., 1985:table 92) identified only 3 Grass Mesa Subphase household clusters at Rio Vista Village. However, the site was not completely excavated, and smaller, outlying settlements were not subjected to investigation. Even allowing for the possible presence of undetected household units, average momentary population for Rio Vista was likely less than 10 households for the A.D. 880-900 period and less than 5 households after A.D. 900. It is questionable whether the Grass Mesa pattern of organization and subsistence was adopted at more than a few of the other northern Dolores ninth century settlements. The magnetometer reconnaissance of Cline Crest Village suggests the subsurface pattern of architecture was similar to McPhee village and thus probably conformed to the Periman Subphase type. Even less of a statement can be made concerning the contemporary late ninth century occupation at Windy Ruin, although the village contains a horseshoe-shaped roomblock, and hence may be organizationally more similar to the Cline Crest and McPhee Communities. Stronger leadership groups at these communities may have acted to preserve traditional forms of household and corporate group organization. Downstream (northwest) of the Grass Mesa site, a substantial Grass Mesa occupation has been recorded at LeMoc Shelter (Hogan 1983:153-162), and possible occupations are present at Prince Hamlet and Hanging Rock Hamlet, based on the presence of post-abandonment use surfaces and features in the fills of Periman Subphase pitstructures. However, these occupations appear to have been seasonal. Most of the Grass Mesa Subphase residential structures likely were built at the Grass Mesa site, with small Grass Mesa occupations at a few of the other northern river valley settlements. Given the apparent increase in average momentary populations at Grass Mesa Village in the A.D. 880's, some of the outlying Periman Subphase population within the Grass Mesa Locality and other nearby areas (for example, at the Hanging Rock Hamlet and Prince Hamlet sites) may have moved to the former location. Total average population for the Grass Mesa Subphase was perhaps 150 ± 30 households (600 to 800 individuals) for the early part of the assigned period (A.D. 870-890) and much lower after A.D. 890.

In addition to the just-described population upheavals in local communities, some major changes in other lifeways also are evident during the Grass Mesa Subphase. While some of the project staff (chap. 7) have chosen to interpret these changes as "intensification" consistent with the economic model of change at Dolores (chap. 6), it might be more suitable to characterize the changes as diversification and simplification. To present some expectations that contrast with those derived for the economic model, an alternative "extensification" model is presented here. For both models, the factors responsible for the change are the same: increasing subsistence and social stress resulting from continuing high population levels in the face of worsening and more unpredictable climate. Wolf's (1985b) agricultural production simulation study suggests that a series of

production shortfalls began in the A.D. 860's and became more severe in the A.D. 870's and 880's. These "bad times" must have stimulated some major cultural responses. The economic model suggests "intensification" would be a preferred strategy; more effort would be expended in increasing the yield from existing food sources, and alternate, more costly sources would be tapped as well. Intensification would necessitate increased managerial overhead to coordinate and direct the increased subsistence effort. The extensification model postulates a combination of strategies to cope with increased subsistence and social stress. These are, first, a shift to alternate subsistence resources, primarily animals and wild and ruderal plants, and less reliance on corn agriculture; second, increased mobility and more flexible organization; and lastly, reduction in social overhead and control. In many respects, the extensification strategies are a regression to the Tres Bobos and Sagehill lifestyles. Expectations for the extensification model can be derived for trends in architecture, social organization, tools and containers, and subsistence resources. These expectations are presented in table 5.4, and are discussed and evaluated in the following presentations of Grass Mesa Subphase architecture, social organization, and material culture, although no formal statistical procedures were used to test the validity of the expectations.

Several shifts in Grass Mesa subsistence-related and organizational practices are indicated by the architectural data. Domestic architecture exhibits a number of different forms, with the high degree of variability representing a significant departure from the Periman pattern of uniformity/conformity. Household dwellings variously consisted of: (1) roomsuite complexes where the front (south) rooms functioned as habitation rooms and the rear (north) rooms as storage facilities (a continuation of the traditional Periman pattern); (2) surface room complexes where the original back rooms served as habitation rooms and the former front rooms were modified into ramadas or outdoor work areas; (3) small pithouses with associated isolated surface rooms; and (4) pithouses without associated surface structures (Lipe et al. 1985:18.152-18.155). This suggests some groups, albeit a minority, maintained the traditional "interhousehold" form of domestic-economic organization, while most groups shifted to a more independent form with less direct cooperation among nuclear families.

In many ways, the organization of the latter groups probably was similar to the early Tres Bobos-Sagehill ("Basketmaker III") type of organization characterized by economically independent nuclear family households. These small, autonomous household units are thought to have practiced a subsistence strategy featuring diversity of exploited resources and a relatively great degree of mobility.

Grass Mesa Subphase households probably cooperated to a comparatively greater degree with other neighboring households in economic and social functions, based on the relatively close spacing of household clusters at the Grass Mesa site and the apparent clustering or spatial ordering of these units (Lipe et al. 1985:18.58-18.65,18.152-18.155). The feature assemblages common to Grass Mesa Subphase pitstructures suggest that internal activities were almost exclusively domestic or economic in nature; ritually oriented features are often absent in these structures (Lipe et al. 1985:18.45), or, if present, are usually in the form of simple sipapus or clusters of paho marks. This is in marked contrast to the Periman Subphase, when ritual feature complexes were ubiquitous in pitstructures. This again suggests the breakdown of organization at the interhousehold level and the increasing independence of nuclear family units. Lipe et al. (1985:18.155) suggest that some Grass Mesa Subphase households residing in small "pocket pithouses" may have been associated with remnant Periman Subphase interhouseholds. If so, the more autonomous Grass Mesa nuclear family households might have maintained social affiliations with these more traditional groups and might have accessed their facilities.

The DAP identified and investigated a structure (Pitstructure 32) that apparently functioned solely as a ritual/ceremonial location for the Grass Mesa Subphase populace (Varien 1985:4.344-4.357; Lipe et al. 1985:18.156-18.157). Pitstructure 32 is "oversized," comparable in floor area to the earlier Periman oversized pitstructures at Grass Mesa, and lacks floor-associated features and artifacts indicative of domestic activities. The structure also lacks most ritual feature complexes common to Periman Subphase oversized structures; however, cylindrical, sand-filled pits that may be equivalent to the "altar anchors" identified in Periman pitstructures were identified on the floor of Pitstructure 32 (refer to architecture discussion in this chapter and to Wilshusen [1985:27-35]). The floor area is also noteworthy for its low density of features and artifacts of any sort. The low density of floor-associated features and materials suggests the structure could have been used for large group assemblages or coordinated activities with only few restrictions on membership. In this respect, Pitstructure 32 is more similar to then-contemporary great kivas than to Periman Subphase oversized structures, which are characterized by relatively "cluttered" floors and formally structured, immovable feature complexes.

Based on this difference, Lipe et al. (1985:18.156-18.157) have suggested a restructuring of ritual patterns

Several ceramic types (Mancos Gray, Cortez Black-on-white, McPhee Black-on-red, and other sherd-tempered red wares) are introduced into the archaeological record or increase markedly in frequency during the Grass Mesa Subphase. These changes apparently are regional and are not related to the adaptation shifts characterizing the subphase. They are valuable, however, in temporal and cultural assignment of excavated and survey-recorded site deposits.

The flaked and nonflaked lithic tool data also exhibit some changes probably related to adaptational shifts. In the flaked tool collections, the proportions of projectile points and nonlocal raw materials increase through time at the Grass Mesa site. Phagan (1985:14.33) argues the increase may be due to more frequent visits to distant areas by Grass Mesa residents after A.D. 840, and especially after A.D. 880, probably in conjunction with long-distance hunting. This interpretation is consistent with the model of increased subsistence diversity during the Grass Mesa Subphase. In the nonflaked lithic tool assemblage, frequencies of some agriculture-associated tools, such as two-hand manos, hammerstones, and used cores/cobble tools, increase during the Grass Mesa Subphase (chap. 3, fig. 3.5; chap. 11, fig. 11.2). This change might be interpreted as indicating intensification of agriculture (hammerstones and used cores/cobble tools were perhaps used to shape and maintain manos and metates). However, the proportions of other nonflaked lithic tools that have agricultural applications (trough metates and miscellaneous nonflaked lithic tools) decrease, which renders interpretation of the data equivocal. Although Phagan (chap. 11) argues that proportion of trough metates is not a good indicator of subsistence strategies, arguing for agricultural intensification based on an increase in two-hand manos and a decrease in trough metates seems difficult. Most of the smaller portable nonflaked lithic tools (e.g., manos, hammerstone, used cores) probably had multiple purposes, and therefore, increases in their proportions cannot be said to directly indicate intensification. Lipe et al. (1985:18.105-18.106) argue the changes may be due instead to shifts in settlement behavior and seasonality. This seems a reasonable explanation; with the partial dismantlement of the field house system, more plant-processing activities would have been based at the principal residence. Also, organizational changes may have affected the composition of lithic toolkits. During the Periman Subphase, a large proportion of agricultural produce processing was performed by the interhousehold in the shared pitstructure facility (refer to the discussion of architecture in this chapter). With the dissolution of the interhousehold during the Grass Mesa Subphase, the entire burden of food processing would have reverted to the nuclear family household; hence, household nonflaked lithic tool inventories would have to be augmented to accommodate the additional processing demands.

Some whole-assemblage measurements of the lithic data also have implications for interpretation of subsistence strategies. Grass Mesa Subphase ratios of flaked lithic tools to nonflaked lithic tools are much lower during the Grass Mesa Subphase than during the preceding 2 periods (chap. 11, fig. 11.1). This might superficially be interpreted as an increase in plant processing and agricultural "intensification" (see chap. 11 and Lipe et al. [1985:18.103-18.105]). However, the expectations for this ratio seem to be the reverse of what might intuitively be expected, given the established trends in organization and subsistence based on other data sources. The flaked tool/nonflaked tool ratio is relatively low for the Tres Bobos and Sagehill Subphases (characterized by simple organization and generalized subsistence) and relatively high for the Dos Casas and Periman periods (characterized by complex organization and agriculturally dominated subsistence). Thus, this ratio is more difficult to interpret than a first perusal would indicate (table 5.3). Probably more significantly, the Grass Mesa Subphase ratio is closer to the Tres Bobos and Sagehill values than to those for the Dos Casas and Periman Subphases. The Grass Mesa Subphase diversity and equitability measurements reflect the patterns thought to be indicative of a generalized resource adaptation; that is, flaked lithic assemblages are characterized by relatively high Shannon-Wiener diversity and equitability indices, while the nonflaked lithic tool indices are comparatively low. For both the flaked and nonflaked lithic tool indices, the relevant Grass Mesa Subphase values are closest to the comparable values for the Tres Bobos and Sagehill Subphases (chap. 3, figs. 3.4 and 3.6). However, the low diversity index for the Grass Mesa Subphase reflects in large part the high proportion of two-hand manos, while the high indices for the Tres Bobos and Sagehill Subphases are in part due to the high proportions of miscellaneous tools.

The faunal and botanical remains are more difficult to interpret, partly because of the difficulty in quantifying such data. The faunal data suggests that hunting and reliance on animal resources increased during the Grass Mesa Subphase. This interpretation is based on an increase in the ratio of total number of bones deposited per household for the Grass Mesa Subphase compared to the preceding Periman Subphase and on an increase in the bone to sherd ratios between the Periman and Grass Mesa screened midden collections (Neusius and Gould 1985:fig. 15.10); sherds were chosen as an index based on the assumption of fairly stable rates of deposition through time.[2] The straightforward interpreta-

[2]Kohler's (1985:table 3.7) figures suggest a sharp decline in sherd deposition rates during the Grass Mesa Subphase, which would affect this interpretation.

tion of these measurements is that more animals per household were being processed and consumed during the Grass Mesa Subphase. The analysts responsible for the Grass Mesa data urge caution regarding the certainty of this interpretation and suggest some possible complicating factors (Neusius and Gould 1985:15.135-15.136; Lipe et al. 1985:18.99).

The botanical data contain some nuances that can be used to support the extensification model, although other interpretations are possible. Matthews (1985) analyzed and reported on the botanical remains recovered during archaeological investigations at the Grass Mesa site and found the abundance and ubiquity of pioneer plants (those species adapted to recently disturbed areas, including agricultural fields) and of wild plants increased during Periods 4 and 5 (A.D. 840-880 and A.D. 880-920, respectively; or roughly equivalent to the Periman and Grass Mesa Subphases). Lipe et al. (1985:18.94) suggest increased limitations on arable land during the Grass Mesa Subphase (due to cooler climate) might have hampered corn agriculture and caloric requirements were being met by a shift to greater reliance on pioneer and wild plants. Also, in chapter 7, a slight decrease in the ubiquity of corn and an increase in the ubiquity of wild plant remains were noted for Period 5 (late Periman Subphase and Grass Mesa Subphase). Although in chapter 7 this shift is interpreted as intensification, given the direction of the changes, the apparent increased dependence on wild and pioneer plants and decreased dependence on corn in the Grass Mesa Subphase portion of the Period 5 data, could be viewed as support for the extensification model. The separate resource mix study presented in appendix D supplies some supporting evidence for the extensification model regarding use of corn during Period 5. Grass Mesa Subphase hearths contained significantly less corn than contemporaneous Periman hearths (app. D, table D.2), although the significance of the difference is weak. In this study, no diversification of the botanical resource base during the subphase was identified. In chapter 4, section 2, it is suggested that late Periman and Grass Mesa Subphase agriculturalists may have deliberately chosen to grow more 10-row corn (perhaps similar to a Pima-Papago variety), although most corn remains were of the 12-row variety (perhaps related to the Chapolote type). This increase in 10-row corn is suggested to reflect intensification because the hybrid would be more productive in terms of yield, although less storable. However, Anasazi 10-row corn also probably was more hardy in terms of resistance to cold. Thus, it seems equally likely that the Grass Mesa groups may have selected planting mixtures with greater proportions of 10-row corn as a means of coping with cold years. Less storability would be a favorable trade-off, given the lesser dependence on stored resources by Grass Mesa groups. The latter interpretation is consistent with the extensification model.

The Grass Mesa Subphase is viewed as representing shifts in organizational and subsistence strategies in response to worsening and more unpredictable climate and an associated "squeeze" on arable lands accessible to northern project-wide communities. In terms of organization, the indicated response apparently was a shift to a simpler and more flexible economic organization and a reduction in the overhead associated with social institutions. Economic organization was vested in the nuclear family household as opposed to groups of cooperating, co-resident families. A return to nuclear family organization probably resulted in more freedom and flexibility in terms of resource procurement scheduling and economic mobility. Reduction in overhead associated with social institutions was accomplished by eliminating or reducing the influence of the intermediate groups between the household and the community. Roomblock-level groupings of household dwellings were not present during the Grass Mesa Subphase, and interhousehold-level groups were highly variable in size, form, and spacing of dwellings (Lipe et al. 1985:18.158). It appears that some groups residing at the Grass Mesa site retained the cooperating family-interhousehold form of organization into the A.D. 880's. Lipe et al. (1985:18.159) speculate the remaining interhousehold groups may have been the ones with access to the best remaining agricultural lands who thus were able to maintain traditional forms of subsistence and organization. Of the perhaps 150 contemporaneous households in the A.D. 880's, approximately 30 maintained formal interhousehold architectural affiliations, and the other 120 were only loosely affiliated or were independent. After A.D. 890, virtually all households were of the simple nuclear family type. Thus, the remaining groups were freed of the overhead necessary to maintain the higher-order groups. This overhead would have been in the form of specialized architecture and portable artifacts (white and red ware serving vessels, large cooking pots, items of personal adornment) used at group rituals and gatherings.

Domestic architecture during the Grass Mesa Subphase was much simpler and less costly in terms of materials and labor investment. Dwellings consisted of small "pocket" pithouses rather than roomsuites in surface pueblos and shared interhousehold pitstructures. In addition to simplified social organization, the new forms of domestic architecture also suggest increased mobility for the Grass Mesa households, which probably spent more time away from the central settlement and exploited a larger territory in attempting to compensate for the loss of agricultural produce. The lack of specialized storage architecture during this subphase suggests that storage of agricultural produce was no longer

an important facet of subsistence practices. The architectural data and inferred forms of social organization for the subphase appear to support the extensification model rather than the intensification model. Apparently, less investment in architectural facilities was made, and suprahousehold institutions generally were less influential, even to the point of being dissolved in some cases.

The artifact data also appear to lend more support to the extensification model, although not without exception. Ceramic assemblages feature a higher proportion of gray wares, which suggests more of an emphasis on domestic cooking and storage and less on group activities and potlucks. The lithic assemblages exhibit the low nonflaked lithic tool and high flaked lithic tool diversity measurements thought to be characteristic of simply organized, subsistence-diversified societies. An increase in two-hand manos during the subphase might suggest agricultural intensification; however, this is not accompanied by a complementary increase in metates. Phagan (chap. 11) interprets a decrease in the flaked tool to nonflaked tool ratio as intensification; however, low flaked tool proportions appear to be characteristic of organizationally simple, subsistence-diversified groups at Dolores, if one considers the entire record (table 5.3).

The faunal and botanical data bases are not as readily useful in terms of evaluating the models, and the results must be considered equivocal. Hunting may have increased during the subphase, an interpretation based on the increase in the amount of scrap bone in material collections. The expectation of greater wild and pioneer plant diversity given more flexible subsistence strategies could not be verified. Less corn was probably used by Grass Mesa households than by contemporaneous Periman Subphase groups at other project-area villages. Also, Grass Mesa and late Periman groups may have chosen to plant increased amounts of a type of corn characterized by greater resistance to cold and better yields but less storability. While some DAP staff interpret the changes in the botanical data base as intensification (chap. 4, sect. 2), the data appears just as easily to support the extensification model.

By far the most fieldwork involving the investigation of the Grass Mesa Subphase was accomplished at the Grass Mesa Village site. Investigations at Grass Mesa Village are reported in a single volume (Lipe et al., 1985), where a different overview of the Grass Mesa Subphase is presented. Other substantial Grass Mesa occupations were investigated at Rio Vista Village (Site 5MT2182 [Wilshusen 1985]) and at LeMoc Shelter (Site 5MT2151 [Hogan 1983]). Prince Hamlet (Site 5MT2161 [Sebastian 1983]) and Hanging Rock Hamlet (Site 5MT4650 [Gross 1984b]) might have been the locations of less intensive Grass Mesa occupations based on the discovery of features and surfaces in abandoned Periman Subphase structures, but these phenomena may date to a later period.

Cline Subphase (A.D. 920-1000). – The Cline Subphase represents a middle-10th-century reoccupation of the southern portion of the project area. Most of the Cline expression was centered at McPhee Village, where the reoccupation apparently was confined mainly to 3 of the former Periman roomblock units. A second Cline settlement was recorded at Kin Tl'iish (Site 5MT2336 [Dohm and Gould 1985]), east of the river and about 4 km south of McPhee Village. Possible seasonal Cline occupations have been documented at LeMoc Shelter (Site 5MT2151 [Hogan 1983]) and at Casa Roca (Site 5MT2203 [Brisbin 1982]). Possible limited activity use of several other sites in the Dolores Project area by Cline groups has also been documented.

Originally, the Cline Subphase was assigned an A.D. 900-975 date range. The revised A.D. 920-1000 date range introduced here is founded on the discussion of the McPhee Village occupation by Kane (1985a), in which it is suggested that a short hiatus in village occupation occurred between A.D. 910 and 920. Evidence for a hiatus consists of archaeomagnetic and ceramic dates and on the stratigraphic sequence of construction and abandonment. Also based on the archaeomagnetic and ceramic dates, the Cline occupation may have extended beyond the original A.D. 975 date, perhaps into the A.D. 980's or 990's. The Cline occupation mirrors the trends in relative attractiveness of the Dolores area reconstructed by Petersen (chap. 4, sect. 6, table 4.43); these trends were based on climatic reconstructions for Dolores and nearby areas. The A.D. 900-920 period is characterized as very unattractive, and this corresponds to the proposed occupational hiatus. The A.D. 920-940 period is thought to have been relatively attractive, and it corresponds to the period of influx of the Cline population. The A.D. 940-980 and A.D. 980-1025 periods are characterized as unattractive and correspond to, first, declining population within the Cline settlements, and then to abandonment of the project area by Cline groups.

Momentary population levels during the Cline Subphase were drastically reduced in comparison to the preceding Periman and Grass Mesa Subphases. Brisbin et al. (1985:498) estimate that 9 household clusters or dwellings were used throughout the duration of the Cline occupation of McPhee Pueblo. The extent of the Cline occupation at other village roomblocks is less clear. At Masa Negra Pueblo (Site 5MT4477), Kuckelman (1984a:274) estimates that at least 4 and perhaps additional household dwelling units were present during the Cline Subphase. These domiciles probably were

abandoned before A.D. 950, based on an estimated A.D. 930 date of construction and lack of evidence for remodeling. The Cline occupation at the Site 5MT4476 roomblock probably had at least 2 and perhaps as many as 4 to 6 household dwellings; the Cline occupation at this site probably was confined to the first half of the subphase (A.D. 920-950). Thus, Cline Subphase populations for the village area probably were about 15 to 20 households, or 75 to 100 individuals, for the first half of the subphase, and 8 to 9 households, or 40 to 45 individuals, for the last part of the subphase. Outside the village area, the only Cline settlement excavated by the DAP was at Kin Tl'iish. Dohm and Gould (1985:290, 297-298) suggest the Cline occupation dated between A.D. 900 and 950 and consisted of 2 small pitstructures and associated surface rooms. Assuming a ratio of 2 to 3 households per pitstructure. The Cline occupation of Kin Tl'iish may have consisted of 4 to 6 households.

A search of the DAP site survey file for additional potential Cline Subphase settlements bears out the original interpretation that indigenous population levels in the project area were comparatively very low during this subphase. The search yielded only 10 additional habitation sites within the project takeline assigned to a 10th or 11th century occupation and yielded Cortez Black-on-white sherds (the presence of Cortez Black-on-white would suggest a 10th rather than an 11th century occupation, based on the assumed manufacturing dates for this ceramic type; refer to figure 2.11 in chap. 2). Five of the recorded probable Cline occupations are at the Reservoir Ruin complex (also referred to as "Reservoir Village"), which suggests a substantial Cline occupation at this large, predominantly late Pueblo II-early Pueblo III residential and ceremonial center (see Sundial Phase discussion). The Reservoir Ruin complex is near the southern limit of the project area, on the bluffs that overlook the main portion of the project area and river valley to the north. Also, a possible small Cline occupation settlement is located on the north side of the river opposite the main part of Reservoir Village; by virtue of its location, this settlement probably was closely associated with the village. North of this southern fringe area, only 4 possible small Cline settlements were identified by the survey crews. One is west of the river on the highlands south of the Sagehen Flats area and may have been associated with the Cline occupation at McPhee Village or with an unknown settlement complex located to the south. Two of the small settlements are located a few kilometers west of the McPhee Village area and may have had affiliations with the latter. The last possible Cline occupation settlement is at Cline Crest Ruin (Site 5MT2663), a large, predominantly Periman Subphase settlement roughly 5 km northwest of McPhee. Based on the presence of early Pueblo II ceramics at one of the Cline Crest roomblocks, this settlement may have been the location of a Cline Subphase reoccupation similar to the one investigated at McPhee, albeit on a smaller scale. All small, survey-recorded Cline occupations north of Reservoir Village probably consisted of 2 to 4 households each, based on the suspected presence of single roomblocks with 1 or 2 associated kivas.

Considered together, the excavation and survey data suggest a sparse, low-density indigenous population during the Cline Subphase. The McPhee and Reservoir Village areas may have served as local centers of population and group interaction. If the fringe Reservoir Ruin settlements are excluded from estimates, momentary population levels during the early part of the subphase probably were about 30 to 40 households total (150 to 200 individuals) in the project area north of Reservoir Ruin; late in the subphase, momentary population probably was 15 to 30 households (75 to 150 individuals). If the fringe Reservoir Village settlements are included, the early Cline population was probably in the neighborhood of 50 to 70 households (250 to 350 individuals) and the late population perhaps consisted of 40 to 60 households (200 to 300 individuals). Apparently, the northern and eastern portions of the project area (east of the river, north of Reservoir Village) were abandoned except for seasonal resource exploitation during the Cline Subphase.

Architecture, organization, and subsistence practices generally conformed to the "Pueblo II"pattern as presented in other treatments of Anasazi culture (e.g., Morris 1939:33-35). The traditional McPhee Phase set of architectural facilities (surface rooms in a contiguous roomblock and pitstructures in a plaza area to the south of the roomblock) continues as the main physical manifestation of Cline settlements, although there are several noteworthy changes in construction techniques, morphology, and function. Pitstructures, at least in morphology, appear to have been generally equivalent to "kivas." They were generally circular in outline, incorporated a bench or banquette and a ventilator, and had a roof supported by 4 vertical posts set near or into the walls of the structure. Thus, they were different in form from the previous Periman Subphase pitstructures, which were subrectangular in outline and generally lacked benches. Several other significant changes were present as well. The Cline Subphase pitstructures lacked the Periman-style wingwall that effectively divided the pitstructure main chamber into northern and southern rooms. Also, Cline pitstructures lacked the ritual feature complexes (vaults or complex sipapus, altar anchors, and prayer stick marks) commonly encountered in Periman pitstructures (refer to Periman Subphase discussion). The Cline "kivas," while generally conforming to the "normal" description

just presented, did exhibit a range of architectural variability that seems subjectively greater than their Periman predecessors. For example, some Cline pitstructures (specifically, Pitstructures 4 and 8 at McPhee Pueblo (Site 5MT4475 [Brisbin et al. 1985:461-479 and figs. 116 and 153]) were subrectangular rather than circular, probably because they incorporated portions of abandoned Periman Subphase structures. Also, the location and extent of the bench was variable: Pitstructure 5 at Masa Negra Pueblo (Kuckelman 1984a:fig. 41) incorporated a bench around the southeastern half of the structure, while Pitstructure 8 at McPhee Pueblo had a bench only on the west side. Pitstructure 1 at McPhee Pueblo (Brisbin et al. 1985:fig. 147) incorporated a more "normal" Pueblo II full-circumference bench. Other variations include a partial wingwall in Pitstructure 8 at McPhee Pueblo, a Periman-style complex sipapu in Pitstructure 5 at Masa Negra Pueblo, and possible altar anchors in Pitstructure 2 at McPhee Pueblo. The variability seems to indicate that, while Cline pitstructures in general conformed to Pueblo II "kiva" morphology, in some cases they retained some Pueblo I/Periman Subphase characteristics.

These morphological changes probably are related to some basic changes in function as well. Cline Subphase structures lack the formal mealing areas common to Periman pitstructures, although mealing tools are represented in some of the floor assemblages. The density of floor-associated domestically oriented artifacts, especially storage vessels and nonflaked lithic tools, is much lower when compared to Periman Subphase analogs. Most domestic tasks appear to have been relegated to the roomblock area and the pitstructures generally were reserved for more specialized activities including ritual activities, craft manufacture, and production and maintenance of some tools. The kiva functional interpretation is a generalization. Some Cline pitstructures (for example, Pitstructures 5 and 8 at McPhee Pueblo) yielded floor assemblages with high densities of domestic tools and other "household" furniture. Thus, some pitstructures may have retained a more traditional partial domestic function during the Cline Subphase. Pueblo II kivas usually have been interpreted as primarily "ceremonial and integrative" in function (cf. Morris 1939:34 and Gillespie 1976:86-188). Thus, it seems somewhat contradictory that the elaborate ritual feature complexes common in Periman Subphase pitstructures were not maintained in the Cline "kivas." The discontinuation of the maintenance of the Periman ritual complexes indicates a shift in the type and orientation of ritual/ceremonial activities rather than their removal. The proposed shift would be in the direction of mobile group activities requiring relatively large amounts of open space (e.g., dances), rather than the stationary activities implied by the relatively high feature density, cluttered Periman pitstructures surfaces.

The surface roomblocks north of the plaza-pitstructure area maintained the crescent shape, north-south axis orientation, and double-room row arrangement characteristic of the preceding Periman Subphase. Cline surface room facilities in general appear to have incorporated more coursed stone masonry into room walls than did their Periman predecessors. This trend toward more substantial construction is most evident in the post-A.D. 950 roomblock at McPhee Pueblo. Late Cline Subphase room construction at this roomblock unit featured sturdy walls, usually consisting of large sandstone blocks set in mud mortar. The rear wall of the surface pueblo consisted of blocks and slabs set crosswise in the wall, which substantially increased its massiveness and stability.

The function and spatial organization of individual room facilities within the roomblock generally seem to have remained similar to the patterns evident during the Periman Subphase. Front rooms generally served as the domestic centers for households, while back rooms maintained their traditional function as primary storage facilities. One apparent functional change was the incorporation of mealing stations into some of the rear rooms. For example, Rooms 1, 3, 8, and 78 at McPhee Pueblo (Brisbin et al. 1985:figs. 94, 99, 103, and 112) are back rooms that incorporate at least 1 mealing station (as indicated by the presence of metates). The distribution of the rooms containing mealing stations (one such room per household apartment) suggests these facilities were primarily accessed by household groups. Two of the rooms (Rooms 3 and 78) have only 1 mealing station, while the other 2 (Rooms 1 and 8) have multiple mealing stations; this suggests the latter 2 rooms may have been facilities shared by more than 1 household unit or by several grain processors from the same household.

The patterns of Cline Subphase architecture suggest the traditional Periman form of domestic/economic social organization remained virtually intact during the Cline Subphase. Most, if not all, activities and technologies necessary for economic survival apparently were organized at the nuclear family (household) or cooperating family (interhousehold) level. The retention of the contiguous family apartments and shared pitstructure pattern suggests the interhousehold continued to be the critical social unit in economic production. Higher level organization probably was less structured and less of a factor in everyday life during the Cline Subphase than it was during the organizationally complex late ninth century (Periman) occupation. The drastic decline in local population levels between the Periman and Cline Subphases probably meant the pressure on agricultural

lands inferred for the Periman period was relaxed. Hence, the major impetus for formation and maintenance of corporate groups was no longer a factor. The Cline population apparently continued to use a logistically oriented resource exploitation system incorporating seasonally used camps and agricultural field houses. The DAP excavated a Cline Subphase field house in the Sagehen Flats area in 1979 (Casa Roca; refer to Brisbin [1982]); also, a seasonal Cline occupation, perhaps a base camp, was identified at LeMoc Shelter in the northern part of the project area (Hogan 1983:162-174, 232-233). Small aggregated population centers (settlements with multiple-roomblock units) probably served as the social and ceremonial centers for outlying settlements. This speculation is supported by the presence of larger-than-normal pitstructures (Pitstructure 2 during the early part of the Subphase, Pitstructure 1 during the late part of the subphase; refer to Brisbin et al. [1985:447-461, 590-608]) at McPhee Pueblo. These structures may have served as the locations for local social interchange and ceremony. Reservoir Village may have been another such center during the Cline Subphase.

If the Cline Subphase groups at Dolores maintained the interhousehold form of economic organization, as implied by the associated architectural patterns, then it might be inferred that the Cline groups relied on traditional means of subsistence as well. The interhousehold form of domestic organization should be associated with a relatively great dependence on corn agriculture as a primary subsistence means and with suitable tool and container inventories (table 5.3). This hypothesis can be tested through an evaluation of the associated material culture, including the lithic tool and ceramic container data sets and the faunal and botanical remains.

Measurements of the lithic tool data (chap. 3, figs. 3.4 and 3.6) are ambiguous in terms of support or nonsupport of the hypothesis. Cline Subphase flaked lithic tool assemblages are similar in composition to those of other subphases characterized by agricultural dependence and organizational complexity (the Dos Casas and Periman Subphases [table 5.3]); they contain relatively high proportions (greater than 40 percent) of utilized flakes and relatively low proportions of used cores/cobble tools and high-production-input tools (e.g., thin unifaces, specialized forms, and thin bifaces). Proportions of projectile points, however, are higher in Cline Subphase assemblages than predicted by the hypothetical relationships in table 5.3. The equitability and Shannon-Wiener diversity measurements for the Cline Subphase flaked lithic tool assemblages (chap. 3, fig. 3.4) are consistent with the high agricultural dependence model. While both measurements are somewhat higher than the comparable Dos Casas and Periman indices, they are more similar to these subphases than to the organizationally simple Tres Bobos, Sagehill, and Grass Mesa Subphases.

The measurements for Cline Subphase nonflaked lithic collections are more ambiguous in terms of the organization-lithic assemblage correlations suggested in table 5.3. In general, the proportions of tool types within the assemblages seem consistent with the expectations for an organizationally complex, highly agriculturally dependent society. Proportions of two-hand manos, large hafted items, and ornaments are relatively high, and proportions of one-hand manos are low, which is consistent with the expectations. However, the equitability and Shannon-Wiener diversity indices (chap. 3, fig. 3.6) are comparatively low and similar to the corresponding Tres Bobos and Sagehill indices, contrary to the hypothetical relationships proposed in table 5.3. Flaked lithic tool to nonflaked lithic tool proportions (chap. 11, fig. 11.1) for the subphase more closely resemble the earlier "nonintensive" Tres Bobos and Sagehill values (although they are not as extreme as the Grass Mesa index) than they do the "intensive" Dos Casas and Periman values.

The characteristics of the Cline Subphase nonflaked lithic assemblages are not easily interpreted, but do contain some characteristics (high proportions of two-hand manos, large hafted items, and ornaments) thought to reflect complexly organized, agriculturally dependent groups. The flaked to nonflaked lithic tool ratio suggests closer overall affinities to the generalized subsistence pattern; however, as previously discussed (refer to Periman Subphase presentation), this measurement is probably not amenable to simple interpretation.

The treatment of ceramic containers (chaps. 2 and 12) is germane to this argument. However, these discussions are primary restricted to Modeling Periods 1 through 5 (A.D. 600-920), both because the available data sets for other periods were very small, and because the pre-A.D. 920 record was most important in terms of the modeling effort. Consequently, only portions of the presentation are useful here.

Blinman's specific discussion of food storage in ceramic vessels (chap. 12, fig. 12.1) suggests Cline Subphase groups continued to rely heavily on bulk cultigen storage in specialized room facilities, rather than on storage in containers; this inference is based on the low proportion of vessels thought to be used for storage of dry and perishable materials in the Cline collections (e.g., seed jars). Blinman also presents estimates of dietary reliance on agriculture based on the ratios of cooking jars to bones and cooking jars to bowls in the assemblages for individual periods (chap. 12, figs. 12.2 and 12.3).

Cline Subphase groups apparently relied to a greater extent on animal food sources than did the preceding Periman groups, based on substantial increases in the animal bone/cooking jar sherd ratio in Cline collections. However, Cline groups also apparently maintained a high reliance on agricultural products based on a continued high ratio of cooking jar sherds to bowl sherds; Blinman's calculations indicate this ratio did not fluctuate much between Modeling Periods 4, 5, and 6 (A.D. 840-980). This ratio may be affected by other factors, and the surface interpretation given here must be tempered with caution. The ratio might be affected by the frequency of "potluck" rituals (requiring serving bowls) and the size of the group for which food is being prepared (larger groups would require larger vessels, which would increase the volume of jar sherds but not the number of actual vessels). The effect of these factors on the relevant ratios could not be judged.

Post-A.D. 920 (Cline Subphase) ceramic collections also differ markedly in presence or absence and proportions of certain types. Corrugated gray ware vessels appear in the record for the first time. Mancos Gray sherds are more abundant than Moccasin Gray; the number of Mancos Gray sherds was augmented by clapboarded sherds from "hybrid" partially corrugated, partially neckbanded vessels (chap. 2). Cortez Black-on-white became the predominant white ware type, Piedra Black-on-white continues to be present, and Mancos Black-on-white is present, but rare; the Mancos Black-on-white sherds probably are attributable to the late portion of the Cline Subphase (post-A.D. 950). These shifts in ceramic types apparently are unrelated to the described change in demography, organization, and subsistence.

Blinman's interpretations (chap. 2) are not well supported by other measurements of the Period 6 (Cline Subphase) faunal data, however. Based on variations in the regression of bone against sherds for the modeling periods, it is suggested in chapter 7 that Periods 4 and 5 may have been characterized by less reliance on total fauna; thus, Period 6 groups may have relied on faunal resources to a greater extent than their large village predecessors. However, Period 6 was longer than Periods 4 and 5, and hence, the difference may reflect length of the deposition period rather than cultural variation. The results presented in chapter 7 cannot be used to verify another of Blinman's (chap. 12) interpretations, that reliance on large game increased during the Cline Subphase.

Also in chapter 7, a series of Period 6 (Cline Subphase) botanical measurements is presented and discussed (figs. 7.8-7.13). Ubiquity measurements (figs. 7.8-7.10) suggest that reliance on corn was relatively low and that use of pioneer plants also was somewhat low, but reliance on wild plants was very high. A different series of measurements, based on ratio of number of plant remains to number of sherds (figs. 7.11-7.13) produced results that did not provide much consistency with the ubiquity measurements. Reliance on corn during Period 6 does appear to be relatively low. On the surface, then, the botanical data do not support the hypothesis of Cline Subphase high agricultural dependence. The resource mix study presented in appendix D, which was designed to control for some noncultural variability in the botanical data set, also suggests that reliance on corn may have been somewhat less during the Cline Subphase than during previous periods, although the differences between periods were not significant. Plant family diversity, which should reflect general dependence on wild and pioneer plants, apparently did not increase during the Cline Subphase. In its entirety, then, the botanical data suggests decreased dependence on corn during the Cline Subphase and, possibly, more frequent use of wild plants. These results tend to contradict the high agricultural dependence hypothesis.

The material culture data provide only equivocal support for the hypothesis that Cline Subphase groups were relatively highly dependent on agriculture, consistent with the interpretation of complex household organization. The Cline flaked lithic tool assemblages are consistent with the complex organization patterns outlined in table 5.3. However, the nonflaked lithic assemblages, perhaps more crucial in terms of measuring reliance on agricultural produce, are more ambiguous in terms of the hypothesis. While some tool proportions are consistent with the complex organization patterns described in table 5.3, the associated diversity and equitability measures are more compatible with the simple organization-diversified subsistence pattern. The ceramic data seem consistent with the high dependence hypothesis. No clear conclusions could be drawn from the faunal data, although one line of evidence suggests that use of faunal resources may have increased during the Cline Subphase, a finding at odds with the hypothesis. Although the botanical data are very difficult in terms of controlling for noncultural factors and in terms of identifying consistent patterns, reliance on corn likely decreased during the Cline Subphase in comparison with the previous Periman Subphase, and use of wild plants may have increased.

Thus, the applicable data in its entirety cannot be interpreted as providing strong support for the model of high agricultural dependency. This suggests some internal variability probably exists in the patterns outlined in table 5.3 and that complex household organization may not be consistently indicative of an economy with high agricultural dependence. Certain circumstances may result in a more flexible economy

with more emphasis on wild plant and animal resources. For example, the Cline Subphase groups were not faced with subsistence competition from nearby settlements, and native wild animals and plants might have reclaimed some of their former range after the exodus of the Periman and Grass Mesa groups and hence may have been more accessible to the Cline groups. While the lithic data from individual subphases seem to generally support the patterns outlined in table 5.3, the suggested correlations between complex household organization and agricultural dependency and simple organization and subsistence diversity are not consistently supported by the data. Evidently, the Dolores Anasazi groups were flexible in their economic pursuits when permitted by circumstance. Competition among neighboring communities and human pressures on native fauna and flora may have limited subsistence options in periods of high population density and resulted in more consistent conformance with the idealized patterns formulated in table 5.3.

More detailed descriptions of Cline Subphase architecture and material culture are provided in the appropriate individual site reports. For the McPhee village area, these include McPhee Pueblo (Site 5MT4475 [Brisbin et al. 1985]) and Masa Negra Pueblo (Site 5MT4477 [Kuckelman 1984a]). Other DAP reports containing descriptions of Cline Subphase occupations include LeMoc Shelter (Site 5MT2151 [Hogan 1983]), Casa Roca (Site 5MT2203 [Brisbin 1982]), and Kin Tl'iish (Site 5MT2336 [Dohm and Gould 1985]).

Sundial Phase (A.D. 1000-1200)

Anasazi use of the project area continued after A.D. 1000, although the occupation of most of the project area after the Cline Subphase probably was less intensive in comparison to earlier phases. DAP site survey records suggest approximately 90 to 100 sites recorded in the project area (within the reservoir takeline) have Sundial Phase components. Of this total, approximately 60 were judged to be limited activity sites, about 30 were classified as seasonal sites, and the remainder (approximately 10) apparently were more permanent habitation sites.

The recorded habitation sites are separate roomblock units at larger aggregated communities. These communities are located on the uplands south and west of the reservoir (formerly the portion of the river valley north and west of Dolores); hence, the inference that most of the project area was used less intensively during this phase. Most of the Sundial Phase sites in the river valley proper or in its vicinity are interpreted to have been seasonal habitations or limited activity locations for nonindigenous groups exploiting the area for particular subsistence resources. Some of the recorded sites with more substantial architecture may represent attempts to recolonize this formerly densely inhabited area. Most Sundial occupations apparently date to the 100 years between A.D. 1050 and 1150. Apparently, less use was made of the project area after the latter date, and even transitory use ceased by approximately A.D. 1200. Two subphases have been defined for the Sundial Phase, the Marshview Subphase (A.D. 1000-1200) and the Escalante Subphase (A.D. 1120-1180). The Marshview Subphase represents mainly seasonal use of the project area by groups maintaining principal residence at larger settlements to the south and west. The Escalante Subphase represents use of the area by groups residing at the Escalante village, a 12th century settlement centered on the Escalante Ruin, a Chocoan trading outpost.

The Marshview Subphase (A.D. 1000-1200). – The Marshview Subphase primarily represents nonintensive, primarily seasonal use of the river valley and adjacent uplands by "late" (late Pueblo II and Pueblo III periods; A.D. 1050-1200) Anasazi groups. According to Petersen's reconstruction of project area attractiveness based on regional climatic variability, Dolores was generally unattractive to immigrants (and probably to indigenous populations) after A.D. 940, except for the period between A.D. 1100 and 1175 (chap. 4, sect. 6, table 4.43). The peak period of Marshview occupation corresponds fairly well with this favorable time, although the influx during the 12th century was not as large as predicted.

Marshview Subphase sites containing architecture are widely dispersed over the southern half of the project area, and generally appear to be distributed in a random fashion (fig. 5.3). Only 2 Marshview sites with associated architecture were recorded in the northern portion of the project area, and both – LeMoc Shelter (Site 5MT2151) and Beaver Creek Shelter (Site 5MT2216) – are in shelter settings, as their names imply. One cluster of recorded Marshview Subphase sites is located near the southern limit of the project area on the bluffs above the river. This cluster represents the seperate roomblock units of Reservoir Village, a large Pueblo II-early Pueblo III settlement. A second site cluster is located approximately 1 km to the northwest; this is Escalante Village, which is the main focus of the Escalante Subphase (see discussion of Escalante Subphase). Settlements with multiple aggregated roomblocks are noticeably absent in the main portion of the project area. A Marshview architecture recorded by DAP field crews exhibits relatively great variability in form and comparatively low investment in materials and labor. Architectural expressions consist of small, isolated pitstructures without associated surface rooms, surface rooms without pitstructures, or single pitstructures associated with surface rooms. Most architectural sites

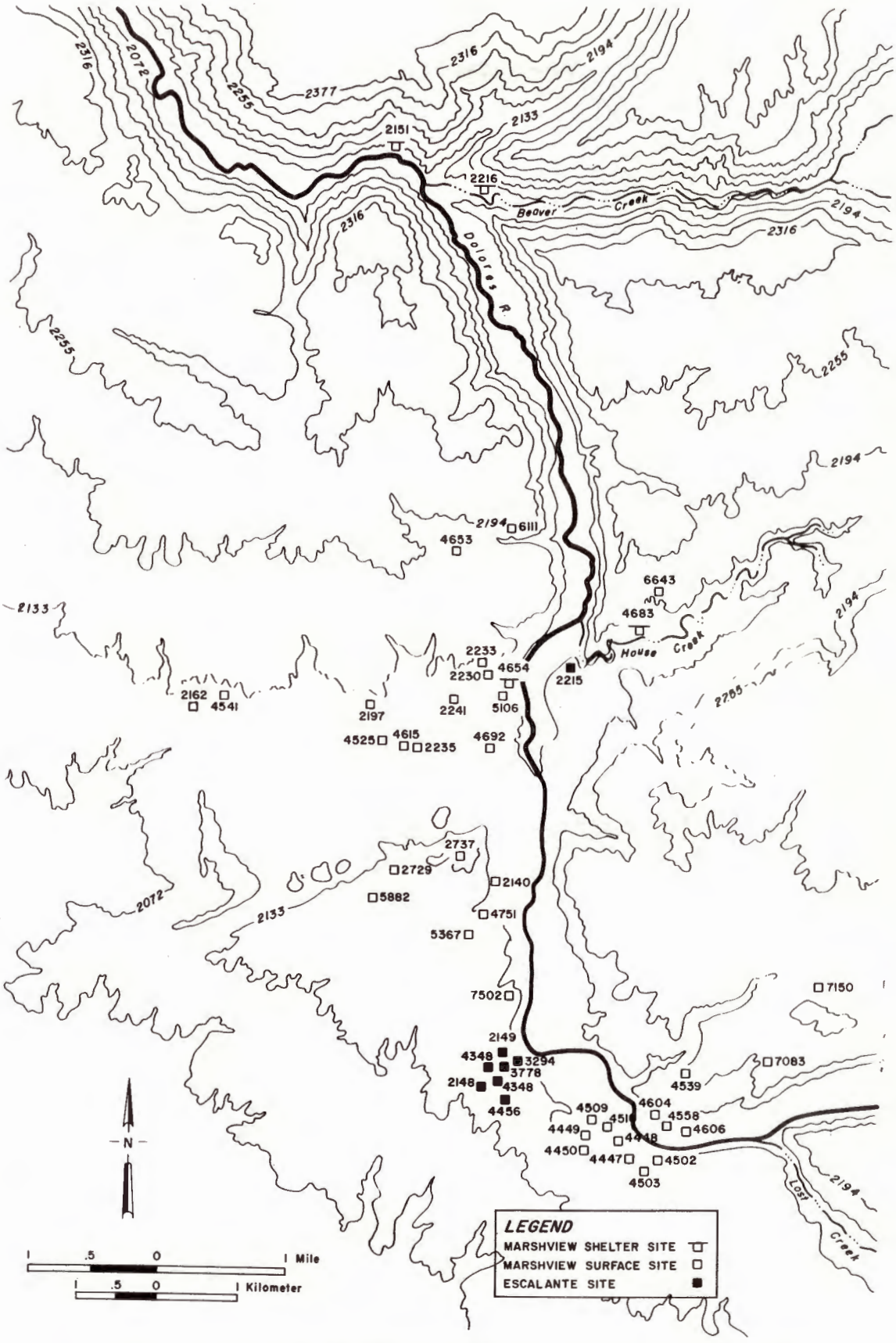

Figure 5.3 – Locations of Sundial Phase (Marshview and Escalante Subphase) occupations in the project area.

were small; the results of DAP excavations suggest most, if not all, Marshview sites with architecture contained only a single pitstructure or a small surface room complex. The size of some of the individual roomblocks at Reservoir Village suggests the presence of multiple pitstructures, but sites within the village area were not investigated.[3]

The accumulated Marshview site survey and excavation data suggest indigenous population levels were very low during this subphase and probably varied according to season, except for the Reservoir Village area. Of the approximately 100 total components assigned to the Sundial Phase, more than 90 probably are affiliated with the Marshview Subphase. Excepting those sites classified as limited activity sites (those sites without structures and with low material culture densities), the Marshview archaeological expression consists of approximately 30 sites classified as seasonal occupations and 10 others classified as habitations (generally individual roomblock units).

Sundial Phase (and Marshview Subphase) seasonal sites are restricted primarily to the southern half of the project area. Only 4 Marshview Subphase seasonal occupations were recorded north of Sagehen Flats and the House Creek drainage. The 2 northernmost recorded occupations, at LeMoc Shelter and at Beaver Creek Shelter, are in canyon talus overhangs in the Grass Mesa Locality. Marshview Subphase settlements are extremely restricted in their spatial extent and appear to be confined to Reservoir Village and its vicinity.

Temporally, most Marshview occupations seem to date to the 100-year period between A.D. 1050 and 1150. To test the accuracy of this inference, project sites that yielded Mesa Verde Black-on-white ceramics in site survey or excavation collections were identified. It was assumed that the presence of Mesa Verde Black-on-white pottery would indicate post-A.D. 1180 occupations, based on the accepted A.D. 1200-1300 manufacturing date range for this type (Breternitz et al. 1974:46; Blinman, chap. 2). Eleven Marshview sites with Mesa Verde Black-on-white sherds were identified, which supports the inference that post-A.D. 1150 Anasazi use of the project area was minimal. Of the 11 identified late occupations, 9 are interpreted to be limited activity loci, based on the individual descriptions provided on the site survey forms. The other 2 late occupations are at Reservoir Village, which suggests this particular settlement remained inhabited into the post-A.D. 1150 period. The presence of late sherds at 3 canyon shelter sites (LeMoc Shelter, Singing Shelter, and Site 5MT2216) suggests such locations were used by later as well as earlier groups in the Dolores area.

In the preceding discussion, it is assumed population levels within most of the project area (with the exception of the southernmost portion) were very low during the Marshview Subphase. Most use probably was confined to the more clement portions of the year, given the inferred emphasis on specialized economic activities. Thus, Marshview use of the river valley and the adjacent uplands was perhaps generally correlated with annual economic cycles, such as the growing season and the hunting season.

One Marshview Subphase occupation investigated by the DAP (at Beaver Trap Shelter [Site 5MT4654]; Hewitt and Harriman [1984]) exhibits architecture that might be indicative of more permanent, year-round occupation. A full complement of domestic facilities (habitation rooms and storage rooms or cists) and a kiva-like integrative structure are present at this shelter location.

Alternatively, some of the sites classified as seasonal settlements might represent attempts to recolonize the middle portion of the valley area. Forms of architecture that depart from the norm, and relatively low investments in architectural facilities would be consistent with colonizer settlements as well as with seasonal use sites. For example, Marshview Hamlet (Site 5MT2235) may represent such an attempt at recolonization. In archaeological investigations at Marshview Hamlet, Wilshusen (1982b:91, 93-94) speculates the site might have been the residence of a nuclear family that budded off from a not-too-distant nucleated settlement.

Regardless of whether Marshview architectural sites are seasonal locations or pioneer settlements, the number of groups to be found in the main part of the project area at any 1 time probably was very low. Even during the peak A.D. 1050-1150 use period, the momentary occupation probably consisted of fewer than 10 nuclear families or economic task groups, and perhaps fewer than 5. During other portions of the subphase, momentary population levels were probably even lower.

Large, permanent, nucleated settlements were present in the southern portion of the project area and outside the project area to the west and south. Reservoir Village and Escalante village (Escalante Subphase) were located a few kilometers west of the present town of Dolores in the area where the river canyon makes a 90° ben to the north. Reservoir Village consists of more th 20 separate residential roomblocks. Also present in village area are a tri-wall structure and a possible g kiva, the latter visible as a large depression associ

[3]Reservoir Village was not directly impacted by project construction and was not investigated by DAP field crews. Most of this presentation is based on the results of fieldwork conducted at the seasonal Marshview sites in the river valley and vicinity, north of Reservoir Village.

with the largest roomblock. Most of the residential units are situated on the high bluff south of the river valley, although 2 roomblocks are located on the edge of the low bluffs on the north side of the valley opposite the main residential area. The DAP archaeological and historic resource survey crew recorded 14 separate roomblocks within the village area, but the village also extends to the west, outside the limits of the project area. MAPCO field crews recorded 7 additional roomblocks in this western area and test excavated 4 of them (Spears 1982; Honeycutt 1982; Lux-Harriman 1982b); other unrecorded roomblock units are present in the vicinity as well. The village might have accomodated a total population of approximately 600 to 700 individuals, based on an estimated total length for all roomblocks of 600 to 700 m, and assuming approximately 1 inhabitant per linear meter of architecture. This conversion has been used in other DAP estimates of village population (Kane 1985a). Momentary population figures were probably somewhat lower. It seems reasonable to assume that at least 70 to 80 percent of the available dwellings were occupied simultaneously during the peak population period (cf. Hill 1970; Kane 1985a); thus, maximum momentary population levels for the village probably were close to 500 to 600 individuals.

The Reservoir Village occupation can be dated by applying the ceramic assemblage typological composition method developed by Blinman (chap. 2) to the DAP site survey collections and to the excavation collections made by MAPCO (Spears 1982:table 5.2-1; Lux-Harriman 1982b:table 5.2-2). Based on the application of several measures suggested by Blinman (table 5.5), most ceramic deposition at Resevoir Village dated to the A.D. 1025-1100 period, with less deposition during the earlier A.D. 910-980 (Cline Subphase) and A.D. 980-1025 periods. The village was abandoned before A.D. 1100, based on the virtual absence of McElmo Black-on-white sherds from the collection. Thus, the occupation at Reservoir Village lasted approximately 100 to 150 years, or perhaps from A.D. 950 to 1075, with the most intensive use probably occurring between A.D. 1025 and 1075. With the exception of Escalante Village, most other post-A.D. 900 settlements on the periphery of the project area appear to be essentially Pueblo II (A.D. 900-1100) occupations. For example, neither the Brumley Ruin (Site 5MT2372, located about 3 km northwest of the Sagehen Flats area and recorded by DAP survey crews in 1974), or 2 other post-A.D. 900 settlements located just to the west of the project area and tested by MAPCO crews (Sites 5MT5495 and 5MT5456; see Lux-Harriman [1982c] and Cavanaugh [1982]) were occupied later than A.D. 1100, based on the ceramic evidence. Thus, the recorded post-A.D. 1075-1100 occupations in the project area likely reflect visits from further-removed settlements (for example, post-A.D. 1100 groups residing at Yellow Jacket Ruin [Site 5MT5], located approximately 10 km west of the project area) or use by the Escalante Village residents (Escalante Subphase), which dates to the 12th century.

Marshview Subphase architecture exhibits a relatively great degree of variability, and except for Reservoir Village, does not conform to "normal" Pueblo II and Pueblo III patterns (Morris [1939:33-46]). Marshview Subphase architectural sites (this discussion refers strictly to those sites outside the Reservoir Village area) invariably lack full architectural complements (habitation rooms, storage rooms, and a plaza area containing kivas). Of the 8 sites with Marshview architecture investigated by the DAP (LeMoc Shelter [Site 5MT2151], Marshview Hamlet [Site 5MT2235], Southview House [Site 5MT2241], Paintbrush House [Site 5MT2729], Beaver Trap Shelter [Site 5MT4654], Singing Shelter [Site 5MT4683], Pinyon House [Site 5MT4751], and Weasel Pueblo [Site 5MT5106]), 5 contain pitstructures, and of the 3 that do not, 2 are in shelter locations. A shelter location might partially obviate the need for a pitstructure, given the availability of natural protection.

One Marshview occupation, at Beaver Trap Shelter (Hewitt and Harriman 1984) did contain a full complement of habitation rooms, storage rooms, and a kiva-like structure.[4] However, the spatial arrangement of the Beaver Trap facilities is unusual in that the kiva is incorporated into the roomblock and the storage rooms are in the form of separate walled-off natural alcoves rather than being incorporated into surface room apartment suites. Much variability is evident in the surface room complement. Given the seasonal or pioneer homestead nature of Marshview Subphase architectural sites, well-constructed surface room complexes may have been considered unnecessary, in terms of investment in materials and construction expense. When present, Marshview Subphase surface room complexes generally consist of a single masonry or pole-and-daub room and associated extramural features, both generally situated to the north of the pitstructure. Most Marshview Subphase surface rooms (for example, the surface rooms at Singing Shelter and Beaver Trap Shelter) seem to have functioned primarily as habitation rooms, based on their feature and artifact content. The only rooms that apparently functioned strictly as storage facilities were the alcove rooms at Beaver Trap Shelter. The form and content or even certain presence of surface rooms at Marshview Hamlet, Paintbrush House, and Pinyon House could not be ascertained because of postabandonment decay or disturbance.

[4]This particular occupation may date either to the A.D. 910-980 (Cline Subphase) or A.D. 980-1025 (Marshview Subphase) period based on the characteristics of the ceramic collection. Here it is somewhat arbitrarily treated as a Marshview occupation.

Table 5.5 – Ceramic assemblage measurements used to date the Reservoir Villge occupation

Measurement	Expectation for particular period*				Results	Inference
	A.D. 910-980	A.D. 980-1025	A.D. 1025-1100	A.D. 1100-1175		
Presence/absence of McElmo Black-on-white	Absent	Absent	Absent	Present	Absent at all collected roomblocks with the exception of the Reservoir site (Site 5MT4450) itself	The virtual absence of McElmo Black-on-white and the rarity of Cortez Black-on-white and Moccasin and Mancos neckbanded types suggest the village occupation dates primarily to the A.D. 980-1025 and A.D. 1025-1100 periods, with abandonment occurring before A.D. 1100. The very low proportions of Cortez Black-on-white and Mancos Gray types suggest an emphasis on the A.D. 1025-1100 period
Presence/absence and proportion of Mancos Black-on-white	Rare	Present	Sole painted white ware type	Predominant	The predominant painted white ware in all collected roomblocks	
Presence/absence and proportion of Cortez Black-on-white	Predominant	Present	Absent	Absent	Present in low proportions at 6 roomblocks, absent at 4 others	
Presence/absence and proportion of Moccasin and Mancos Gray	Predominant	Present	Absent	Absent	Present in very low proportions portions at 7 collected roomblocks, absent at 3 others	
Proportions of rock-tempered white ware to sherd-tempered white ware	Higher proportions of rock temper	Even proportions	Higher proportions of sherd temper	Rock temper virtually absent	For the 8 collected roomblocks for which this measurement was available, the ratio for the total collection was 530 rock temper to 387 sherd temper. Only 1 roomblock unit (Site 5MT4447, the tri-wall structure) exhibited high proportions of sherd-tempered white wares	The results of these two measurements support the inferences based on the first measurements – most village occupation in the A.D. 980-1025 and A.D. 1025-1100 periods. The temper measurement suggests a stronger 10th century presence than stated in the original interpretation; however, the corrugated measurement supports the original strong 11th century interpretation. These measurements also suggest the use of the tri-wall structure (Site 5MT4447) may have continued later than the other architectural units.
Proportions of Mancos Corrugated versus Dolores Corrguated	All Mancos Corrugated	All Mancos Corrugated	Higher proportions of Mancos Corrugated	Dolores Corrugated more common	This measurement was available for all 10 collected roomblocks; the ratio for the total collection was 122 Mancos Corrugated to 55 Dolores Corrugated. Only 1 roomblock (Site 5MT4447) had relatively high proportions of Dolores Corrugated	

* Expectations based on the discussion of ceramic assemblage dating presented by Blinman (chapter 2).

Marshview Subphase pitstructures can be characterized as small, as requiring relatively low investment in materials and labor, and as functioning as domestic and resource processing facilities rather than as "kivas." They generally are round and relatively shallow; construction was simple, with the sides of the original excavated pit serving as the walls of the structure. Often, stone coursing was added in some sections (for example, around the ventilator opening), probably to provide added structural strength. The domestic and resource processing inference is based on an assessment of floor features and artifact content, and the lack of formal, stylized construction generally associated with kivas. Floor features usually consist of a basic set of utilitarian features (central hearth, ash pit, warming pits, ventilator system, and wall and floor cists) that appear to be consistent with the domestic space interpretation. A simple sipapu is usually present as well; its presence is not inconsistent with the domestic interpretation, as any prolonged occupation by small groups probably would have necessitated a simple ritual or worship locus. The associated artifact assemblages appear to be de facto refuse; cooking and serving vessel fragments, expediently processed flaked lithic tools, and manos (perhaps used in mealing activities) are common components of Marshview pitstructure floor collections.

More "normal"architectural patterns are evident at Reservoir Village. Although the lack of relevant excavation data makes a certain conclusion impossible, the survey information suggests the presence of linear L-shaped and C-shaped masonry roomblocks, with associated pitstructures in a formal plaza area to the south. Note should be made of a tri-wall structure, named the Emerson Ruin (Site 5MT4447) in earlier accounts (Fewkes [1919:33-35] and Eddy and Kane [1983:260-261]), and a great kiva within the village area. Specific characteristics of Marshview structures are presented in the architecture summary later. The seasonal activity-pioneer settlement characterization of the Marshview project occupation was derived primarily from the architectural data. Architectural and settlement data were used to develop the discussion of social organization that follows.

The architectural and settlement data suggest that most of the Marshview Subphase sites (with the exception of the Reservoir Village area) were used by small, domestically oriented groups. Given the descriptions of the local Marshview population, settlement patterns, and architecture presented in this section, the Marshview sites were used primarily by nuclear family units, or task-oriented family subgroups. This inference is based on the low indigenous population levels, the lack of any socially derived patterning among Marshview sites (the locations of Marshview sites seem to reflect only economic considerations and the advantages of the location itself in terms of protection against the elements), and the characteristics of the individual sites.

Regarding the last source of inference, only single sets of architectural facilities are usually present, the single exception being Beaver Trap Shelter, where the Marshview occupation contains several individual habitation rooms. With the cited exception, only sites with 1 pitstructure or 1 pitstructure-roomblock complex were identified by DAP excavation crews. Another pertinent point is that investigated structures appear to be strictly domestic or economic in function. The general inference is that most Marshview sites in the project area north of Reservior Village were used by nuclear family or subfamily groups in pursuit of economic ends – either as pioneering homesteads, seasonal farmsteads (field houses), hunting camps, or other locations from which locally available resources could be conveniently accessed.

The Reservoir Village area itself provides a marked contrast in organizational complexity to the rest of the project area (fig. 5.4). This residental complex is noteworthy for 2 prominent settlement characteristics. First, while the village obviously is a single aggregated residential area, the individual roomblocks that constitute the village are dispersed within the village area and conform to no observable regular pattern; a cluster of small roomblocks is in the vicinity of the larger one that contains a great kiva (the Reservoir Ruin [Site 5MT4448]). Second, the individual roomblocks are relatively small,and only a few contain more than 2 to 3 kivas and more than 20 rooms.

Reservoir Village contains 33 known roomblocks with a total estimated roomblock length of 745 m (or an average of about 22.5 linear meters per roomblock; by contrast, in the late A.D. 800's, McPhee Village (Kane 1985a) contained 20 individual roomblock units with a total roomblock length of 915 m (about 46 linear meters per roomblock). Reservoir Village provides a contrast with most known post-A.D. 1000 large Anasazi settlements, which feature relatively large roomblocks with some formal overall organization of the separate residential units (for example, Yellow Jacket Ruin [Site 5MT5; Brown 1975], or Sand Canyon Pueblo [Site 5MT765; Adams 1985]).

At least one post-A.D. 1000 community does exhibit a less regular patterning of residential units and hence may be analogous in some respects to Reservoir Village. This is Mud Springs Ruin (Site 5MT4466 [Fewkes 1919:20-22]), located approximately 20 km southwest of the project area and dating primarily to the 13th century. This variability in internal settlement structure suggest the management or administrative hierarchies at Reservoir and Mud Springs were less well developed

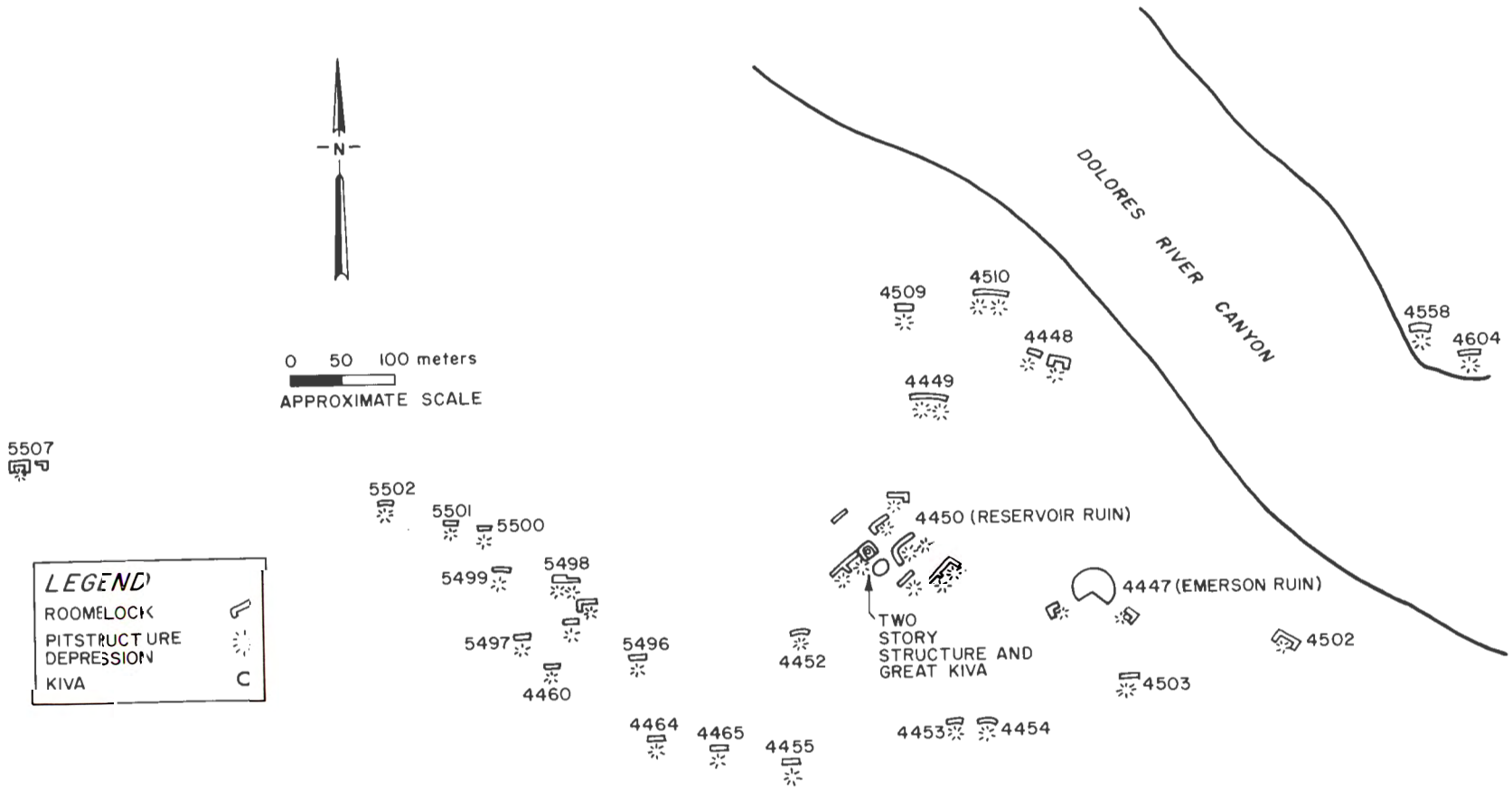

Figure 5.4 – Map of Reservoir Village. Not to scale; approximate scale provided only as a general reference.

and not as powerful as those at the more formally organized settlements. Many of the more regularly patterned settlements contain a separate, compact, multiple-story roomblock that bears morphological resemblance to published descriptions of "Chacoan outliers" (Powers et al. 1983).

These "Chacoan structures" may represent the location of village management or government and their more regularly patterned spatial plan may be due to the influence of these management groups. Reservoir and Mud Springs are not coeval with the Chacoan-influenced sites (Reservoir is 50 years earlier, Mud Springs is 100 years later), and consequently their non-Chacoan management structure may not have been as effective in influencing residential construction within the village area. The 4 largest recorded roomblocks that might have served as the locations of suprahousehold management groups within the Reservoir Village area are fairly well dispersed within the community area and not grouped in 1 location. However, the administrative center of the village is thought to have been in the eastern portion of the village, based on the presence of a great kiva with an associated two-story roomblock and several smaller roomblocks, and a nearby tri-walled structure (Site 5MT4447, the Emerson Ruin).

The last structure deserves further comment. The Emerson Ruin was first mentioned in the archaeological literature by Fewkes (1919:33-35), who provides a ground plan clearly showing the symmetrically placed radial walls characteristic of tri-walled structures. The site was visited by the DAP in 1978; new compass orientations for the radial walls were obtained through transit measurement, and a ground plan map was made (Eddy and Kane 1983:260-261, fig. 9.10); the Emerson Ruin data are included in a wider treatment of prehistoric archaeoastronomy at Dolores (Eddy and Kane 1983). A reconstruction of the tri-walled edifice based on the available project data and archaeological analogs (fig. 5.5), suggests that the ruin was about 20 m in diameter and contained about 17 radial rooms (6 or 7 in the inner circle and 10 in the outer circle). Thus, the Emerson Ruin is comparable in size to excavated tri-walled structures, that is, the comparable structures at the Aztec Ruin (8 inner rooms and 14 outer rooms [Vivian 1959:fig. 5]) and at Pueblo del Arroyo (6 inner rooms and 10 outer rooms [Vivian 1959:fig. 48]). Whether the Emerson Ruin contained a central kiva could not be ascertained; the analogous structure at Aztec Ruin did have such a kiva, while the Pueblo del Arroyo example might have lacked one.

The function of tri-walled structures within the social fabric of local Anasazi communities remains a question. Vivian (1959:85) suggests the structure functioned as the principal dwelling and place of instruction for

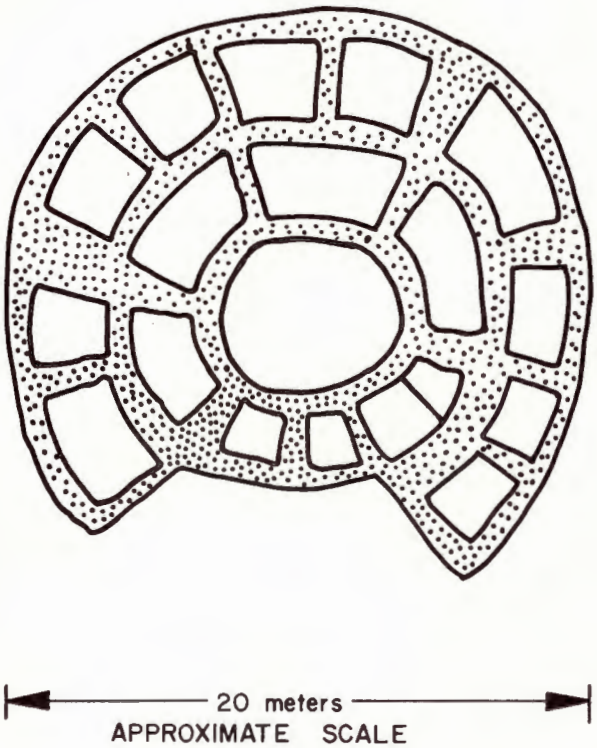

Figure 5.5 – Possible reconstruction of the ground plan of Emerson Ruin, based on the plan provided by Eddy and Kane (1983:fig. 9.10). Not to scale; approximate scale provided only as a reference.

incipient priestly groups. Thus, the presence of tri-walled structures may signify the beginnings of hierarchial class structure in Anasazi society. A difficulty with Vivian's hypothesis is that the radial rooms seem to be rather small to be considered habitation rooms and lack the features (central hearths, storage cists) commonly associated with these types of facilities. The characteristics of the radial rooms are consistent with a storage facility interpretation. In Plog's (1969:149-165) discussion of resource redistribution in prehistoric Anasazi society, tri-walled structures are cited as a possible location for the control and allocation of community food resources. This interpretation is consistent with the inferred storage function of the radial rooms as, in Plog's model, those rooms would have been used to store the communal produce.

Given either interpretation, the presence of tri-walled structures implies the presence of a class-stratified society. Such societies would contain an elite group with theocratic privilege and control over food resources. Thus, the presence of the Emerson triple wall has like implications for the social structure of the Reservoir community. The Emerson tri-walled structure apparently dates to the 11th century; most documented triple walls are believed to have dated 100 or 150 years later,

or to the late 12th or 13th century. The early appearance of a tri-walled structure at Reservoir Village suggests the comparatively early development of complex society in the Dolores area.

One additional project discovery should be mentioned in the general context of Marshview Subphase social relationships. A possible cannibalism incident was investigated at Marshview Hamlet (Site 5MT2235), a small, late Marshview Subphase site in the Sagehen Flats area. While removing postoccupational fill from a pitstructure, the excavation crew encountered a lower stratum containing fragmented human bone. The bone was carefully removed to the laboratory for analysis. The project physical anthropologist was understandably reluctant to conclude that the archaeological context represented prehistoric cannibalism; she did infer, however, that the human remains had been subject to violent treatment, probably forceful blows directly applied to the bones (Wiener 1982:128). The human remains later were sent for additional examination to an authority on prehistoric Southwestern cannibalism, Christy G. Turner II, of Arizona State University. Turner concluded the find could represent cannibalism, based on similarities between the Marshview Hamlet remains and other relevant data:

> "The qualitative and quantitative characteristics of the human skeletal remains excavated at the Marshview Hamlet in southwestern Colorado correspond well with the newly established taphonomic features of prehistoric Southwest mass burials evidencing cannibalism, violence, and behavior never described in missionary, explorer, or ethnographic accounts" (Turner 1982:150).

The distinctive features include massive perimortem bone breakage, burning and cutting of bone, postmortem bone gnawing by animals or humans, excellent bone preservation indicative of rapid deposition, and telltale patterning in missing skeletal elements, particularly vertebrae.

In the site report, the mass of human remains is treated as a secondary burial (Wilshusen 1982b:43-50). The burial consisted of 5 to 6 individuals: 3 adults, a juvenile, and 2 children. The remains apparently were accompanied by grave goods, including 11 pottery vessels, 1 ceramic canine head effigy, and 2 bone tube beads. The grave goods were not arranged on the periphery of the skeletal remains in a regular fashion as one might expect in a primary burial. Rather, the goods were broken and scattered, and fragments of some were recovered from site deposits removed from the pitstructure. This phenomenon led the excavators to believe the burial was secondary in origin (Wilshusen 1982b:47). Based on stratigraphic evidence, the mass burial is believed to date slightly after the abandonment of the pitstructure, or sometime between A.D. 1075 and 1150.

If the Marshview Hamlet remains indeed represent prehistoric cannibalism, it is not known whether the individuals were victims of a foreign group frequenting the hinterland to the north of the primary Anasazi settlement zone, or whether the act was perpetrated by local Anasazi groups, perhaps as a type of "emergency" cannibalism (cf. Nickens 1975). Regardless of the responsible agents, the possible cannibalism at Marshview Hamlet is not an isolated instance in Four Corners prehistory (e.g., Nickens 1975; Luebben and Nickens 1982). Most possible instances of Anasazi cannibalism appear to date to the 12th century, which may reflect increasing subsistence hardships during this period.

What are the expectations for Marshview Subphase material culture given the interpretation of seasonal or pioneer occupation presented earlier in this subphase discussion? In the site report for Paintbrush House (Site 5MT2729 [Kleidon 1984b:19]), it is suggested that "colonization assemblages" should be characterized by relatively high proportions of materials used for construction and in transport and relatively low proportions of heavy objects and materials that accumulate during lengthy occupations. Additional expectations can be developed based on the household organization-lithic assemblage correlations presented in table 5.3. As the 12th century influx of new population into the Dolores area apparently was by nuclear family households or intrahousehold task groups, Marshview Subphase lithic assemblages should exhibit the characteristics correlated with these organizational categories (the left and right columns in table 5.3). Therefore, Marshview assemblages should contain relatively high proportions of easily transportable general-purpose tools and items that can be manufactured with a minimum of effort. Relatively low proportions of heavy or unwieldy items and specialized tools should be found. This characterization suggests diversity/richness indices for both flaked and nonflaked lithic tools should be comparatively low.

Container collections (here effectively restricted to the ceramic data set) should feature high proportions of small, easily transported and low proportions of large storage vessels and ollas, which are more clearly associated with more permanent, over-winter occupations. Also, the sizes of Marshview cooking and serving vessels should be relatively small, given the relatively small size of the groups who are thought to have used these sites. Ratios of ceramic items to lithic items should be relatively low at Marshview sites, given the expectation that use of ceramic containers would be greater at permanently occupied settlement.

The seasonal-pioneer characterization of Marshview occupation also has implications for the content of faunal and botanical collections. The less-than-substantial architecture characteristics of Marshview sites suggests seasonal occupations probably were restricted to the more clement portions of the annual economic cycle; it is assumed Marshview groups usually did not winter in the project area. Given this assumption, Marshview groups were likely relying on a variety of recently procured, "fresh" produce rather than on stored resources. This inference is supported by the apparent low frequency of formal storage facilities (except at Beaver Trap Shelter) in the Marshview architectural record. Conversely, groups that wintered in the area would be expected to rely to a greater extent on stored resources. As for the Anasazi, if stored resources consisted mainly of agricultural produce (especially maize; Wolf [1985a]), then Marshview food refuse should contain greater proportions of faunal refuse and wild plants and ruderals and lesser proportions of corn. Similar expectations can be generated for a seasonal-pioneer occupation model for the Marshview Subphase. Pioneer subsistence strategies initially would be geared to exploiting a variety of expediently available resources; it would require a few years preparation before a more directed agriculturally oriented strategy could be implemented. To become effective, agriculturally based subsistence systems would require a fairly substantial labor and construction investment in associated tools and facilities, such as prepared fields, suitable storage environments, drying areas, milling tools, and cooking wares. It would probably require at least a year and perhaps longer for a pioneer group to accomplish the necessary preparations. In the meantime, the group probably would practice a more generalized food resource procurement strategy. In the following discussion, the relevant data from the lithic, ceramic, faunal, and botanical data bases are considered in the context of this argument.[5]

Marshview Subphase flaked lithic assemblages (chap. 3, fig. 3.4) exhibit very high proportions of utilized flakes (nearly 60 percent of the total assemblage) and comparatively very low proportions of virtually every other tool type. As might be expected, this dominance of utilized flakes is reflected in the Shannon-Wiener diversity and equitability indices, which are the lowest when considering all subphases. The characteristics of the flaked lithic tool data set thus support the seasonal-pioneer model of Marshview Subphase occupation; there are high proportions of expediently produced, general-purpose tools (utilized flakes), and diversity-equitability indices are as predicted. Marshview Subphase nonflaked lithic assemblages also appear to generally conform to the expectations of the seasonal-pioneer occupation model. The comparative figure prepared by Phagan (chap. 3, fig. 3.6) indicates that Marshview nonflaked lithic collections consist of moderate to fairly high proportions of miscellaneous tools and two-hand manos (miscellaneous tools probably can be considered low-production-input, general-purpose tools; two-hand manos are relatively high-production-input tools, and their possible role in tasks other than milling grain is speculative). Subphase variation in the proportion of two-hand manos exhibits little correspondence with trends in the proportions of trough metates. Indeed, an increase in the proportion of two-hand manos often seems to be accompanied by a decrease in the proportion of trough metates (for example, during the Grass Mesa and Marshview Subphases), perhaps indicating multiple-functions for these particular tools. Proportions of heavy, difficult-to-transport items, such as trough, slab, and basin metates, are low in Marshview assemblages, as are proportions of items that might be associated with long-term site use, such as large hafted items and ornaments. The Marshview production evaluation index, which reflects the percentage of well-made items in the assemblage, is relatively low and less than that for the preceding Periman, Grass Mesa, and Cline Subphases. As predicted, the Marshview Shannon-Wiener diversity and equitability indices are comparatively very low, reflecting the dominance in the collections of miscellaneous tools and two-hand manos. This is again consistent with the expectations derived from the model.

The Marshview stone tool assemblages can also be compared with the general seasonal site profiles (chap. 3, figs. 3.7 and 3.8). Again, the flaked lithic assemblage features a very high proportion of utilized flakes and low proportions of high-production-input tools (thick bifaces, thin bifaces, and projectile points); some of the other tool proportions are not similar, but the implications of this variation are unclear in terms of the model. The relevant nonflaked lithic tool indices illustrate similar proportions in the tool types singled out as especially pertinent in terms of the model; proportions of miscellaneous tools and two-hand manos are moderate to high; proportions of metates are low; and proportions of ornaments are very low (chap. 3, fig. 3.9).

One other stone tool assemblage measurement is relevant in the evaluation of the model. This is the flaked lithic tool/nonflaked lithic tool ratio in the total Marshview assemblage (chap. 3, fig. 3.6). This ratio is relatively high in comparison with the ratios for the other subphases, which is consistent with an expedient technology that features high proportions of utilized flakes.

[5]Generally, with the exception of the lithic data sets, project analysts used modeling periods rather than subphases as temporal units. In this discussion, "Period 7" (A.D. 980-1250) is equivalent to the Marshview Subphase.

The ratio also is closest to the comparable values for the Dos Casas and Periman Subphases. The factors that produced high proportions of flaked lithic tools may be different, however. The high proportions in the Dos Casas and Periman Subphases are thought to reflect an expedient approach to flaked lithic tool technology; that is, flaked lithic tools were quickly produced for the job at hand and then discarded. This behavior would result in a relatively high discard rate in comparison with the more specialized and probably curated nonflaked lithic tools. The high proportions of flaked lithic tools in the Marshview Subphase assemblages may to some extent reflect an expedient approach to lithic technology (this approach would seem consistent with expectations for a seasonal-pioneer occupation), but also might reflect low proportions of heavy and unwieldy nonflaked lithic items. Some characteristics of the Marshview Subphase stone tool assemblages seem consistent with the expectations derived for the seasonal-pioneer occupation model.

Blinman limits his discussion of ceramic containers (chap. 12) to Periods 1 through 6; hence, the expectations derived for the ceramic data base could not be formally evaluated through comparison of subphase assemblages. Here, 2 ad hoc tests are presented that compare individual site data (table 5.6). The first test is a comparison of the bowl sherd/jar sherd ratio at Marshview sites versus the same ratio at two Dos Casas Subphase and 2 Periman Subphase roomblock units. The expectation is that the ratio would be higher at Marshview sites, because serving vessels (bowls) are assumed to have been necessary at seasonal-pioneer sites, while food and water storage vessels and perhaps a full complement of cooking vessels (jars and ollas) are not. The results of this test support the model. For 3 of the 4 Marshview sites, the bowl/jar ratio is higher than that for any of the Dos Casas or Periman roomblock sites. The average ratio for the 4 Marshview sites is 0.172, versus 0.103 for the roomblock sites.

The second test uses the same sites in a comparison of the ratio of total ceramic items versus total lithic (flaked and nonflaked) items. The expectation is that this ratio will be lower at Marshview sites, given the assumption in the model that seasonal or pioneer groups would make less use of ceramic containers than their counterparts at permanent habitation sites. The results of this test also support the seasonal-pioneer model. All 4 Marshview Subphase sites in the test set had lower ceramic item/stone tool ratios than any of the Dos Casas-Periman roomblock sites. The average ratio for the Marshview sites was about 3.5 sherds per stone tool, while the Dos Casas-Periman sites ratio was about 11.5 sherds per stone tool. A Mann-Whitney U-test was implemented using the table data to determine whether the Marshview ratio was significantly larger. The difference was significant ($P \sim 0.04$) at a 0.05 level of confidence.

Little relevant data for evaluating the model is contained in the resource studies chapter (chap. 7). Because of low sample numbers, Periods 6 and 7 were combined in a study of changes in the use of faunal resources. The results (chap. 7, tables 7.3, 7.5, and 7.6) appear to support the seasonal-pioneer hypothesis, as the indices for Period 6-7 (the Cline and Marshview Subphases) are relatively high compared to indices for the other periods. However, the difference in period length (Period 6-7 is 330 years long; most other periods are 40 to 80 years in length) was not considered in the calculations. The possible effect of variations in period length on the measurements is unknown, although it is probably severe. Hence, the measurements presented in chapter 7 must be considered ambiguous in terms of support or lack of support for the model presented here.

The discussion of botanical resource use in the same chapter and the resource mix study presented in appendix D are limited to Periods 1 through 6 and are not germane to this discussion. Because of limited sample size and inherent interpretive difficulties, ad hoc evaluations of the seasonal-pioneer model using the botanical data base were not developed as for the ceramic data base.

The lithic and ceramic data appear to support the seasonal-pioneer model of Marshview Subphase occupation. Marshview groups were using a set of tools and containers that was characterized by high proportions of general-purpose items, by low-production cost, and by ease of transportation. However, this interpretation could not be further supported by the faunal and botanical data, either because analysis results were difficult to interpret or because pertinent studies were not undertaken.

Reports summarizing specific DAP field investigations of Marshview occupations are available from other sources. These include the site reports for Marshview Hamlet (Site 5MT2235 [Wilshusen 1982b]), Southview House (Site 5MT2241 [Morris 1983]), Paintbrush House (Site 5MT2729 [Kleidon 1984b]), Beaver Trap Shelter (Site 5MT4654 [Hewitt and Harriman 1984]), Singing Shelter (Site 5MT4683 [Nelson and Kane 1985]), Pinyon House (Site 5MT4751 [Kuckelman 1984b]), and Weasel Pueblo (Site 5MT5106 [Morris 1984]). In addition, Blinman and Wilson's report on Pueblo II and Pueblo III ceramics in the project area (Blinman and Wilson 1985b) also contains pertinent information.

Escalante Subphase (A.D. 1125-1175). – The Escalante Subphase represents use of the project area by groups

Table 5.6 – Tests of the Marshview seasonal-pioneer occupation model using ceramic data

Site	Ceramic item/stone tool ratio				Bowl sherd/jar sherd ratio		
	Total ceramic items	Total flaked lithic tools	Total nonflaked stone tools	Ratio	Total bowl sherds	Total jar sherds	Ratio
Marshview Hamlet (Site 5MT2235)*	3 233	538	347	3.653	552	2 650	0.208
Southview House (Site 5MT2241)†	570	114	37	3.775	52	508	0.102
Paintbrush House (Site 5MT2729)§	419	152	11	2.570	65	348	0.187
Pinyon House (Site 5MT4751)**	721	134	42	4.096	116	598	0.194
Average Marshview ratio				3.523			0.173
Windy Wheat Hamlet (Site 5MT4644)††	10 939	1251	331	6.915	981	9 730	0.101
Periman Hamlet, Area 1 (Site 5MT4671) §§	7 465	818	272	6.849	833	6 577	0.127
Aldea Alfareros (Site 5MT4479)***	12 221	346	298	18.977	801	11 257	0.071
Pueblo de las Golondrinas (Site 5MT5107)†††	27 605	1727	331	13.413	2771	24 330	0.114
Average Dos Casas/Periman ratio				11.538			0.103

* Data from Wilshusen (1982b:tables 12.A.1, 12.B.1, and 12.B.3).
† Data frum M. Morris (1983:tables 3, 4, and 5).
§ Data from Kleidon (1984b:tables A.1, A.3, and A. 4).
** Data from Kuckelman (1984b:tables A.4, B.1, and B.3).
†† Data from Brisbin (1984a:tables A.1, A.2, and A.4).
§§ Data from Wilshusen (1983:tables 34, 35, and 37).
*** Data from Kleidon (1984a:tables A.3, A.9, and A.12).
††† Data from Brisbin (1984c:tables A.1, A.2, and A.4).

affiliated with Escalante Village, a Pueblo III settlement located near the southern limit of the project area. Architectural sites seem to be almost totally confined to the village area, with one possible exception (Sundance Hamlet [Site 5MT2215]; Harriman [1983]). Nonarchitectural Escalante occupations are virtually impossible to identify, as stone toolkits and ceramic assemblages are essentially the same as those for the late Marshview Subphase. Some post-A.D. 1100 project-area nonarchitectural contexts assumed to be late Marshview Subphase occupation may have actually been Escalante occupations.

Escalante Village is located on the bluffs overlooking the Dolores River valley and main project area to the east and north; the village area is only about 500 m north of the residential area integral to nearby (but not contemporaneous) Reservoir Village (fig. 5.3).

Escalante Village consists of the Escalante Ruin itself (Site 5MT2149) and a number of small, dispersed residential units (fig. 5.6). The Escalante Ruin was partially excavated by University of Colorado crews in 1975 and 1976 (Hallasi 1979) and stabilized for public visitation. The site consists of a single rectangular roomblock containing 25 separate rooms and a kiva. A second kiva is situated to the south of the pueblo and a refuse midden is located to the west.

The results of tree-ring dating of construction timbers (Hallasi 1979:392-396, table 46) suggest the main architectural complex was constructed in the late A.D. 1120's, with major remodelings in the A.D. 1130's. The presence of late use surfaces in the rooms superimposed over roof fall and original room floors suggests a relatively lengthy occupation, probably extending into the last half of the 12th century. Escalante Ruin has been interpreted as a Chacoan outlier based on diagnostic architectural characteristics. These include: (1) large-scale planning before construction, based on the symmetry of the roomblock about a north-south axis and incorporation of an intramural kiva; (2) masonry wall styles, including core-and-veneer construction and decorative banding on the exterior of the roomblock walls; (3) ceiling height (original ceiling height was probably in excess of 2 m, based on the existing heights of nearly 2 m in some cases [Hallasi 1979: figs. 37 and 44]); and (4) kiva architecture, including horizontal pilasters, eight-pilaster roof-support pattern, subfloor ventilator, absence of southern recess, and presence of lateral floor vaults (Hallasi 1979:fig. 58). The material culture inventory generally supports the Chacoan outlier interpretation. Although only a small fraction of the sherds were identified as originating in the Chaco Canyon area, many unusual items are in the collections, including trade wares from the Kayenta, Cibola, and Chaco areas (Hallasi 1979:254), a sandstone "paint grinder" (Hallasi 1979:296), an inlay pendant (Hallasi 1979:298, fig. 23), several building stones with incised designs (Hallasi 1979:figs. 25-30), and a stone effigy, which probably was mortised into a room or kiva wall (Hallasi 1979:fig. 31). The Escalante Ruin and its Chacoan affinities are futher described in the Chaco Center reports summarizing outliers of the Chaco system (Powers et al. 1983:167-169).

Based on previous archaeological survey and the results of a walk-over reconnaissance by the author and a member of the Anasazi Heritage Center staff, the Escalante Village area also contains at least 16 and probably more "unit" type pueblos, characterized by single, small, linear or L- or C-shaped roomblocks with single kivas (cf. Prudden 1903:234-239, fig. 6). These roomblocks are dispersed over the lower slopes of the Escalante hill itself and across a small drainage to the west. The distribution of these smaller sites approximates a fan shape to the east, south, and west of the Escalante Ruin (fig. 5.6). The distribution suggests several factors determined the specific locations of these smaller residential units including proximity to Escalante Ruin, southern exposure, and terrain amenable to roomblock and kiva construction.

Based on their surface manifestations and data available from the excavation of 2 units, these small roomblocks exhibit a remarkable uniformity in architectural content. Each apparently consists of a small linear roomblock, with the length of the block ranging from 6 to 12 m, and single kiva. The excavated roomblocks are the Dominguez Ruin (Site 5MT2148), investigated by the University of Colorado in 1976 as part of the Bicentennial Escalante Trail Project, and Casa de Sueños (Site 5MT3778), investigated by the Bureau of Land Management in 1983 as a portion of a cultural resource mitigation program associated with the construction of the Anasazi Heritage Center. Both roomblock units are similar in building styles to other 12th century "Mesa Verde" settlements (for example, Big Juniper House on Wetherill Mesa [Swannack 1969], Site 5MT499 in the Far View group at Mesa Verde [Lister 1964], and Sites 5MTUMR1238 and 5MTUMR2346 in Mancos Canyon [Nordby 1973, 1974]), and lack the characteristics of Chaco-system architecture. In comparison to contemporaneous residential architecture, the small excavated Escalante roomblocks appear to exhibit relatively low investments in materials and labor. Considering surface room complements, Dominguez Ruin contains a small linearly oriented roomblock with 3 fairly small rooms. The wall masonry is of relatively good construction quality, consisting of double courses of flaked and pecked sandstone blocks (Reed 1979:16). Casa de Sueños contains a single surface masonry surface room. Less care is evident in the wall construction when compared to Dominguez; the walls incorporate both sandstone blocks and

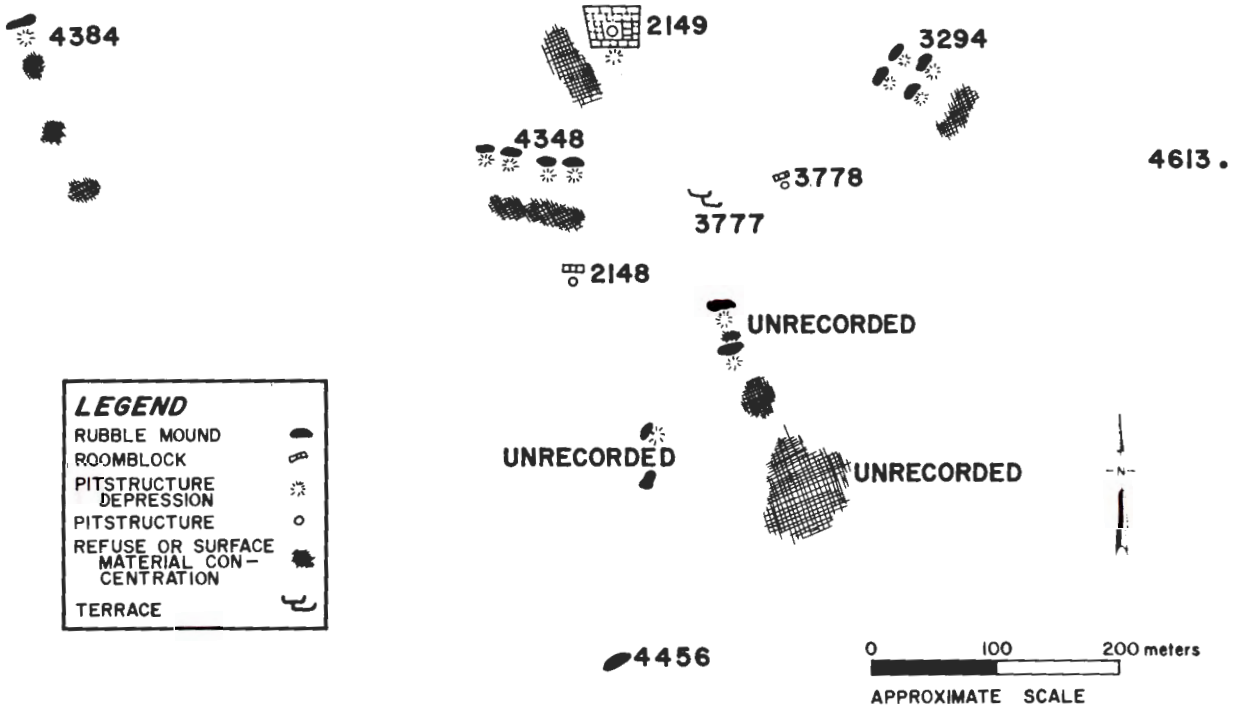

Figure 5.6 – Map of Escalante Village. Not to scale; approximate scale provided only as a general reference.

river cobbles, which were laid in irregular fashion (Douthit 1984:figs. 10-12). The overall effect is that of a double-coursed structure, but the masonry is not as regular as at Dominguez. Both small units incorporate a small kiva, and each kiva features earthen walls below and above the bench, although the pilasters (several of which had collapsed after abandonment) are of stone masonry construction. Twelfth century kivas usually incorporate masonry walls and sturdy construction. The inference of low material and labor investment was based partially on the simple appearance and rudimentary construction of the Dominguez and Casa de Sueños kivas.

The architectural and material complements of these 2 sites would seem to approximate the facilities used by a single household social unit. Deserving of comment is the presence of a high-status burial at the Dominguez Ruin (Reed 1979:99-102, figs. 31-33). The burial consists of 1 female adult and possibly 1 infant interred on the floor of the west surface room. The adult was accompanied by a large assemblage of grave goods, including 3 turquoise, shell, and hematite pendents; 6900 turquoise jet and shell beads (probably the remnants of several necklaces or other strung jewelry); bone tools; and 2 ceramic vessels. The contradiction of a high-status interment and an architecturally impoverished settlement is immediately apparent. The obvious inference is that the high-status individual was a resident of Escalante Ruin itself rather than a member of the Dominguez resident household (Reed 1979:129-130). This association reinforces the interpretations that the Escalante and Dominguez sites were absolutely contemporaneous and that clear social relations existed between the groups living at the 2 settlements.

The results of prior investigations and the on-the-ground reconnaissance undertaken by the author suggest the locations of other areas of prehistoric activity within the village in addition to the roomblocks already described; some of these locations are indicated in figure 5.6. Site 5MT3777, located just west of Casa de Sueños, apparently was an agricultural terrace, based on the results of 1983 excavations conducted by the Bureau of Land Management (Douthit 1984). Concentrations of surface materials located approximately 450 m west and 400 m south of Escalante Ruin appear to be the refuse areas usually associated with roomblock units. However, no building rubble indicative of surface rooms was identified. Perhaps the associated roomblocks are not visible from the surface or possibly different types of activity are indicated.

Outside of the village area, occupations associated with the Escalante Community are difficult to identify; temporal assignments of late occupations in the project area are based almost solely on ceramic types (Blinman and Wilson 1985b); however, the composition of ceramic collections does not allow more specific cultural identification, in this case, whether occupations assigned to

the 12th century are associated with Escalante Village or with "Mesa Verdean" communities located near the fringes of the project area. Here, 2 other sources of evidence, architectural style and proximity to the village area, suggest that some archaeological contexts outside the village area may have affinities with Escalante.

As presented in the previous Marshview Subphase discussion, project area architectural sites dating to the 12th century seem to conform to a seasonal-pioneer model of occupation. The use of seasonally occupied sites is thought to have corresponded with economic seasons such as the growing season or the hunting season. It seems reasonable to assume that the agricultural system that supported Escalante Village did not extend more than a few kilometers from the village area, given the relatively small size of the settlement. In terms of local topography, this would restrict the agricultural lands associated with the community to the mesa top area west of the river valley and south of the House Creek fault escarpment, to that portion of the river valley in the vicinity of Escalante, and perhaps to the relatively flat areas above the low bluffs on the east side of the river.

Three A.D. 1100-1175 occupations were recorded in this area (Blinman and Wilson 1985b:fig. 6), and one, Pinyon House (Site 5MT4751 [Kuckelman 1984b]), was excavated by the DAP. None of these sites seems to exhibit any architectural or material culture attributes suggestive of a particular affiliation with Escalante Village. However, Escalante Village is the closest known 12th century settlement in each of these cases. Additional 12th century sites in the project area are further removed (north) from the Escalante Village area. With 1 possible exception, the occupations seem to correspond with the Marshview seasonal-pioneer use model.

The 1 exception is Sundance Hamlet (Site 5MT2215 [Harriman 1983]), which contains several noteworthy architectural characteristics. The site is located on the low bluffs above the Dolores River valley, just east of the river and south of House Creek. Sundance Hamlet consisted of 2 connected surface rooms and a pitstructure. Wall construction in the surface roomblock consists of double-coursed core-and-veneer masonry, similar to that at Escalante Ruin itself. The sizes of the surfaces rooms (approximately 15 m^2 of floor area) and the pitstructure (almost 20 m^2 of floor area) are substantially larger than the sizes of structures at other Sundial Phase architectural sites (mean size is 5 to 6 m^2 for surface rooms and about 7 m^2 for pitstructures; Wilshusen [1985c:tables 2 and 3]). Thus, wall construction techniques and structure sizes at Sundance suggest a departure from the low material-labor investment expectation developed for the Marshview occupation.

Unfortunately, the aboriginal construction at the site was not completed, nor was the site occupied beyond the construction period; hence, material culture from site contexts was not available for comparison. The site may have had affinities with Escalante Village because of the noted similarities in wall construction techniques and the dissimilarities of contemporaneous Marshview Subphase sites which are thought to reflect "Mesa Verdean" styles. Twelth century occupations in rockshelters in the project area (at Singing Shelter and LeMoc Shelter) may also represent use by Escalante Subphase groups, although, this is not obvious in the material remains. Such use may reflect long-distance faunal and botanical resource procurement strategies.

Use of limited activity locations by Escalante Subphase groups is even more difficult to document due to the absence of structures and the low densities of material remains. Thus, no limited activity occupations investigated by the DAP were singled out as possibly having affinities with Escalante Village, although the possibility of such affiliations is noted.

Escalante Village appears to have been small, in terms of resident population, when compared to the aggregated communities previously described. The total linear extent of the recorded village area roomblocks is approximately 200 m (assuming the average length of the small roomblocks is 8 m and summing the east, north, and west sides of the rectangular Escalante Ruin). Assuming 1 linear m per person, perhaps 200 persons occupied the community area at peak use, or if 75 percent of the residential units were occupied at any one time, maximum population may have been about 150 to 200 persons. Additional roomblocks in the village area probably went undiscovered, however, which suggests maximum village population may have been in excess of the original 200-person estimate.

Architecturally, the identified Escalante settlements appear to consist of masonry roomblock-kiva complexes, which is the "normal" complement for the early Pueblo III period in the Mesa Verde Region (cf. Prudden 1914, 1918; Lister 1964, 1966; Nordby 1973, 1974). Generally speaking, the construction styles and techniques exhibited in the excavated sites also correspond to normal Pueblo III patterns, albeit the Escalante Ruin itself shows many architectural similarities with the "Chacoan" communities of northwestern New Mexico rather than with local "Mesa Verdean" settlements. Attention is also drawn to the contrast in architecture between the smaller roomblocks within the village area and Escalante Ruin. The small roomblocks are characterized by low investments in materials and construction labor (small rooms and kivas, lack of masonry veneer in kivas), while Escalante Ruin is a single preplanned architectural unit, which required planning

and a coordinated labor force. Most of the walls at Escalante Ruin are of compound construction with a rubble core and coursed stone masonry veneers. These walls often are more than 50 cm in width and 2 m or more in original height, and must have required a substantial initial effort in quarrying, transporting, and stockpiling building materials.

The intramural kiva (Kiva A) exhibits a high degree of engineering sophistication lacking in the smaller roomblock units and in most 12th century "Mesa Verde" architecture. The inner shell of this structure (Hallasi 1979:fig. 58) apparently was constructed first; this initial phase required excavation of the kiva space, and construction of the masonry veneer walls, subfloor ventilator, and roof-support system. The latter is a Chaco eight-pilaster type incorporating horizontal log supports anchored into the fill behind the kiva walls (Hallasi 1979:fig. 63). After construction of the inner shell, the structure was buttressed by a framework of outer walls, including a high-standing concentric wall to the north and east, which probably served to partially cushion the inner walls from load-bearing stresses and to protect from percolating moisture. The overall effect is similar to Chacoan-style tower kivas (for example, the tower kiva at Salmon Ruin [Irwin-Williams 1974:frontispiece]). Thus, a marked architectural contrast exists between Escalante Ruin and the other roomblock units within the village area. This dichotomy probably reflects a social hierarchy within the village.

The smaller roomblock units within the village area probably were the domiciles for small family households integral to the community. Total roofed space, counting both pitstructures and rooms, was approximately 24 m² for Casa De Sueños and 37 m² for the Dominguez Ruin. This relatively low amount of total enclosed space, the few number of structures per roomblock units, and the lack of duplicated domestic facilities (no more than 1 surface room containing a working hearth, only 1 formal milling area at each roomblock unit) suggest the 2 excavated roomblock units housed small household groups, perhaps nuclear families. Based on comparable sizes, this generalization concerning the size of the domestic group inhabiting the small roomblocks probably can be extended to the uninvestigated units as well. Some of the larger units may have housed extended families.

By contrast, the Escalante Ruin contains over 300 m² of roofed space, including the intramural kiva. The patterning of the rooms suggests the interior space can be divided into 5 "suites" (east, northeast, northwest, west, and south apartments; fig. 5.7), counting the larger five-room addition built onto the south side of the original pueblo. The individual room content of the excavated east suite seems to support this reconstruction; the outermost rooms seem to be storage and work rooms, while the 3 inner rooms (Rooms 2, 8, and 10) functioned as habitation or resource processing spaces. Thus, these 5 rooms appear to contain the total facilities needed by a household group. Each suite contains 55 to 60 m² of floor space. Even considering that the resident groups at Escalante Ruin were of high status and thus had larger living chambers, it appears the five-room roomsuite arrangement and relatively great amount of total space probably represents a larger household group, probably an extended family, than the smaller architectural groupings at the other village roomblocks. This inference is supported by the presence of duplicated facilities in the excavated suite: Rooms 2 and 6 contain cooking hearths, and Room 10 contains multiple grinding stations in 2 separate clusters. Kiva A served as an integrative shared facility for the complex. The pitstructure is "oversized" (±31 m² in floor area) by DAP standards and contains a floor vault in the western portion of the floor.

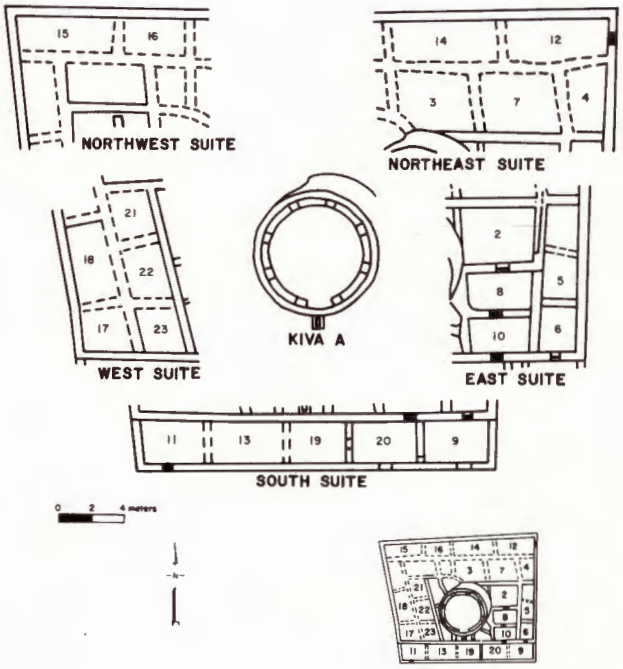

Figure 5.7 – Suggested household suite groups, Escalante Ruin (adapted from Hallasi [1979:fig. 6]).

Based on the contrasts in architecture and the interpretation of the Dominguez Ruin status burial, a social hierarchy existed within the Excalante Community, with the residents of Escalante Ruin proper constituting the upper tier, and the residents of the smaller, peripheral roomblocks constituting the lower tier. The exact relationship between the upper and lower tiers must be speculative. The low-status groups may have provided basic support for the upper tiers by supplying agricultural produce and gathered faunal and botanical resources, while the upper tier provided religious

guidance and managed the affairs of the village; this speculation is similar to the interpretation offered by Reed (1979:136-137). Reed (1979:137) also suggests the lower tier groups may have been a labor force that harvested perishable resources in the field for transport to the Chacoan towns of northwestern New Mexico. Hallasi (1979:399-403) also makes some speculations regarding the social organization of the village. She suggests the groups residing at Escalante Ruin were members of a Chaco colony later absorbed into the mainstream Mesa Verdean culture through intermarriage. Hallasi also notes (1979:399-400) the original Chaco-affiliated occupation of the Escalante Ruin roomblock was followed by 2 later Mesa Verdean-style uses. These later occupants built new, stratigraphically higher floors and used Mesa Verde-style tools and ceramic containers. The 2 small roomblocks excavated did not exhibit any evidence of reoccupation.

The small roomblocks are architecturally "poor" even when compared to other 12th century Mesa Verdean settlements. For example, Site 5MT499 on Chapin Mesa ultimately consisted of 15 to 20 rooms (including some two-story rooms), 2 kivas, and a tower, although it was originally in the form of a three-room surface roomblock and associated kiva, similar to the Dominguez ruin (Lister 1964:42-45, fig. 10). Site 5MTUMR2346 also exhibits growth from a small, simple unit to a more complex form with added rooms (Nordby 1974:figs. 31 and 38). Other southwestern Colorado Chacoan "outliers" (for example, Yucca House [Powers et al. 1983:fig. 84]) often are associated with long linear alinements of Mesa Verdean-style roomblocks. Why the peripheral roomblocks at Escalante did not exhibit internal growth or aggregation consistent with the patterns observed at other 12th century settlements is an important question. Maybe, the small roomblock units were not inhabited for a long enough period for growth to occur, or possibly growth was discouraged by the high-status Escalante Ruin groups because of management considerations (i.e., a larger population might have been more difficult to control).

A summary of Escalante Subphase material culture is not presented here, as no Escalante-affiliated site collections were recovered by DAP field crews, and the collections recovered during the University of Colorado (Bicentennial Escalante Trail Project) and BLM investigations are not directly comparable to project collections because of differences in field recovery and analytical techniques. For more detailed descriptions of the Escalante Village roomblock units, associated material culture, and the field investigations themselves, refer to the site reports (Reed 1979; Hallasi 1979; Douthit 1984).

Numic and Late Pueblo Traditions (A.D. 1500-1870)

Use of the project area by post-Anasazi Numic (Shosonean) and late Puebloan groups has been documented through the presence of diagnostic ceramics in survey collections and through the discovery and investigation of several protohistoric burials. Representative samples of Numic or late Pueblo Tradition structures and material culture, however, are lacking in the DAP data sets. The paucity of information regarding late occupations is probably due to 2 factors. First, the post-Anasazi use of the area appears to have been seasonal or transitory in nature, and hence associated structure populations and material culture densities were probably low. Second, post-Anasazi occupations are part of the general "aceramic problem." That is, a sizable minority of sites recorded by DAP survey crews (roughly 400 of the approximately 1600 recorded sites [Dolores Archaeological Program 1985:1]) could not be assigned to a recognized DAP cultural tradition (Archaic, Anasazi, or Numic/Late Pueblo). These sites are characterized by lack of easily recognizable structures, high proportions of flaked lithic items (tools and debitage), very low proportions of other material classes, and the scarcity of diagnostic items. These unassignable remains are thought to represent occupations by Archaic, Anasazi, or post-Anasazi groups, or use by groups representing 2 or more of these traditions. Thus, confident assignment to a particular tradition is often impossible. A more thorough treatment of the aceramic problem is presented in a separate DAP report (Dolores Archaeological Program 1985).

Given the lack of representative information regarding late occupations, no systematic attempt to reconstruct lifestyles has been included in the individual phase presentations. Two phases have been defined for the late occupations; the separation was based on whether the groups had or did not have contact with historic Anglo or Spanish cultures.

Beaver Point Phase (A.D. 1500-1800)

Use of the project area by Numic and late Puebloan peoples after the Anasazi abandonment and before historic contact is assigned to the Beaver Point Phase. Errickson and Wilson (1985) identify 17 sites in the project area with associated material collections that contain post-Anasazi ceramics.[6] In addition, a radiocarbon date of 290 B.P. ± 50 (A.D. 1660) was recovered from Lone Aspen Camp (5DL444), an open, multicomponent site located on the high plateau of the river canyon (Kleidon 1984c). Of the 15 identified late contexts, 13 are archaeologically represented as survey

[6]Errickson and Wilson (1985) also identified these late occupations from survey collections representing sites removed from the project area.

surface collections, while the other 2 (at Lone Aspen Camp and Singing Shelter [Site 5MT4683]; Kleidon [1984c] and Nelson and Kane [1985]) are excavation contexts. According to Errickson and Wilson (1985:table 1), indeterminate or micaceous brown ware sherds were recovered from 11 sites; these ceramic fragments are interpreted as being indicative of Numic (Shosonean) occupations. Also, 174 Awatovi or Jeddito Yellow ware sherds indicative of late Puebloan (Hopi) were recovered from 10 sites. Survey collections from 3 sites yielded both Shoshonean and Hopi ceramics (Errickson and Wilson 1985:table 1). The locations of these sites are depicted in figure 5.8.

The survey form descriptions for the post-Anasazi sites suggest that associated structures generally were absent. A structure was investigated at Lone Aspen Camp, and evidence for a possible structure (a concentration of fire-cracked rock) was noted at Site 5MT6693, located just north of the House Creek Canyon drainage, east of the Dolores River. Most of the project-area post-Anasazi site occupations conform to the "sherd and lithic scatter" type thought to be indicative of hunter and gatherer adaptations in montane and plateau provinces of southwestern Colorado (Gleichman and Legard 1977:155-388).

Errickson and Wilson (1985:11) note that 12 of the 17 post-Anasazi sites (or 18, if Lone Aspen Camp is included) are located along major canyon rims and, with the exception of Singing Shelter, all are located in topographically prominent locations. They (1985:15) also point out that for 11 of the recorded post-Anasazi occupations, Pueblo II (Marshview Subphase) sherds were also present in the surface survey collections. This probably is indicative of similar preferences by Marshview Subphase and post-Anasazi groups for limited activity site locations. Both groups probably used the project area with similar economic goals (acquisition of resources targeted by hunting and gathering activities).

The Beaver Point Phase subsurface contexts investigated by DAP field crews do not add much in the way of interpretable data to this description. The post-Anasazi sherds at Singing Shelter were recovered from shallow, disturbed deposits; because of the ambiguous provenience of these artifacts, the authors of the site report merely note the presence of a post-Anasazi occupation and do not speculate as to its intrasite associations or nature (Nelson and Kane 1985:49). The possible Beaver Point Phase occupation at Lone Aspen Camp[7] consists of the remains of a post-supported structure and an associated collection of artifacts (Kleidon 1984c:46-51). The archaeological remains of the structure consisted of 27 postholes arranged in an oval pattern; the postholes might represent a wickiup-like structure (Kleidon 1984c:51). The structure apparently was about 2.7- by 2.0-m, with a floor area of approximately 4 m^2. The associated artifacts included over 100 pieces of debitage, several utilized flakes and unifacially flaked tools, 1 thin bifacially flaked tool, 1 grooved abrading/grinding stone, 1 metate fragment, and 2 red ware sherds. The last, of Anasazi origin, may reflect contamination from an earlier occupation of the site centered approximately 20 m southwest of the structure.

Little specific dating evidence is available for the survey-recorded sites with late ceramics. The architectural and stone tool data are not amenable to precise dating inference. The project staff relied largely on the associated ceramic data in dating the area's Anasazi occupations, but this source is of limited value in dating post-Anasazi archaeological contexts. Based on a survey of published descriptions, Errickson and Wilson (1985:3) surmise that micaceous brown ware sherds had a wide prehistoric distribution over the late prehistoric West and Southwest. The dates of their introduction into specific areas are uncertain; they may have been introduced into Nevada and western Utah as early as A.D. 1050-1300 (Errickson and Wilson 1985:8), based on the co-occurrence of these wares in strata also containing Virgin Anasazi and Fremont ceramics (Fowler et al. 1973:16-19). In southwestern Colorado, some evidence indicates introduction of micaceous brown wares before A.D. 1500 (e.g., Annand 1967:58-59); however, most evidence seems to favor a post-A.D. 1500 introduction date (Buckles 1971). Based on these sources, Errickson and Wilson (1985:9) suggest a date range of A.D. 1500-1850 for the Dolores area sites with micaceous brown wares. The dating of Hopi wares is more clearcut, although a long time span of use is evident. According to Colton (1956), Jeddito wares date to A.D. 1300 to the present. This information does not affect the original date estimate of A.D. 1500-1850 provided by Errickson and Wilson (1985:9). The A.D. 1660 ± 50 radiocarbon date obtained from Lone Aspen Camp supports this general date range for Beaver Point Phase occupations.

The archaeological evidence indicates the Beaver Point Phase (post-Anasazi, pre-Anglo contact) use of the project area was seasonal or transitory in nature. The use probably was part of a wider economic strategy directed toward the use of local faunal and botanical resources. These inferences are based on the locations of the Beaver Point sites, which provide a good vantage point over the surrounding terrain,and the characteristics of the sites themselves, which conform to the sherd-and-lithic

[7]The radiocarbon dating of 290 B.P. ± 50 (A.D. 1660 ± 50) was obtained from one of the construction posts associated with the structure; however, Anasazi sherds also were recovered from the same area, raising a question concerning the true cultural affiliation of the structure and material remains. Here, the radiocarbon is interpreted to reflect the use of the structure.

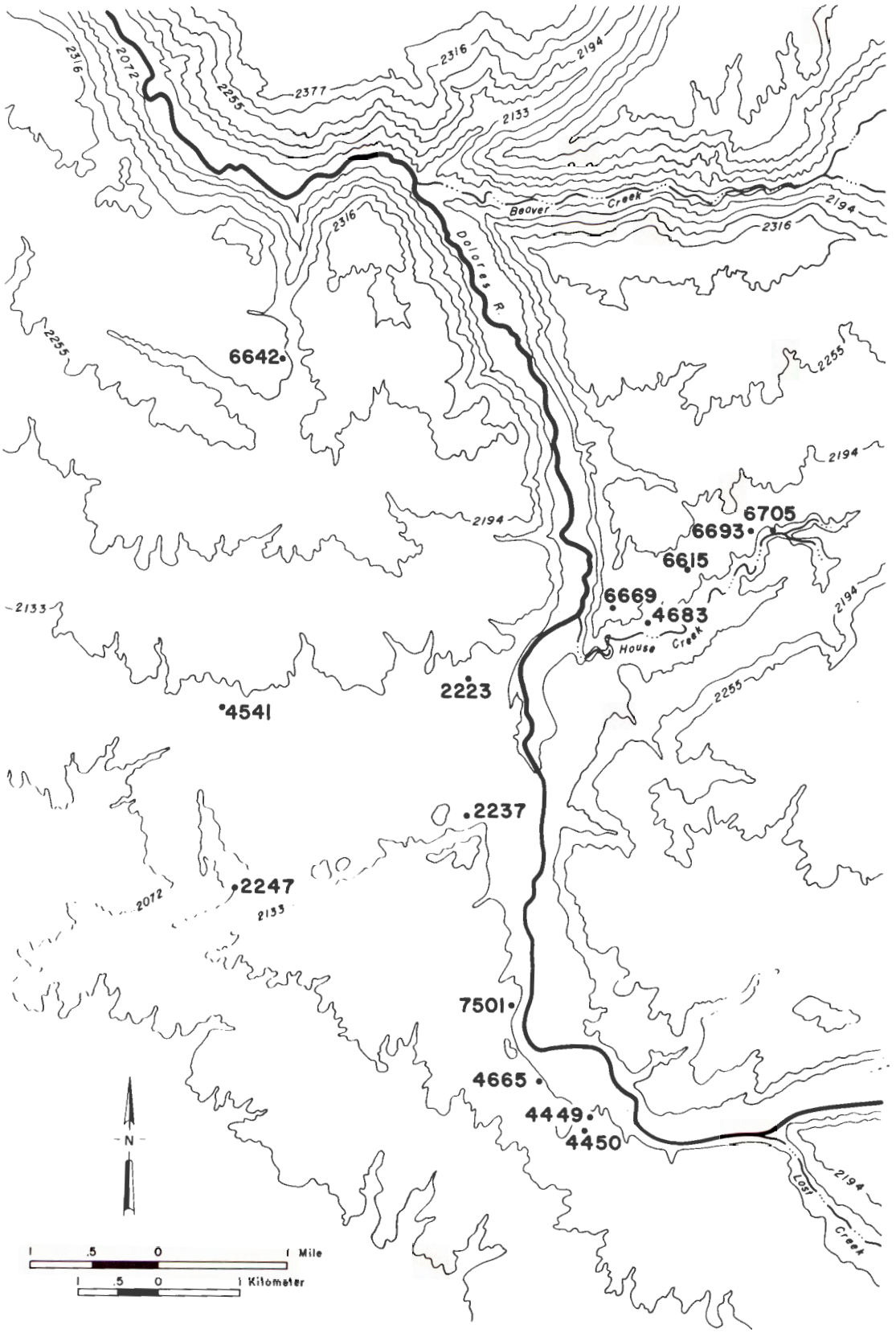

Figure 5.8 – Locations of Dolores Archaeological Program sites yielding Shoshonean or Hopi ceramics (adapted from Errickson and Wilson [1985:fig. 2]). Four sites, including Lone Aspen Camp, are located beyond boundaries shown on map.

scatter, low-structure-density pattern indicative of highly mobile hunting and gathering groups. The wickiup-like Beaver Point structure investigated at Lone Aspen Camp, considering its small size and simple construction, is consistent with the high-mobility interpretation. Based on the available evidence, only a general date range of A.D. 1500-1850 could be derived for the Beaver Point occupations; this range includes both the Shoshonean and the Hopi occupations. Recorded site density for the period is very low – only 18 Beaver Point occupations were identified after evaluation of the survey and excavation data. However, other post-Anasazi contexts likely were present, but lacked diagnostic artifacts. Additional information regarding the Beaver Point Phase and post-Anasazi use of the project area is available in other DAP reports (Dolores Archaeological Program 1985; Errickson and Wilson 1985; Kleidon 1984c).

Protohistoric Phase (A.D. 1750-1870)

The Protohistoric Phase represents use of the Dolores area by Native Americans during the period of contact with and settlement of the area by historic Anglo and Spanish groups. Protohistoric occupations were identified through the presence of diagnostic artifacts (trade beads, metal and glass projectile points) in DAP survey or excavation collections.

Three Protohistoric Phase project-area occupations were recognized in the excavation data set. These were 2 human interments (1 probably representing deliberate burial and the other perhaps the result of an accidental or natural death) and a temporary camp in a shelter location.

The deliberate burial was discovered in a natural crevice in the rimrock forming the southern wall of the Dolores River canyon a few kilometers west of the town of Dolores; the rimrock and talus also includes a small rockshelter used by the Anasazi. The burial and shelter were treated as 1 site by DAP field crews (Star Bead Shelter [Site 5MT5380]; Hovezak [1983]). The human remains apparently were placed in the bottom of the crevice and covered with sandstone slabs. Items of personal adornment apparently were left with the body: over 40 000 seed beads, several larger beads, 5 percussion caps, 2 lead balls, and 3 pieces of German silver were recovered. The beads and silver are probably remnants of clothing and jewelry. The percussion caps, lead balls, and a fragment of possible patching material indicate the individual carried a muzzle-loading handgun or rifle. The burial artifacts allowed fairly precise dating; Hovezak estimates that the interment occurred between A.D. 1860 and 1880 based on manufacturing dates for the burial-associated items and the condition of the items (1983:48). The context of the burial and the nature of the associated artifacts suggest the burial was probably Shoshonean in origin (Hovezak 1983:49).

The other protohistoric burial (Los Atavios [Site 5MT5399]; Chenault [1983]) was discovered in the Sagehen Flats area in the vicinity of the McPhee Recreation Area boat ramp, about 4.5 km northwest of Dolores. The burial consisted of the remains of an adult female and associated items classified as domestic tools, adornment, or the remains of clothing. These included over 17 000 seed beads, elk tooth pendants, rusted metal items (shears, 1 knife, 1 nail, and 1 awl or punch), 1 brush, and 1 piece of worked glass, possibly used as a cutting implement. The characteristics of the artifacts suggest affiliation with the Protohistoric Phase, with interment of the remains probably occurring between A.D. 1850 and 1890. The burial did not show any signs of deliberate interment, although the author of the report believes interment rather than accident is more likely, given the condition of the burial (Chenault 1983:20). The shallow ravine in which the burial was discovered would have provided a convenient location to cover a body. Chenault (1983:20-21) suggests the remains are Shoshonean in origin, based on the characteristics of the associated items.

The other protohistoric field context was discovered at Beaver Trap Shelter (Site 5MT4654 [Hewitt and Harriman 1984]); the shelter is located in the cliffs north of the McPhee Village area, about 6 km northwest of Dolores. During field investigations, a single glass seed bead was recovered from disturbed cultural strata near the surface of the shelter. The strata also yielded Anasazi and historic artifacts and sheep and cattle dung, which probably is indicative of extreme disturbance and mixing of deposits. Several use surfaces and associated features (shallow pits and hearths) were identified in this part of the shelter, and a fragment of vegetal matting, perhaps indicative of a sleeping location, was recovered from one of the use surfaces. The relationships between the historic, protohistoric, and Anasazi occupations, the recorded surfaces and features, and the recovered artifacts were difficult to judge because of the extreme disturbance. Hewitt and Harriman (1984:59) note, however, that beads similar to the bead recovered from the shelter were common into the 20th century. The high density of ash and charcoal in the strata suggests the kindling of numerous fires over an extended period. Hewitt and Harriman (1984:91) propose that the shelter was used frequently by Protohistoric groups.

Additional information regarding the Protohistoric Phase can be gleaned through research into early historic accounts of the area. Spanish explorers and traders apparently were active in the area as early as the middle portion of the 18th century (Bloom 1984:56), and documented accounts of some of these early occupations

date from the Rivera expedition of A.D. 1765. Dominguez and Escalante did not encounter any native Americans in or near the project area during their expedition in A.D. 1776, although the local area was considered the territory of the "Muhuache's Yutas" (Muwach Band of the Ute Tribe, the modern Southern Utes). The expedition later encountered small transitory groups of Tabehuachi Utes in the Montrose area and a large encampment of the same band on Grand Mesa southeast of Grand Junction (Chavez 1976:17-33).

Early Native American-Anglo settler relations in the Dolores area apparently were characterized by frequent violent interchange. The public lands in the project area were surveyed and opened for homesteading in the A.D. 1870's (Bloom 1984:58). Early Anglo settlement of the area created a conflict between the new settlers and the local Ute groups who continued to forage in the area. In A.D. 1885 a small encampment of Utes camped near the mouth of Beaver Creek (probably in the vicinity of or on the Grass Mesa site [Site 5MT23]) was attacked by local cowboys; 6 Native Americans were killed (Bloom 1984:61). With the aid of military troops from Fort Lewis, the area was pacified, and trouble between settlers and Indians was rare after A.D. 1890.

Except for possible inferences regarding burial practices, the DAP protohistoric data is too scant to draw in-depth interpretations regarding cultural practices. Use of the project area during the Protohistoric Phase was probably similar to that during the preceding Beaver Point Phase; the area was used on a seasonal or transient basis by small groups in pursuit of game or wild plant resources. The previously cited historic records confirm that the area was part of the home territory of the Muwach Ute band, and that small transitory groups were frequenting the area in the 18th century.

A SUMMARY OF DOLORES ANASAZI ARCHITECTURE

This section summarizes characteristics of surface structures and pitstructures and the intrasite patterning of these units for the Anasazi subphases of the DAP phase scheme. This presentation is descriptive and is intended to provide a comprehensive overview of DAP Anasazi architecture. The architectural data categories considered are, first, general site layout and architectural populations; second, characteristics of surface structures; and third, characteristics of pitstructures. Separate discussions are included for each Anasazi subphase as enumerated in the DAP phase scheme discussion. The presentations are based on a general assumption of Pecos classification normal patterning for each subphase; however, substantial variations are pointed out. The Grass Mesa and Marshview Subphases in particular are characterized by abnormal patterns. Many of the size and shape statistics reported in the individual descriptions are taken from other project studies of architecture (Hewitt et al. 1983; Kane 1984b; Wilshusen 1985c).[8]

Cougar Springs Phase (A.D. 1-600)

No Cougar Springs Phase structures were discovered by DAP field crews. The one investigated Cougar Springs occupation (at Cougar Springs Cave [Site 5MT4797]; Gross [1984a]) consisted of use surfaces and associated features and artifacts in a small, north-facing shelter. The presence of Basketmaker II structures (perhaps similar to those discovered in rockshelter settings near Durango, Colorado [Morris and Burgh 1954]) in uninvestigated locations within the project area cannot be ruled out.

Tres Bobos Subphase of the Sagehen Phase (A.D. 600-700)

Tres Bobos Subphase architecture appears similar in most respects to other early Basketmaker III patterns investigated in the Mesa Verde Region (for example, on Wetherill Mesa [Hayes and Lancaster 1975; Birkedal 1976] or west of the project area [Rohn 1975; Gerwitz 1982; Adams 1982]). The Tres Bobos Subphase architectural data were collected from several individual site investigations; these included Tres Bobos Hamlet (Site 5MT4545 [Brisbin and Varien 1981]), Chindi Hamlet (Site 5MT4684 [Tucker 1983]), Apricot Hamlet (Site 5MT2858 [Montgomery 1982]), and Poco Tiempo (Site 5MT2378 [Brisbin 1984b]).

General Layout and Structure Populations

Habitation sites usually contain 1 pitstructure, an arc of surface structures and outdoor activity areas north and west of the pitstructure, and a refuse scatter, or midden, south of the pitstructure (fig. 5.9). Other smaller extramural features or structures, such as hearths, pits, ramadas, and borrow areas, may be present as well. Overall dimensions of habitation sites are about 40 to 60 m east-west by 40 to 60 m north-south; average site area is about 2000 to 2500 m^2. The surface structures, pitstructure, and refuse deposit usually are

[8]The figures provided in this section are intended to illustrate typical or representative architectural units at different points in the Anasazi sequence. The site and structure plans are composites based on patterns observed at many sites and represent the author's idealized view of what a "typical" site or a "typical" structure might resemble. The citation provided for each figure refers to the map that served as the basis for the illustration, although many changes will have been made for adaptation to this report.

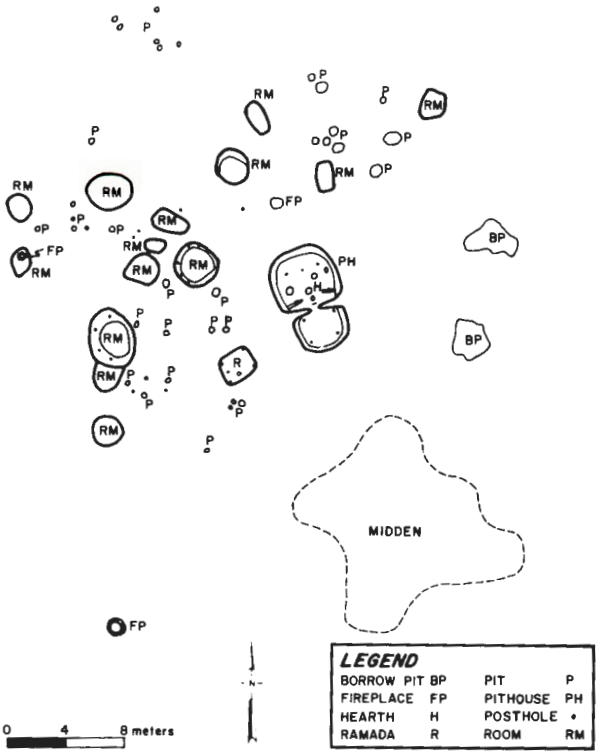

Figure 5.9 – Tres Bobos Subphase habitation site layout (adapted from Brisbin and Varien [1981:fig. 2.11]).

alined northwest-southeast or north-south. Sites with more than 1 pithouse have been recorded in the project area, but no aggregations of dwelling units such as those reported in the Yellow Jacket area west of the project (Rohn 1975; Wheat 1955).

Surface Structures

The more common and substantial surface structures are small, oval rooms with "beehive" roofs. These rooms average slightly over 3 m² in area (Wilshusen 1985c:table 3) and are semisubterranean, with a prepared floor surface excavated 20 to 30 cm below ground surface. The rooms generally lack floor features, although small hearths situated against the southwall have been recorded (Brisbin 1984b:42, fig. 21). Roof construction for these structures does not conform to the usual four-post roof-support pattern recorded for most Anasazi structures. Rather, the best reconstruction based on the available evidence is that the superstructure was beehive or tipi-like in form and was constructed of a daub outer layer over a pole framework that formed an enclosure around the perimeter of the excavated floor. This slanting superstructure served as walls and roof. Functionally, these structures appear to have served primarily as storage and general-purpose facilities. This conclusion is based on the general lack of internal features and artifact concentrations, the small size of the structures (rendering it difficult to perform activities inside the structure), and the recovery of charred corn and other vegetal materials from some structures. The presence of small hearths in a few rooms suggests activities besides storage might have taken place. Populations of these small rooms range between 8 and 18 per site, and appear to cluster in groups of 3 to 4, perhaps indicating functional associations or differential use by the inhabitants of the site.

Also present at Tres Bobos habitations are more ephemeral surface structures that probably can be classed as ramadas. These appear to be less common than the semisubterranean rooms (1 to 2 per site). These structures apparently were without substantial walls or roofs; they are recognized and defined on the basis of 4 postholes at the edges of a use surface. Although no evidence is available from project excavations, temporary pole and brush walls may have been present. Mean floor area for these structures apparently is about 4 m². Interior features include hearths and pits. Ramadas apparently served as outside work areas that provided some protection from the elements.

Pitstructures

Tres Bobos Subphase pitstructures conform to the "normal" Mesa Verde Region Basketmaker III pattern (Birkedal 1976; Hayes and Lancaster 1975). Based on the artifacts left at abandonment, most indoor activities probably were domestic; therefore, these structures are termed "pithouses." Tres Bobos pithouses usually consist of a larger room ("main chamber") to the north and a smaller antechamber to the south connected by a passage. The chambers are roughly D-shaped, with the flat sides facing each other. Figure 5.10 illustrates a Tres Bobos Subphase pitstructure. The architectural specifications are provided in the following list:

1. Shape. The squareness index (a value of 1.000 is square; 0.0785 is round; Hewitt et al. [1983:table 1]) for Tres Bobos pitstructures is 0.90; this is the lowest index for all temporal units used in the study by Hewitt and her associates.

2. Size. The mean size of Dolores area Tres Bobos pitstructures is about 25 m², including main chamber and antechamber (Wilshusen 1985c:table 3); however, considerable variability in size is noted (the standard deviation is about 9 m²).

3. Depth. Depths (prehistoric ground surface to floor) of Tres Bobos pitstructures average about 1 m (Wilshusen 1985c:table 3); this is relatively shallow when compared to the pitstructures of later periods.

4. Roof construction. Tres Bobos pitstructures are characterized by the "normal" four-post roof-support pattern. The 2 southern posts are in the

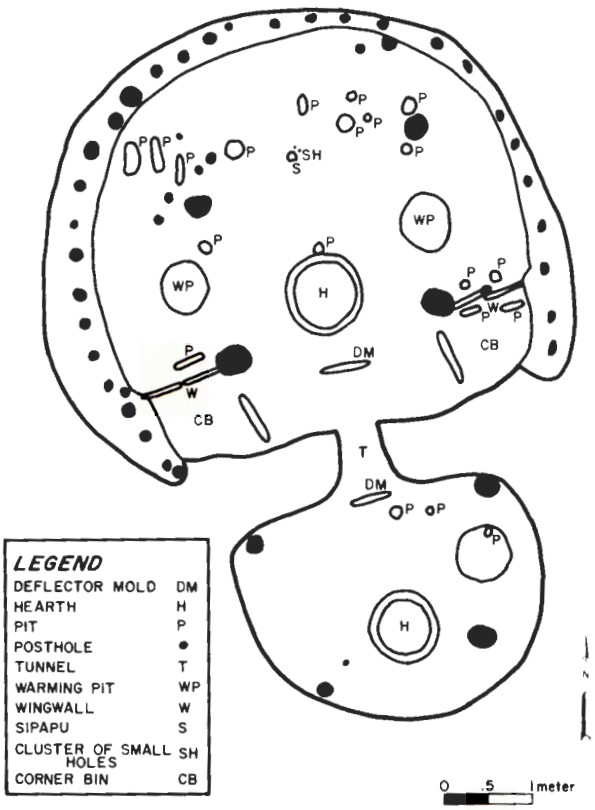

Figure 5.10 – Plan of a Tres Bobos Subphase pitstructure (adapted from Brisbin [1984b:fig. 29]).

wingwall or against the south wall of the main chamber. The northern posts are located in the northwest and northeast quarters; they are positioned nearer the center of the pitstructure than in later pitstructures. Leaner posts usually are anchored on the outer perimeter of the bench. Auxiliary posts may be positioned to shore up weak portions of the roof.

5. Bench. Benches usually are present in the main chamber and may be present in the antechamber as well. They are wider (0.5 to 1.0 m) than in later pitstructures.

6. Wingwall. A wingwall is usually present; it separates the southern quarter of the main chamber from the remainder of the chamber. The wall usually is constructed of vertical slabs and usually forms 1 wall of an associated corner bin.

7. Bins. Two above-floor bins are usually present in the southwest and southeast corners; these are similar to "cupboards" in that they were roofed and had a side entry hole with a cover (cf. Adams 1982:fig. 6.6-4).

8. Ventilation system. Air apparently flowed into the main chamber from the antechamber passage; a deflector slab is positioned within 0.75 m of the south wall of the main chamber.

9. Hearth and heating complex. A cooking hearth, also used to warm the structure, is located near the center of the main chamber north of the wingwall. Tres Bobos central hearths are shallow and usually smaller than in later pitstructures, perhaps indicating that the group using the hearth was smaller. An ash pit is usually associated with the hearth and is located to the south on the north-south axis. A pair of warming pits (cf. Brisbin 1984b:fig. 29) may be present; these are usually located approximately 1 m to either side of the hearth in the main chamber. These pits are shallow and basin shaped and probably were used as an auxiliary source of heat; fire-cracked cobbles often are found in these pits. A small central hearth may be present in the antechamber.

10. Domestic and economic activity areas. One or two metate grinding stations are usually located in the northeast quadrant of the main chamber or adjacent to the east or west walls. The metates may be temporarily stored by being leaned against the east or west walls in an upright position (Tucker 1983: fig. 22).

11. Ritual activity areas. A sipapu is usually located on the north-south axis of the main chamber between the central hearth and the north wall. This feature may be a simple cylindrical pit without associated features, or it may be a cylindrical pit associated with a cluster of smaller conical pits. The latter have been inferred to represent the marks left by prayer sticks, or "pahos" (Wilshusen 1985b:4-5).

As domestic pithouses, Tres Bobos pitstructures are thought to represent the primary dwelling space or "house" for early Anasazi families. Small pithouses (perhaps those pitstructures with less than 25 m^2 of total floor area) were probably used by small nuclear families, while larger pitstructures may have housed 2 nuclear families, perhaps related by kinship ties.

Sagehill Subphase of the Sagehen Phase (A.D. 700-780)

Sagehill Subphase architectural patterns appear to be similar in most respects to "late" (post-A.D. 700) Basketmaker III regional patterns. Descriptions of site-specific Sagehill architectural descriptions are available in other DAP reports (Sagehill Hamlet [Site 5MT2198; Hewitt 1983c]; Aldea Sierritas [Site 5MT2854; Kuckelman 1983]; Prairie Dog Hamlet [Site 5MT4614; Yarnell 1982a]; Pozo Hamlet [Site 5MT4613; Nelson 1984]).

General Layout and Structure Populations

The layout of Sagehill Subphase habitation sites is similar to that of Tres Bobos Subphase sites: 1 pitstructure, an arc of surface structures north and west of the pitstructure, and an area of sheet refuse to the south or southeast (fig. 5.11). The Grass Mesa site is an exception; Lipe et al. (1985:18.8-18.15 and table 18.1) report the documented or suspected presence of at least 13 Sagehill Subphase pitstructures at this site. These seem to be distributed in 2 clusters – a smaller one in the eastern portion of the site, and a larger one centered on a contemporaneous oversized pitstructure (Pitstructure 93) in the western portion of the site. In addition to surface rooms and pitstructures, Sagehill Subphase habitation sites contain outdoor features such as hearths, pits, and borrow areas. Overall site dimensions of Sagehill Subphase habitation sites range from 40 to 60 m east-west by 40 to 60 m north-south; site areas average about 2000 to 2500 m².

Surface Structures

Sagehill Subphase surface structures appear more variable in form and function than their Tres Bobos Subphase predecessors. Three gross structural-functional categories are suggested by the data, although the available sample is too small to test the validity of these categories. One category (thought to correspond to the definition for "living" room) includes relatively large structures with substantial roof and wall construction and with relatively numerous floor artifacts and features representing indoor activities. Included in the second category are relatively large structures with insubstantial walls and roofs and with relatively few floor artifacts and features. These structures are thought to be "ramadas" – outside work areas partially protected from the elements by pole and brush superstructures. The third category consists of relatively small rooms that may have functioned primarily as storage space. In form, some of these may have been similar to Tres Bobos "beehive" rooms (for example, Rooms 1, 2, and 3 at Pozo Hamlet [Nelson 1984:figs. 17 and 19]), while others apparently were rectangular in outline with vertical walls (for example, Room 6 at Prairie Dog Hamlet [Yarnell 1982a:fig. 6.34]). The storage interpretation is based on the relatively small sizes and low densities of internal features and artifacts.

Sagehill surface structures are noncontiguous and are arranged in an arc west and north of the pitstructure area. The structures may be spatially clustered in functionally associated groups, a phenomenon also noted for Tres Bobos Subphase sites. The number of surface structures per site ranges between 6 and 12. Specific architectural details are as follows:

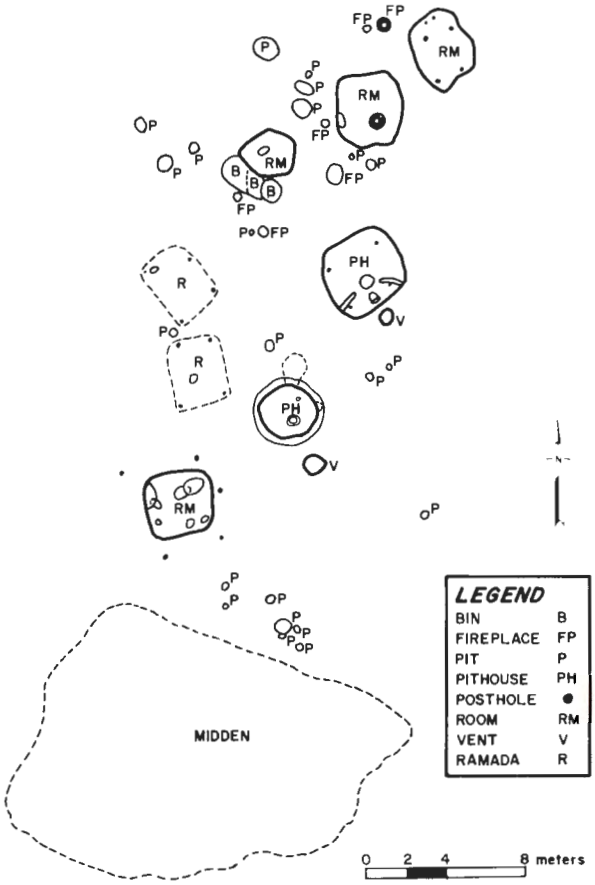

Figure 5.11 – Plan of a Sagehill Subphase habitation site layout (adapted from Yarnell [1982a:fig. 6.9]).

1. Shape. The structures usually are subrectangular or oval in plan.

2. Size. The distribution of room sizes appears to be bimodal; most of the rooms are small (3.3 to 6.0 m²), but a significant minority are larger (10.0 to 14.0 m²). This dichotomy apparently reflects functional differences: the smaller structures are storage rooms, while the larger are living rooms or ramadas.

3. Wall construction. The lack of sandstone slabs or rubble in the fill of Sagehill Subphase surface structures suggests that walls were constructed of jacal, adobe, or daub. The structural integrity and substantiveness of these rooms is conjectural; some of the "rooms" might have had only partial walls or might have been ramadas.

4. Roof construction. Most structures have postholes in the corners, which suggests that a standard four-post support pattern was prevalent for roof construction; ramadas probably had insubstantial roofs of poles and brush.

5. Floor. The floors of Sagehill Subphase surface structures exhibit little evidence of preparation or finishing. Usually they consist of the leveled earthen surface that was cleared or excavated for the room and a veneer of dried mud or sand. The floors of some structures were excavated 15 to 30 cm into the prehistoric ground surface (these were probably true "rooms" with daub or jacal walls), while others apparently lacked sunken floors (these may have been ramadas).

6. Domestic and economic activity areas. Most rooms lack in situ artifacts and features and are thought to represent storage facilities, although there is little direct evidence for this. Some of the large rooms might have functioned as centers of domestic activity: Room 3 at Prairie Dog Hamlet (Site 5MT4614 [Yarnell 1982a:79-85]) contains a fireplace, lithic debitage, and an in situ metate, which suggests that cooking, stone tool manufacture, and mealing were performed in the structure.

Pitstructures

Sagehill Subphase pitstructures differ markedly in form from Tres Bobos pitstructures. The antechamber is replaced by a tunnel and shaft ventilator system. The structures are deeper and usually are subrectangular in plan rather than D-shaped. Typically, they lack benches. Usually only one contemporaneous pitstructure occurs per habitation site, although the presence of several noncontemporaneous pitstructures suggests multiple building episodes might have taken place. Feature populations and in situ artifacts generally reflect domestic or economic activities; hence, the term "pithouse" probably is an appropriate designation for most Sagehill pitstructures. An oversized Sagehill pitstructure was identified in Area 5 of Grass Mesa Village (Site 5MT23 [Lightfoot et al. 1985:7.246]). This structure was only partially trenched, and hence its characteristics are speculative. It probably was rectangular in outline with an antechamber and a floor area of over 40 m². It may have resembled a Basketmaker III oversized pitstructure investigated by the MAPCO project a few kilometers west of the Dolores Project area (Lux-Harriman 1982a:fig. 6.2-4). A normal-size Sagehill Subphase pitstructure is illustrated in figure 5.12. Architectural characteristics are as follows:

1. Shape. Sagehill Subphase pitstructures generally can be characterized as subrectangular (squareness index is 0.92, compared to 0.90 for Tres Bobos structures). "Subrectangular" is only a general description; many are irregular with reference to wall orientations and outlines.

2. Size. Sagehill Subphase pitstructures average about 18 m² in area (Wilshusen 1985c:table 2); this is substantially less than comparable Tres Bobos structures. There is also less size variability in pitstructures assigned to this subphase, perhaps indicating less variation in the sizes of groups using the pitstructures. The pitstructure population includes 2 very small examples (considered "outliers" in the graphed distribution of all Dolores pitstructures); the true average might be somewhat higher than 18 m².

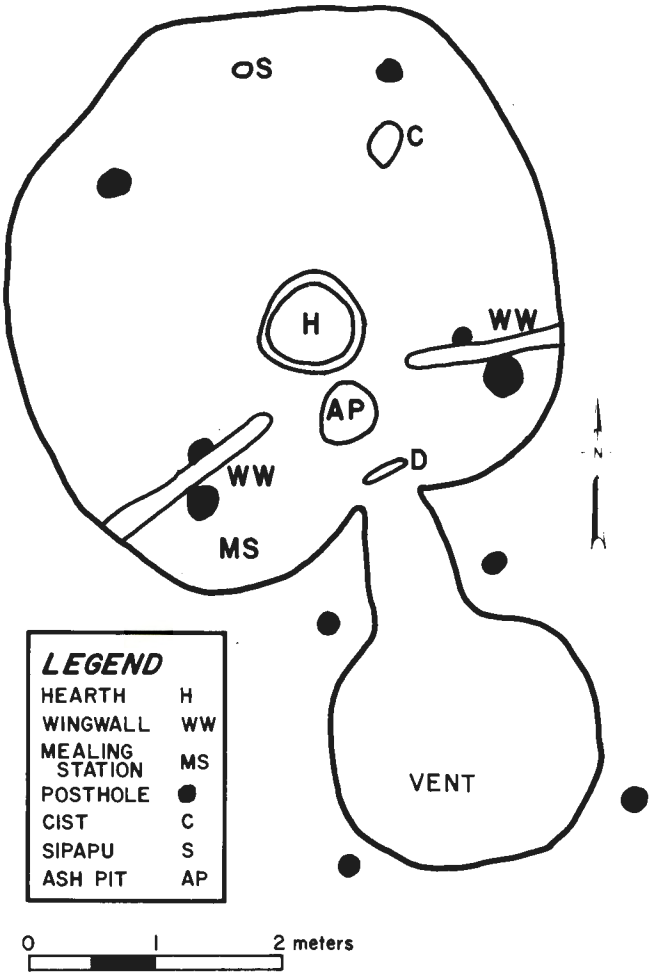

Figure 5.12 – Plan of a Sagehill Subphase pitstructure (adapted from Hewitt [1983c:fig. 5.7]).

3. Depth. Depths of Sagehill Subphase pitstructures average about 1.5 m (Wilshusen 1985c:table 2); this is about 0.5 m greater than Tres Bobos structures and about 0.4 m less than Periman Subphase structures.

4. Roof construction. Sagehill Subphase pitstructures incorporate the standard four-post roof-support system. Leaners apparently were grounded on the outside of the pit, perhaps on a prepared

"leaner" shelf. Brisbin et al. (1982:44) report the presence of such a feature in Pitstructure 1 at Dos Casas Hamlet (Site 5MT2193). Auxiliary posts might have been employed to shore up weak areas of the roof.

5. Bench. Most Sagehill Subphase pitstructures lack a bench. Pitstructure 1 at Pozo Hamlet (Site 5MT4613 [Nelson 1984:fig. 10]) is an exception. This structure contains a fairly narrow bench (ca. 40 cm wide) along the west and east walls.

6. Wingwall. Sagehill Subphase pitstructures usually incorporate a wingwall that separates the southern quarter of the main chamber from the rest of the chamber. An approximate 1.5 m gap is present between the 2 halves of the wingwall. Wingwalls are usually built of adobe or mud and sometimes are reinforced with vertical poles or sandstone slabs.

7. Bins and cists. No corner bins are present in Sagehill Subphase pitstructures. Wall cists or floor cists, apparently used for storage of tools or materials, may be present.

8. Ventilation system. Tres Bobos antechambers are replaced by tunnel and shaft ventilator systems. Ventilator shafts are much larger in diameter than those in pitstructures assigned to later subphases, and may also have served as storage areas or as loci of other activities. The deflector is usually located between the wingwall and the southwall, approximately 50 cm north of the ventilator tunnel entrance.

9. Hearth and heating complex. A heating and cooking complex is present in the form of a central hearth and ash pit; warming pits are sometimes present to the east and west of the central hearth.

10. Domestic and economic activity areas. A metate station is usually present in the southwest or southeast corner of the structure, behind the wingwall. The opposite southern corner is often used for storage of lithic tools (e.g., axes, cores, manos).

11. Ritual activity areas. A simple sipapu is usually present; it is located on the north-south axis of the structure between the central hearth and north wall.

Sagehill Subphase pitstructures appear to be similar in function to their Tres Bobos antecedents; they apparently served as the dwelling and primary domestic space for small family units. The discovery of multiple grinding stations in Pitstructure 1 at Dos Casas Hamlet (Brisbin et al. 1982:50-51) suggests this particular pitstructure may have been used by several family groups.

Dos Casas Subphase of the Sagehen Phase (A.D. 760-840)

Dos Casas Subphase architecture is similar to the general Pueblo I pattern in the Mesa Verde Region (Brew 1949; Morris 1939; Hayes and Lancaster 1975; Martin and Rinaldo 1939; Gillespie 1975). Descriptions of Dolores site-specific Dos Casas architecture are available in other DAP reports: Windy Wheat Hamlet (Site 5MT4644 [Brisbin 1984a]), Periman Hamlet (Site 5MT4671 [Wilshusen 1983]), Dos Casas Hamlet (Site 5MT2193 [Brisbin et al. 1982]), Hamlet de la Olla (Site 5MT2181 [Etzkorn 1983]), and Dovetail Hamlet (Site 5MT2226 [Nelson 1985]).

General Layout and Structure Populations

Dos Casas Habitation sites usually contain a single major roomblock with a double row of rooms, a plaza-pitstructure area to the south,and a refuse midden (fig. 5.13). However, several of the large roomblock complexes at the major Periman Subphase villages were probably first established during the Dos Casas Subphase. Roomblocks usually have 2 to 5 front rooms and

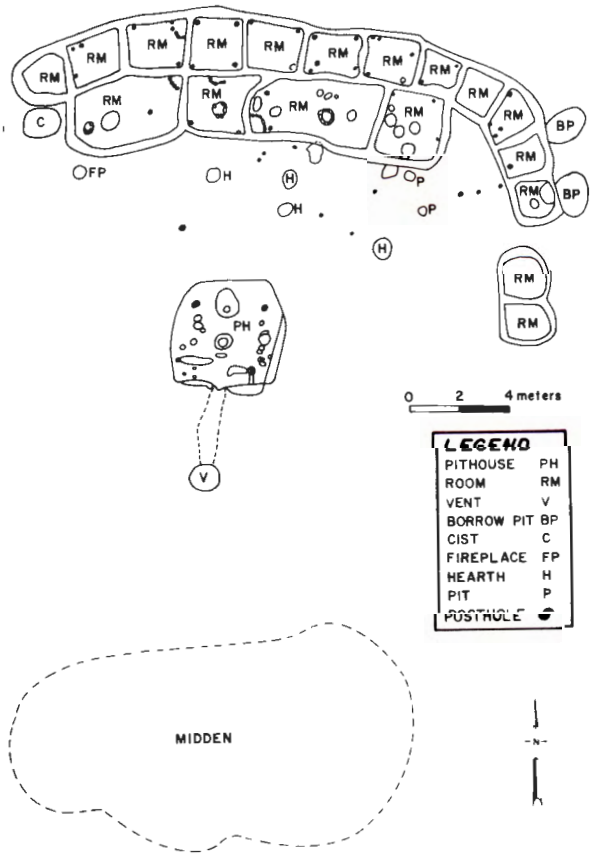

Figure 5.13 - Dos Casas Subphase habitation site layout (adapted from Wilshusen [1983:fig. 11]).

4 to 15 back rooms, although some larger units were encountered by the DAP. Single, noncontiguous rooms or ramadas also may be present, either east or west of the roomblock, or both. South of the roomblock is a plaza containing outside work areas and features and 1 or more pitstructures. South, southeast, or southwest of the plaza is a midden area that usually can be better characterized as a "mound" rather than as "sheet refuse." Dos Casas Subphase habitation sites exhibit greater size variability than earlier sites. Small habitation sites average about 1000 m² (30 m east-west by 35 m north-south) in area, while large ones may be over 5000 m² (75 m east-west by 75 m north-south) in area.

Surface Structures – Back Rooms

Most back rooms in the main roomblocks are assumed to have functioned as storage facilities because of the relatively high investment in wall and roof construction and the lack of floor features. Other excavations of late A.D. 700's to early A.D. 800's settlements in the Northern San Juan Area (Morris 1939; Brew 1946) have revealed rooms similar to Dolores area Dos Casas back rooms. Burned back rooms are often discovered during excavations, and these may be filled with the remains of cultigens (usually maize). This is additional evidence to support the storage function inference. In addition to serving as loci for storage of cultivated crops, the Dos Casas back rooms probably also functioned as storerooms for tools. Activities other than storage, such as animal and plant product processing or tool maintenance, also might have taken place in these locations (Wolf 1985a:62-63).

The "normal" Dos Casas pattern is 2 rear rooms per 1 front room; this three-room unit served as the dwelling unit for a family; an example of a Dos Casas three-room apartment is illustrated in figure 5.14. There do not seem to be any structural or functional differences when the 2 rear rooms common to a dwelling until are compared. Specific architectural details of Dos Casas rear storage rooms are as follows:

1. Shape. The structures are rectangular or subrectangular in plan.

2. Size. The size distribution of back rooms appears to approximate a normal curve. The mean floor area is approximately 3.5 m² (Wolf 1985a:table 1; Gross chap. 13, table 13.1), approximately 0.5 m² greater than comparable Sagehill Subphase structures. This increase may indicate the growing importance of storage as an economic practice. Gross (chap. 13) discusses the relationship among storage room characteristics, their contents, and reliance on stored resources.

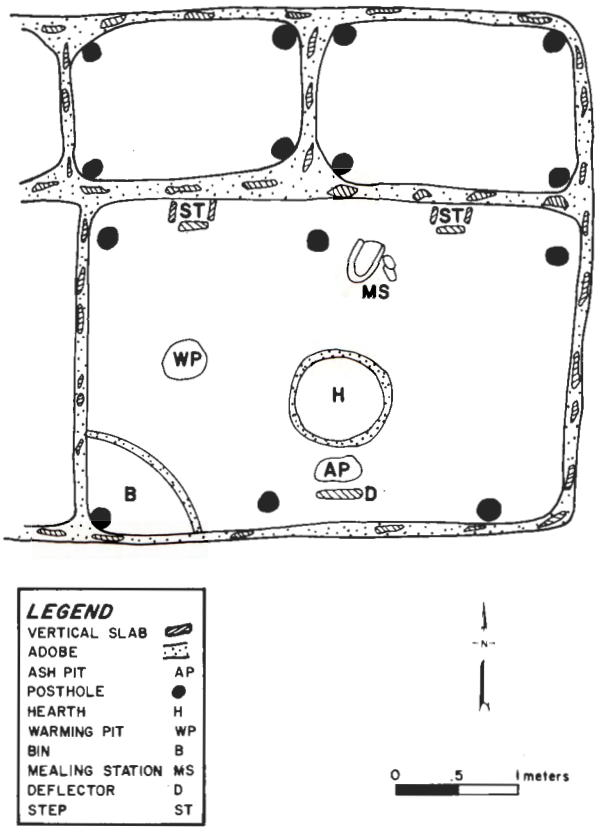

Figure 5.14 – Plan of a Dos Casas Subphase three-room apartment (adapted from Brisbin [1984a:figs. 49, 50]).

3. Wall construction. A variety of materials was used in construction of Dos Casas back room walls. Back rooms at Dos Casas Hamlet (Brisbin et al. 1982), Windy Wheat Hamlet (Brisbin 1984a), and Dovetail Hamlet (Nelson 1985) are characterized by vertical sandstone slab construction for the base course and what is believed to be post and daub construction for upper portions. At Area 1 of Periman Hamlet (Wilshusen 1983), lower walls consisted of masonry courses with horizontally laid sandstone blocks and river cobbles; upper courses were primarily daub, with some sandstone rubble incorporated as filler material. At Prince Hamlet, Site 5MT2161 (a settlement occupied primarily in the late ninth century, but at which initial construction probably began somewhat earlier [Sebastian 1983]), the lower courses of rear room walls consisted of a combination of horizontal slab/block coursing and very large vertical slabs.

No certain conclusions regarding the distribution of construction modes can be drawn because of the inadequate size of the excavation sample; 2 tentative trends are suggested for future evaluation. First, construction of room walls was expedient, and materials

available within a short distance of the site were used. Hence, in the Sagehen Flats area, thin sandstone slabs were the only stones incorporated because few workable sandstone outcrops were available in the vicinity of the sites. Sandstone and river cobbles were readily available within a short distance of the sites located within the canyon proper (Prince Hamlet and Periman Hamlet) and were used in greater amounts. Second, construction seems to become more substantial and incorporates more stone masonry late in the subphase (post-A.D. 800). This might reflect the increasing importance of storage facilities to the prehistoric groups in the Dolores area. More materials and labor were invested in Dos Casas Subphase back rooms than in analogous structures of the Tres Bobos and Sagehill Subphases. This is also interpreted as reflecting the increased importance of storage in later periods.

4. Roof construction. Most rooms contain postholes in the corners, suggesting four-post roof-support construction.

5. Floor. Floors of Dos Casas Subphase back rooms usually do not appear to have been prepared or finished. Usually they are merely a leveled surface that became compacted through use; a thin layer of charcoal-mottled sand or mud may be present. Floor features often are limited to 4 corner postholes for the roof-support posts; corner bins and small storage cists are sometimes present.

6. Domestic and economic activity areas. The distribution of floor artifacts in Dos Casas Subphase back rooms does not suggest spatially discrete activity areas; rather, the distributions seem to be the result of abandonment activity and postabandonment processes. If the rooms have burned, quantities of burned corn kernels and beans are usually discovered, suggesting that a primary function was food storage. In Room 4 at Windy Wheat Hamlet (Brisbin 1984a:fig. 48), a storage vessel associated with a large quantity of beans was found. Nonflaked lithic tools (e.g., metates, manos, axes) are sometimes present, but their positions (e.g., leaning against walls, in corners) suggest temporary storage rather than use within the room. Two possible gaming pieces were recovered from Room 4 at Periman Hamlet (Wilshusen 1983), perhaps indicating that items in addition to tools were stored in back rooms. Dos Casas back rooms also contained low densities of flaked lithic tools and debitage. These items may represent tool maintenance activities, but more likely reflect abandonment or postabandonment deposition.

Surface Structures – Front Rooms

Front rooms in Dos Casas roomblocks are interpreted as habitation rooms or as processing rooms. Habitation rooms usually are arranged in apartment "suites" consisting of 1 or 2 back rooms and a front room. Habitation rooms contain full complements of features associated with domestic activites: central hearths, warming pits, corner bins, and mealing stations. Some front rooms may have served as specialized processing facilities; these are usually smaller in area and contain a more restricted feature complement. A definition problem, especially for the early part of the subphase, is whether these structures are completely enclosed "rooms" or are partially enclosed "ramadas," as suggested by McKenna (1981:11-12); here they are considered to be rooms. Specific architectural details are as follows.

1. Shape. Dos Casas front rooms are rectangular or subrectangular. The north walls and 2 northern corners form square (90°) angles where the front rooms abut the rear rooms. The front (south) walls and south corners are often rounded, giving a "scalloped" appearance to plan views of Dos Casas roomblocks.

2. Size. Front rooms range from 5 to 20 m^2 in area. An inspection of the distribution of room sizes suggests a double peak that probably represents 2 size and function populations. Front rooms with a mean area of about 14 to 15 m^2 probably can be functionally typed as habitation or domestic rooms; smaller front rooms have a mean area of about 8 m^2 and represent more functionally specialized processing rooms or remodeled or added-on habitation rooms.

3. Wall construction. Walls of front rooms are less substantial than those of rear rooms, and incorporate less stone; an exception is the north wall, which is shared by both front and rear rooms. Evidence for pre-A.D. 800 construction methods is scant, because most early Dos Casas sites investigated by the DAP were in upland plowed areas. Front rooms might have been constructed of mud, perhaps in the form of turtleback courses; the walls might have formed complete enclosures or they might have been only 1 to 1.5 m high. After A.D. 800, lower wall portions consisted of cobbles, or of sandstone blocks or slabs; upper courses were of dried mud that incorporated stone rubble. Front rooms at some canyon sites (for example, Prince Hamlet [Site 5MT2161] and Periman Hamlet [Site 5MT4671]) incorporate lower courses of vertical slabs or horizontal stone masonry (Sebastian [1983] and Wilshusen [1983]).

4. Roof construction. The locations of postholes in Dos Casas front rooms suggest that the four-post roof-support system was the standard practice, although sometimes an extra pair of support posts were located near the north and south walls on the

north-south axis of the structure. The latter posts probably were used as additional support for the primary beams in larger rooms that have relatively long east-west dimensions. The posts also may have supported an additional north-south primary beam across the center of the room.

5. Floor. The floor usually is excavated approximately 10 to 15 cm below prehistoric ground surface. The surface is formed by a veneer of dried mud that is covered by a layer of sand, and frequently has a dark cast, probably due to the inclusion of charcoal and other organic material. Usually a much greater density of artifacts and features occurs in front rooms than in back rooms. Some features that might be present include the following:

a. Corner bins. One corner bin per room is usually present. The location is not consistent; it may be situated in a front or back corner.

b. Hearth-ash pit complex. A large hearth is always present in a habitation room and may be supplemented with an ash pit; specialized processing rooms may lack hearths or contain multiple hearths. The hearth is usually centrally located, although sometimes it is situated in the west-center or east-center of the room.

c. Step-ups. Step-ups may be present along the back walls in front of the possible locations of hatchways to the back rooms. These features apparently served as steps to enter the back rooms. Step-ups may consist of an enclosure or "bin" formed by vertical slabs, or they might consist of a single vertical slab.

d. Ventilation system. Ventilation systems were present in Rooms 2 and 16 at Periman Hamlet (Wilshusen 1983:52, 70-71). These systems consist of a subwall tunnel located near the center of the south wall and deflector positioned between the interior tunnel opening and the hearth.

e. Mealing stations. Dos Casas front rooms may incorporate mealing stations (a metate, often seated on a rest; one or more manos; and a collecting basin), usually in the southwest or southeast quarter of the room.

f. Features in small front rooms. The features in the small rooms believed to be processing rooms differ from those in the larger living rooms. In addition to the 4 postholes needed for roof support, processing rooms may contain a hearth or series of hearths for heat or fire processing and 1 or more floor cists or pits for temporary storage of materials and tools.

6. Functional and feature complement variability. The architectural descriptions of surface rooms are based on a perception of "normal" distributions in the available data. However, exceptions to the normal pattern do occur, for both the Dos Casas Subphase and the succeeding Periman Subphase. Examples of exceptions are large back rooms that apparently served as living rooms; these were constructed by removing the shared center wall between 2 small back rooms and adding features. Also, partitioned front rooms that apparently served as storage facilities and small front rooms that appear to have functioned as living quarters rather than as processing facilities exist.

7. Domestic and economic activity areas. Large front rooms (habitation rooms) usually contain the space and features necessary for completion of day-to-day domestic tasks. The complement of features includes facilities for heating and cooking, food preparation, tool manufacture and maintenance, and temporary storage. Space for sleeping is usually available also. Small front rooms (processing rooms) contain features and space used for processing raw materials usually associated with subsistence. No ritual features (sipapus, basin-shaped pits with "paho" marks, or "paho" marks on floors) have been recorded in Dos Casas Subphase surface rooms.

Pitstructures

An example of a Dos Casas Subphase pitstructure is shown in figure 5.15. The architectural characteristics of Dos Casas pitstructures differ from those of Sagehill pitstructures, but the differences are not as extreme as those between Tres Bobos and Sagehill structures. Excavation data suggest that there are usually 1 to 2 pitstructures per habitation site; larger Dos Casas Subphase roomblock-pitstructure complexes at the large village sites probably were destroyed by later Periman Subphase construction or remodeling; numerous Dos Casas pitstructures were identified at the Grass Mesa site (Site 5MT23 [Lipe et al., 1985]). Dos Casas pitstructures are about as deep as Sagehill pitstructures, but have larger mean floor areas (Wilshusen 1985c:table 2). Dos Casas pitstructures usually incorporate a bench, vertical-slab-based wingwalls, and a ventilation system. Central hearths are comparatively large and associated ash pits are common. Functionally, most Dos Casas pitstructures can probably be classified as "protokivas" (Morris 1939; Hayes and Lancaster 1975:183), since investigated inside activity areas seem to be either domestic/economic or ritual/ceremonial in function. Some Dos Casas pitstructures (for example, Pitstructure 2 at Windy Wheat Hamlet [Site 5MT4644; Brisbin 1984a]) can probably be classified as oversized pitstructures by virtue of their size (greater than 30 m^2

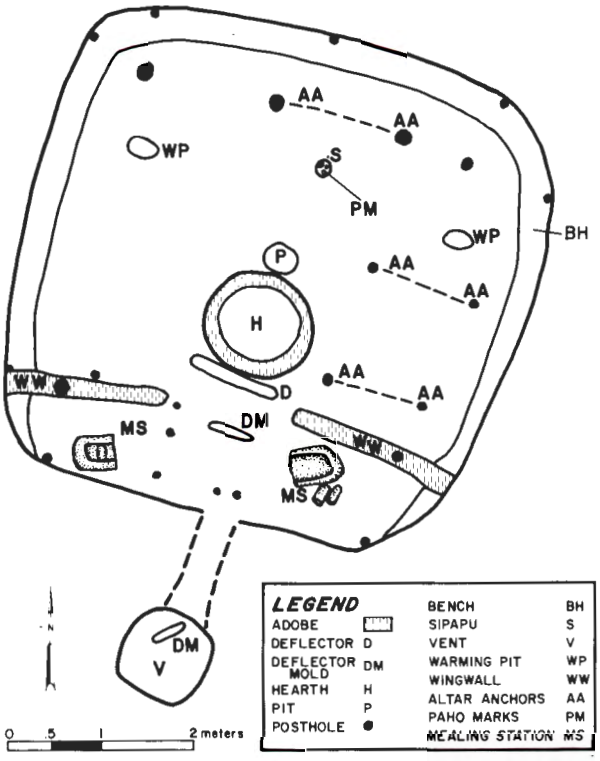

Figure 5.15 – Plan of a Dos Casas Subphase pitstructure (adapted from Brisbin [1984a:fig. 15]).

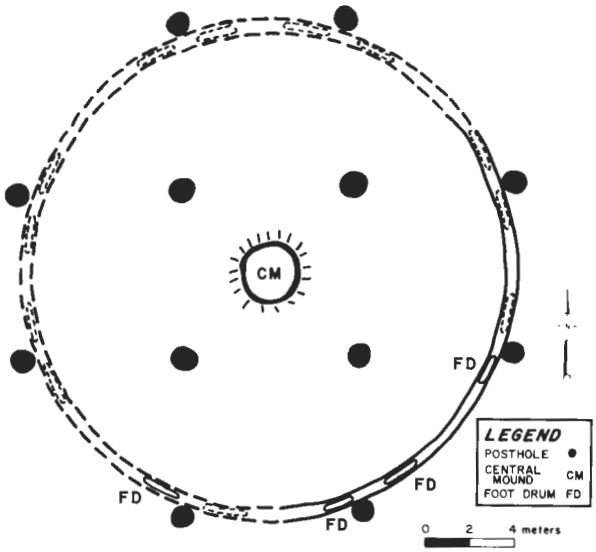

Figure 5.16 – Possible reconstruction of the plan of the Dos Casas Subphase great kiva at Grass Mesa. For actual plan of this structure as recorded during excavation, refer to figure 7.14 in Lightfoot et al. (1985), which served as the basis for this hypothetical reconstruction.

of roofed area) and feature complement. Their presence may be related to the appearance and growing influence of suprahousehold corporate groups in ninth century A.D. Dolores Anasazi society. A Dos Casas Subphase great kiva was identified and partially excavated at the Grass Mesa settlement (Lightfoot et al. 1985:7.51-7.112). This structure is round, very deep (the floor is approximately 1.8 m below the prehistoric ground surface), and very large (about 22.5 m in diameter and approximately 400 m^2 of roofed area, including the bench). Recorded internal features include 6 reinforced postholes serving as the footings for vertical roof supports, a bench, and a centrally located raised mound. The floor also contained over 150 shallow, basined pits. These are probably attributable to postabandonment processes rather than kiva use, however (Lightfoot et al. 1985:7.84). This great kiva may be the largest Basketmaker III – Pueblo I roofed structure in the prehistoric northern Southwest; sophisticated engineering skills are evident in its specialized roof construction (Lightfoot 1984). A possible reconstruction of the floor plan of the kiva is depicted in figure 5.16; for the actual floor plan of this structure, as recorded during excavation, refer to Lightfoot et al. (1985:fig. 7.14). Figure 5.15 illustrates the general architectural characteristics and feature layout of more typical Dos Casas Subphase pitstructures. Specific architectural characteristics are as follows:

1. Shape. Dos Casas pitstructures are more regular in shape and more square than Sagehill structures. Dos Casas pitstructures apparently are subrectangular; the mean squareness index is 0.937, which is greater than that for Sagehill pitstructures (Hewitt et al. 1983:table 3).

2. Size. Dos Casas Subphase pitstructures average about 23 m^2 in area (Wilshusen 1985c:table 2), about 5 m^2 more than Sagehill Subphase pitstructures. Size variability is somewhat greater than during the Sagehill Subphase: standard deviations in size are close to 9 m^2 (Dos Casas), compared to approximately 6.6 m^2 (Sagehill); this greater variation in size may reflect more variation in the size of and number of groups using the structure.

3. Depth. The mean depth of Dos Casas pitstructures is about 1.6 m, which is slightly greater than the figure obtained for Sagehill Subphase pitstructures.

4. Roof construction. Four-post roof-support patterns were present in all investigated structures, with the exception of the Grass Mesa Village great kiva. The northern 2 postholes are near the corners, while the southern postholes are incorporated into the wingwall. Auxiliary posts (e.g., smaller supports paired with the wingwall posts or 2 additional supports against the south wall) may be present. Leaner posts were footed on the bench.

5. Bench. Dos Casas Subphase pitstructures usually incorporate a 3/4 bench on the east, north, and west walls. The bench served as a foundation for the leaner poles that formed the vertical portion of the roof. The bench was also used for temporary storage of tools and containers.

6. Wingwall. Wingwalls usually are present in Dos Casas Subphase pitstructures. Wingwalls form a partition across the southern end of the structure, which creates a separate southern room or work area separated from the main chamber. The wingwalls are usually parallel to the north and south walls of the pitstructure. A gap may exist in the center portion of the wingwall on the north-south axis, perhaps to accommodate access between the main chamber and south room. Wingwall construction usually consists of a veneer of hardened mud and plaster over an internal support of vertical sandstone slabs or small posts set into the floor. If vertical slabs are incorporated, they are arranged in either a single row or a double row with a core of mud or adobe (Brisbin 1984a:fig. 29). The southern 2 main post supports usually are incorporated into the wingwall in Dos Casas Subphase pitstructures.

7. Bins. No corner or other floor bins have been recorded in Dos Casas Subphase pitstructures.

8. Ventilation system. Dos Casas pitstructures contain a standard ventilation system in the form of a vertical shaft and a horizontal tunnel, the latter opening into the pitstructure in the center of the southwall at floor level. The floor of the ventilator shaft is smaller in mean area than the floor of Sagehill shafts (1.1 m^2 versus 1.6 m^2) (Hewitt et al. 1983:138) and apparently was not used for storage or other activities. A deflector slab is positioned between the tunnel entrance and the central hearth. Usually this slab is located immediately south of the hearth, although one example (Pitstructure 2 at Dos Casas Hamlet [Brisbin et al. 1982:fig. 5.18]) was recorded where the deflector was in the south end of the structure very close to the tunnel entrance.

9. Hearth and heating complex. Dos Casas Subphase pitstructures contain a central hearth that often is complemented by an ash pit just south of the hearth. The hearth is usually slightly larger than Sagehill counterparts.

10. Domestic and economic activity areas. A mealing station is usually present in the south end, either in the eastern or western corner. The other south corner often was used as a storage area for lithic tools (e.g., manos, axes, cores). Additional metate stations may be present north of the wingwall; these usually are located west of the central hearth. During investigations of Pitstructure 2 at Dos Casas Hamlet (Brisbin et al. 1982), a flat sandstone slab with a lump of raw clay was found in situ west of the hearth. This suggests that during this period preliminary stages of ceramic vessel manufacture might have been based in pitstructures.

11. Ritual activity areas. Apparently, a ritual activity area centered around a sipapu usually was situated north of the hearth on the north-south axis. Several sipapu forms have been recorded: simple cylindrical holes thought to be sipapus; "complex" sipapus incorporating small pits believed to represent marks left by prayer sticks or "pahos"; and clusters of small, cylindrical pits surrounded by prayer stick marks. In addition, some Dos Casas pitstructures have sand-filled pits that are thought to have functioned as altar anchors (Wilshusen 1985b:21-29)

The larger mean size, greater variation in size, and increase in the number and complexity of ritual features associated with Dos Casas pitstructures suggest some functional shifts as well. While Tres Bobos and Sagehill pitstructures have been interpreted as representing the "house" or domestic headquarters used by a nuclear family group (occasionally 2 nuclear families), Dos Casas pitstructures are thought to represent space shared by 2 or more cooperating and related nuclear families. These families are allied in a more complex household organization, termed the "interhousehold" by the DAP. While each constituent nuclear family maintained its own domestic space in the associated surface roomblock, certain activities were shared by the interhousehold as a group; these included some meal sharing, ritual and ceremony, and perhaps some routine domestic tasks such as preparation of cornmeal. Oversized Dos Casas pitstructures (more than 30 m^2 in floor area) may have served as the locations for ritual and ceremony that integrated several interhouseholds.

Periman Subphase of the McPhee Phase (A.D. 840-910)

Periman Subphase architecture again is similar to regional Pueblo I patterns (Morris 1939; Martin and Rinaldo 1939; Brew 1946; Hayes and Lancaster 1975). Specific architectural descriptions are available in the following DAP reports: Prince Hamlet (Site 5MT2161 [Sebastian 1983]), Grass Mesa Village (Site 5MT23 [Lipe et al., 1985]), Rio Vista Village (Site 5MT2182 [Wilshusen, comp. 1985]), House Creek Village (Site 5MT2320 [Robinson and Brisbin 1984]), McPhee Village (multiple site numbers [Kane and Robinson 1985a]), and Little House (Site 5MT2191 [Hewitt 1983d]).

General Layout and Structure Populations

Habitation sites seem to conform to 1 of 2 general patterns: large aggregated villages consisting of several to more than 15 roomblock units (fig. 5.17), and isolated single-roomblock settlements (termed "outlying settlements" by the DAP), which are assumed to be socially related to specific aggregated villages. The roomblock units within the large villages exhibit the "right-tailed" total size distribution common in DAP data (fig. 5.18). The ranked size distribution does exhibit a small secondary peak at 80 to 90 m, which suggests that Periman Subphase roomblocks might be categorized as "small" (less than 10 to approximately 60 m in length) or "large" (more than 60 m in length). With the exception of Roomblock Unit 39 at Grass Mesa Village, all of the "large" roomblocks are situated at the 3 largest project area villages (McPhee Village, Windy Ruin, and Cline Crest Ruin [Site 5MT2663]). This relationship is further discussed in the social organization chapter (chap. 14). The "small" roomblock units generally consist of 8 to 20 individual rooms and 1 to 3 pitstructures, while the "large" units consist of 30 or more individual rooms and 5 or more pitstructures. The small roomblocks appear to be spatially patterned according to the locations of the more centralized large units, and the intravillage spatial arrangements are believed to reflect social affinities. Also, the presence of the small roomblocks might be partially explained by population growth; they may reflect late immigrations into the area or "budding" from established roomblock units.

Internal roomblock configurations conform to the general pattern described for the preceeding Dos Casas

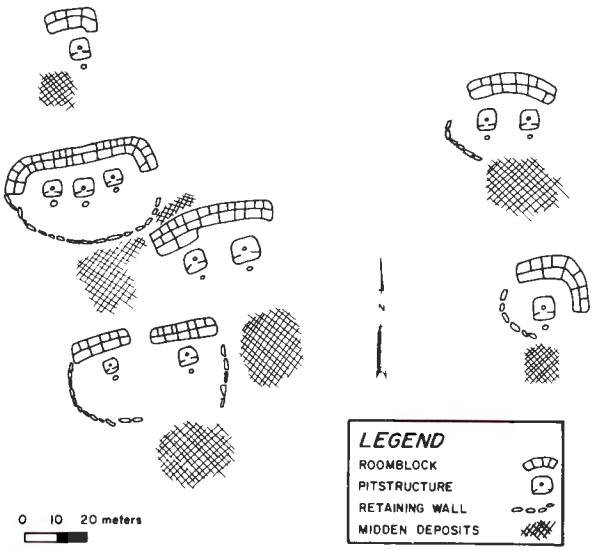

Figure 5.17 – Periman Subphase habitation site layout (adapted from Wilshusen [comp. 1985:fig. 2]).

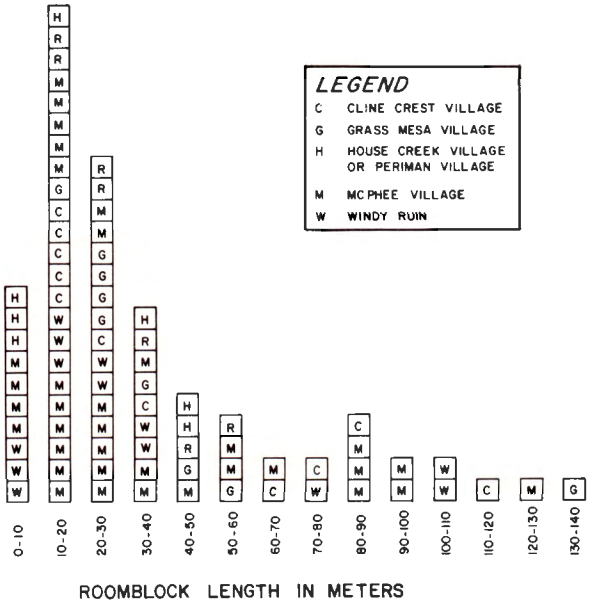

Figure 5.18 – Ranked display of Periman Subphase roomblock lengths.

Subphase: a roomblock, usually cresent shaped or possibly horseshoe shaped; a plaza area south of the roomblock containing pitstructures and extramural work areas; and a midden or possibly 2 to 3 separate refuse mounds south of the living complex. Small roomblock units range from 0.1 to 0.2 ha in area, while the large roomblock units usually cover between 0.2 to 0.4 ha. Village areas may be several to up to 10 ha in area.

Besides roomblocks and pitstructures at habitation sites, Periman Subphase architecture also includes agricultural field houses. Such sites usually are located a few kilometers away from the large aggregated multiple roomblock settlements and consist of 1 or a few surface rooms and outdoor activity areas. The field house rooms are relatively small and appear to have functioned as storage facilities; a larger room with a hearth was investigated at Little House (Site 5MT2191 [Hewitt 1983d]). Periman field houses exhibit less investment in materials and labor and less substantial construction than surface rooms at habitation sites. These field houses were not included in the data set used for the Periman surface room discussion. Field house architecture is discussed further in pertinent DAP site reports (Little House [Site 5MT2191; Hewitt 1983d], Moonlight House [Site 5MT2205; Kleidon 1982], and Hamlet de la Olla [Site 5MT2181, Etzkorn 1983]).

Surface Structures – Back Rooms

Periman Subphase back rooms are in many ways morphologically similar to their Dos Casas predecessors. The back rooms are arranged linearly within the contiguous roomblock, and 1 or 2 back rooms are found

per 1 front room; a Periman Subphase roomsuite consisting of 2 back rooms and a front room is depicted in figure 5.19. Specific architectural characteristics are as follows.

1. Shape. Without exception, the structures appear to be rectangular or square in plan.

2. Size. The distribution of room sizes approximates a normal curve. The mean size (floor area) is approximately 5.5 or 6.0 m² (Wolf 1985a:table 2; Wilshusen 1985c:table 3), which is substantially larger than the mean size of Dos Casas back rooms (3.5 m²); this may indicate increased investment in and reliance on storage facilities (Wolf 1985a; Gross chap. 13). Some exceptions to the normal distribution have been observed; for example, Room 18 at Pueblo de las Golondrinas (Site 5MT5107 [Brisbin 1984c:136]) is more than 10 m² in area. This may represent a modification of the original architectural pattern to meet functional needs.

3. Wall construction. A variety of wall construction types are observed for Periman Subphase back rooms. Most back room walls were of composite construction; the lower portion (0.5 to 1.0 m) was masonry, and the upper portion was daub or jacal. Wall foundations were of daub, horizontally laid sandstone slabs, or vertically placed sandstone slabs; subfloor trenches were often prepared to accommodate the foundation materials. Vertical-slab foundations in Periman Subphase back rooms may represent retention of original wall bases dating to the previous Dos Casas Subphase. Variability in wall construction for the late Pueblo I period (A.D. 800-900) has also been described by Brew (1946:218-219) in a synthesis of early Anasazi architecture. The increased investment in materials and labor necessary to build partial masonry walls for back rooms may reflect increased dependence on storage and the need for a secure storage environment. Access to back rooms apparently was by means of a small door or hatch in the south wall. Field observations suggest that the hatch was above the floor level and may have been reached by means of a step in the front room.

4. Roof construction. Most back rooms have 4 postholes near the 4 corners, which suggests that the standard four-post roof-support pattern was employed. The roof itself apparently consisted of primary beams, secondary beams, and several layers of closing materials. Postholes in back rooms are deeper, and they more consistently incorporate bracing and footing materials than do postholes in front rooms, perhaps indicative of more substantial roof construction.

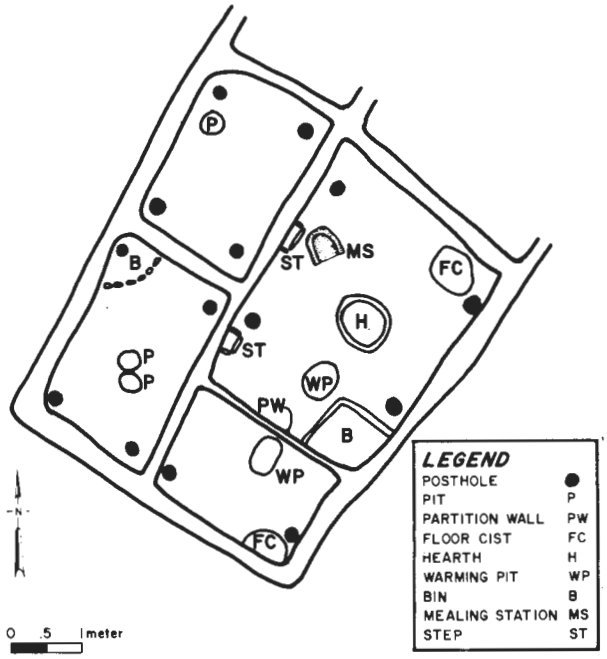

Figure 5.19 – Plan of Periman Subphase three-room apartment (adapted from Kleidon [1984a:figs. 16, 18, 26]).

5. Floor. Floors in back rooms usually consist of the use-compacted excavated ground surface, perhaps with a veneer of dried mud. They usually are located 10 to 20 cm below prehistoric ground surface and are level or basin shaped.

6. Domestic and economic activity areas. Pueblo I back rooms usually are assumed to have functioned primarily as storage facilites (Brew 1946:190-191; Hayes and Lancaster 1975:182-183). The DAP data mostly support this assumption, with some exceptions (Wolf 1985a:53). Periman Subphase back rooms apparently were multipurpose, based on their contents. They functioned as granaries (for storage of cultivated foodstuffs such as corn and beans), as storerooms (for storage of domestic tools and agricultural implements, of wild or ruderal plant foods such as amaranth and chenopods, and perhaps of firewood or construction materials), and infrequently as locations for processing activities. The occasional presence of mealing tools in Periman Subphase back rooms (Wolf 1985a:62) suggests that preparation of cornmeal or other milled foodstuffs might have taken place on occasion. Rectangular bins and subfloor bell-shaped cists have also been recorded in Periman subphase back rooms; this suggests that activities in these rooms included compartmentalized storage, perhaps for items in bulk.

Architectural characteristics and functions of Periman Subphase back rooms appear similar to those of the

preceding Dos Casas Subphase. Periman Subphase back rooms are larger, incorporate more substantial construction, and were used for a greater variety of activities, although produce storage remained the primary function.

Surface Structures – Front Rooms

The sizes and feature populations of Periman Subphase front rooms have bimodal distributions. Large (greater than 10 m^2 floor area) front rooms usually have feature populations consistent with definition of the structures as habitation or domestic rooms, while small (less than 10 m^2 floor area) front rooms may have functioned as habitation rooms or as processing facilities. The similarity in form and content between Periman and Dos Casas front rooms suggests that the original functional patterns established in the late A.D. 700's remained basically unchanged into the late A.D. 800's. Remodeling and other modifications that resulted in departures from the normal pattern apparently were more frequent during the Periman Subphase. Examples of this phenomenon include use of small front rooms as living rooms and division of large front rooms into 2 smaller units. Specific architectural characteristics of Periman Subphase front rooms are as follows:

1. Shape. Periman front rooms are rectangular or subrectangular in plan. The south corners may be rounded, which results in a "scalloped" appearance along the roomblock outline. Shape distributions are similar to those of the previous Dos Casas Subphase.

2. Size. Room sizes for Periman front rooms range from about 7 m^2 to 25 m^2. The distribution has 2 peaks and closely resembles the distribution for Dos Casas front rooms. The mean floor area for large rooms is about 17 m^2, which is slightly more than that for large Dos Casas rooms, while the mean for small rooms (approximately 8 m^2) is about the same as that for small Dos Casas Subphase rooms.

3. Wall construction. Periman front room walls are similar in form and construction to Dos Casas front room walls. With the exception of the north wall, Periman front rooms incorporate less substantial materials than do back rooms; most construction is probably of daub turtlebacks or jacal. Foundations and some lower wall portions are of vertical sandstone slabs or of horizontally positioned stone blocks or cobbles.

4. Roof construction. Periman front room roofs probably were similar to Dos Casas front room roofs. The standard Anasazi four-post support system was common, although sometimes 2 or even 4 additional support posts were used near the center of large rooms. In such cases, the additional posts probably were used to support additional construction members in rooms with relatively long east-west dimensions.

5. Floors and associated features. Floor construction and feature complements in Periman front rooms are similar to those described for comparable Dos Casas structures; refer to the Dos Casas description for details.

Pitstructures

Periman Subphase pitstructures exhibit greater variability in form and function when compared to earlier pitstructures. Between 2 and 8 pitstructures per roomblock unit is characteristic of Periman Subphase habitation sites, and more than 40 pitstructures may have been in simultaneous use at some of the larger villages. Periman pitstructures appear to be consistently located in the plaza area south of the roomblock. Size, feature complement, and function are interrelated. Based on size rankings (chap. 14, fig. 14.2), Periman Subphase pitstructures are characterized as "small," "oversized," or "great kivas." Most "small" pitstructures contain a preponderence of domestic and processing features with some contents or features believed to have had ritual functions; these structures probably are "protokivas." Figure 5.20 depicts the plan of a Periman Subphase "small" pitstructure. "Oversized" (greater than 30 m^2) Periman pitstructures generally contain both domestic and ritual features and items, although the population of ritual features is more complex when compared to "small" pitstructures. The 2 largest recorded "oversized" pitstructures (Pitstructure 9 at Pueblo de las Golondrinas [Site 5MT5107] and Pitstructure 3 at McPhee Pueblo [Site 5MT4475]) are associated with horseshoe-shaped roomblocks and are thought to represent locations of suprahousehold organizations and managerial power (chap. 14). These 2 structures lack artifacts and features indicative of domestic activities; rather, the feature and artifact content (rectangular central pits, floor vaults, paho marks, ornaments) appears to entirely reflect ritual and ceremony. A plan of an oversized pitstructure is illustrated in figure 5.21.

A possible Periman Subphase great kiva was investigated at Singing Shelter (Site 5MT4683 [Nelson and Kane 1985]); the "possible" qualification is necessary because use of the structure could only be assigned an A.D. 800-900 bracket date based on stratigraphic relationships and associated ceramics. This structure is very large (approximately 800 m^2 of floor space), even when compared to other described Pueblo I great kivas. The structure contains a circumferential bench and may have been enclosed by a row of rooms on the south and

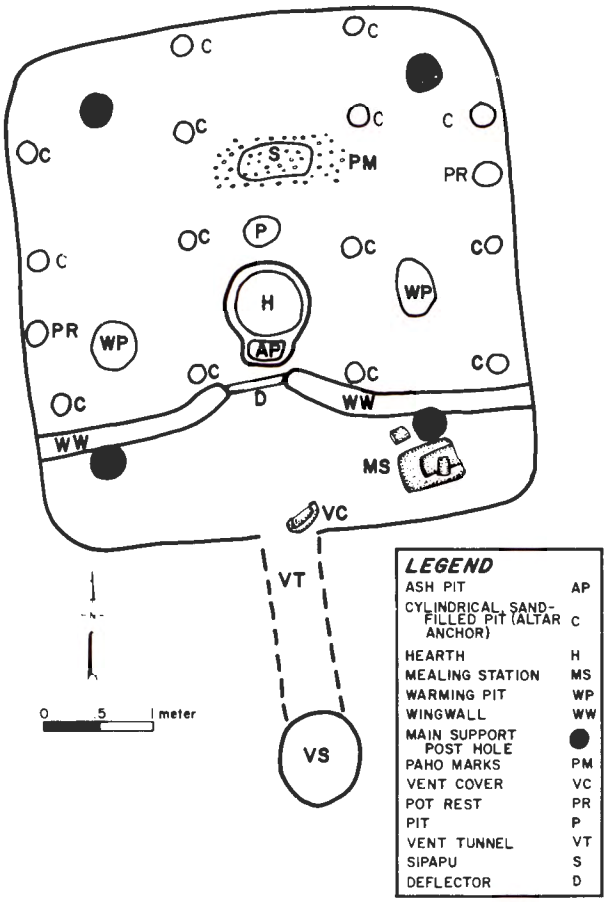

Figure 5.20 – Plan of a Periman Subphase "small" pitstructure (adapted from Kleidon [1984a:fig. 33]).

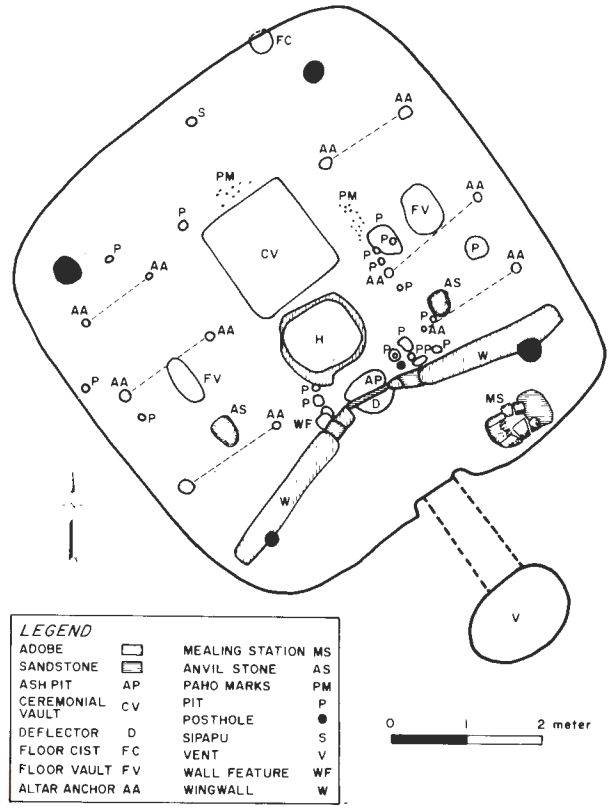

Figure 5.21 – Plan of a Periman Subphase oversized pitstructure (adapted from Kuckelman [1984a:fig. 20]).

west sides. It apparently was not roofed, although the natural shelter setting would have provided partial protection for the north and east portions. The true nature of associated artifact and feature populations could not be accurately estimated because only small parts of the floor were preserved; however, a possible reconstruction of the floor plan of this structure is offered in figure 5.22. This reconstruction represents the author's concept of what the floor of such a structure might look like; evidence for specific features and other architectural details shown in figure 5.22 was not necessarily encountered during excavation of the Singing Shelter great kiva. Refer to Nelson and Kane (1985:fig. 21) for the actual floor plan of this structure, as mapped during excavation.

Specific characteristics of Periman pitstructures are as follows. This discussion does not take into consideration the Singing Shelter great kiva.

1. Shape. Periman pitstructures are rectangular with rounded corners; the mean squareness index is 0.934, very close to the value for Dos Casas pitstructures (0.937 [Hewitt et al. 1983:135]).

2. Size. The size distribution of Periman pitstructures conforms to a right-tailed curve, reflecting a diverse size and functional population (chap. 14, fig. 14.2). Small pitstructures have a mean floor area of 17 to 18 m². Oversized pitstructures have a mean floor area of about 40 m². The 2 pitstructures at McPhee Village associated with horseshoe-shaped roomblocks have floor areas of 63 m² and 50 m².

3. Depth. The mean depth for the smaller pitstructures is about 1.6m; for the larger structures, it is about 2.0 m. Periman pitstructures are somewhat deeper than Dos Casas pitstructures. Pitstructure 3 at McPhee Pueblo is anomalous, with a depth of over 3 m.

4. Roof construction. Roof patterns are similar to those for Dos Casas Subphase pitstructures. Four main support postholes are present; these are located in the northeast and northwest corners and in the wingwall; auxiliary posts may be present. Leaner posts apparently were footed on a ground-level shelf around the margin of the structure, as benches are absent in Periman pitstructures.

5. Bench. Benches are almost invariably absent in Periman pitstructures. The only recorded Periman

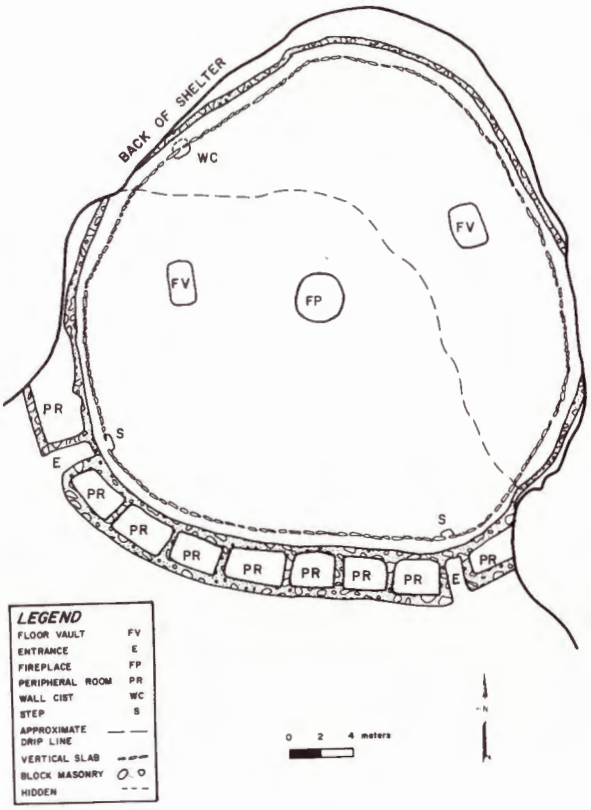

Figure 5.22 – Possible reconstruction of the plan of the Periman Subphase great kiva at Singing Shelter. Reconstruction represents the author's idealized concept of what the floor of such a structure might look like; evidence for specific features (e.g., the central fireplace, floor vaults) and other architectural details was not necessarily encountered during excavation of this specific kiva. Refer to Nelson and Kane (1985:fig. 21) for the actual floor plan of this structure, which served as the basis for this hypothetical reconstruction.

benches are in Pitstructure 3 at McPhee Pueblo, and in Pitstructure 9 at Pueblo de las Golondrinas. The former consists of a low, raised platform fronted by slabs and situated against all 4 walls of the structure. In form and function, the bench in this structure is probably more akin to great kiva benches than to similar features in Tres Bobos or Dos Casas pitstructures. Pitstructure 9 at Pueblo de las Golondrinas included a partial bench against the north wall.

6. Wingwall. Wingwalls are found in most Periman Subphase pitstructures and are similar in general form and position to those in Dos Casas pitstructures. Wingwalls in oversized Periman pitstructures are very regular and stylized in form and are more massive in construction than are the wingwalls in the smaller pitstructures. Periman pitstructure wingwalls often are constructed of horizontal masonry or vertical posts rather than of the vertical slabs commonly used during preceding periods. Periman wingwalls often incorporate 2 notches and steps on either side of the deflector, for access to the south room.

7. Bins. Bins are usually absent in Periman pitstructures; however, Pitstructure 2 at Prince Hamlet (Sebastian 1983) contains a corner bin built into the southwest corner of the main chamber north of the wingwall.

8. Ventilation system Periman pitstructure ventilation systems are similar to those of the preceding Dos Casas Subphase. The deflector is usually an extension of the wingwall, but sometimes it is built into the south rim of the central hearth. The wingwall may jog north to incorporate the deflector. The deflector is usually a vertically positioned sandstone slab, but in some cases it may be constructed of horizontally laid masonry. At Pitstructure 3 at McPhee Pueblo, the ventilator shaft and tunnel also may have served as entrance and exit for the structure.

9. Hearth and heating complex. A central hearth and ash pit are present in Periman pitstructures. The ash pit is located south of the hearth; in some pitstructures, this complex may be augmented with shallow, basin shaped heating pits east and west of the hearth. A small, cylindrical "sand receptacle" (e.g., Brisbin et al 1985) is sometimes present north of the hearth. This may have provided a convenient container for sand used to prop vessels in the hearth or may have been used for other hearth-related activites.

10. Domestic and economic activity areas. Locations of domestic and economic activity areas are similar to those in Dos Casas pitstructures. A mealing station is located in the west or east corner of the south room, with a tool storage area located in the opposite corner. Additional mealing stations may be located immediately north of the wingwall in the 2 corners formed by the wingwall and pitstructure walls. A lapstone is often found north of or to either side of the hearth, perhaps indicating that stone tool manufacture or maintenance took place in these areas. Pot rests are often located adjacent to the east and west walls and probably were used for temporary storage of water or raw materials in ceramic vessels.

The above description applies primarily to the small, domestic Periman pitstructures; the oversized pitstructures contain fewer features and artifacts that indicate the presence of domestic or economic activities. A metate station was recorded in the southeast corner of Pitstructure 2 at Masa Negra Pueblo

(Site 5MT4477 [Kuckelman 1984a]), and 2 lapstones were located just southeast and southwest of the central hearth in the same pitstructure. A lapstone was also recovered from the floor of Pitstructure 9 at Pueblo de las Golondrinas. Oversized pitstructures at Rio Vista Village and Grass Mesa Village also contained some domestically oriented features and materials.

11. Ritual activity area. In small Periman pitstructures, a ritual or integrative activity area is usually located north of the central hearth on the north-south axis. This complex may consist of a sandfilled oval basin with small circular pits (perhaps from prayer sticks or "pahos") arranged in an east-west arc within and to either side of the basin. Or the ritual feature may be a simple cylindrical hole or sipapu or a cluster of superimposed cylindrical holes and paho marks (Wilshusen 1985b:2-15).

Small Periman Subphase pitstructures also contain a complement of paired, symmetrically positioned, sand-filled, cylindrical pits believed to have functioned as "altar anchors" (Wilshusen 1985b:21-30, table 1); figure 5.23 illustrates the normal placement of these pits in a small Periman pitstructure. Generally speaking, there are between 10 and 20 of these features per pitstructure, which is fewer than the comparable population in "oversized" Periman pitstructures. Small pitstructures generally lack other ritual-ceremonial features, such as rectangular central pits, lateral vaults, and zoomorphic pits, recorded in "oversized" Periman pitstructures. Exceptions to this generalization have been identified at Grass Mesa Village, where some "normal-sized" pitstructures contain rectangular central vaults.

More complex ritual-ceremonial feature assemblages are present in oversized Periman pitstructures. A roofed, rectangular central vault is situated to the north of the hearth/ash pit complex and is associated with numerous small tapered pits (paho marks). A pair of lateral vaults is situated to the east and west of the hearth; the rectangular central vaults and lateral vaults may be functionally interrelated (Wilshusen 1985b:17). Oversized pitstructures also contain the series of cylindrical sand-filled pits thought to be indicative of altar placements; subjectively, there appear to be greater numbers of these altar locations when compared to small pitstructures.

The formal variability of Periman Subphase pitstructures, manifest as different sizes and associated feature and artifact populations, suggests a relatively large degree of functional variability as well. Functional

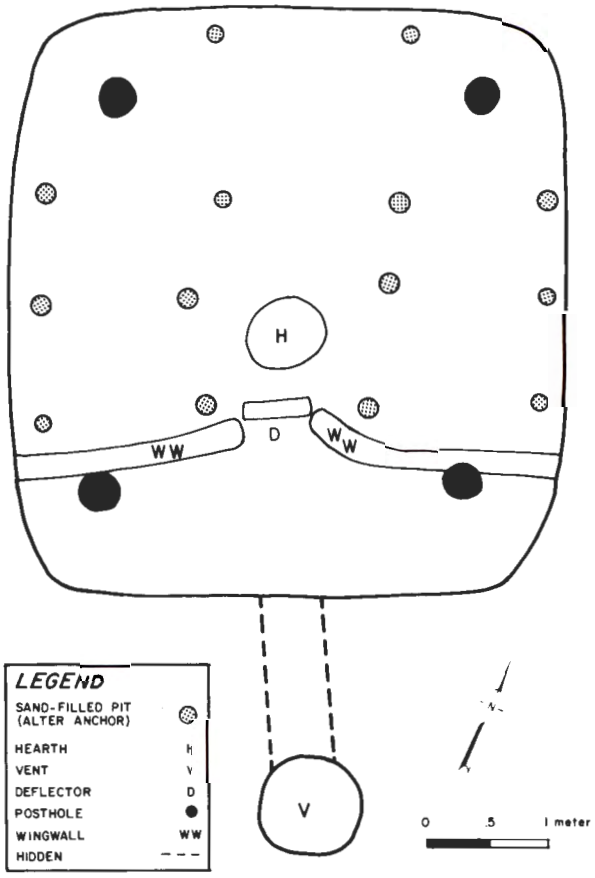

Figure 5.23 – Example of locations of cylindrical sand-filled pits (altar anchors) in small Periman Subphase pitstructures (adapted from Kleidon [1984a:fig. 33]).

interpretations for Periman pitstructures are similar to those inferred for the preceding Dos Casas Subphase. "Small" (normal-sized) pitstructures are thought to have been facilities primarily used by the interhousehold social unit. Members of the interhousehold used small pitstructures for such domestically oriented activities as cornmeal preparation and tool and container manufacture and maintenance. The interhousehold groups probably also shared at least some meals in the structure, although the exact composition of pitstructure meal-sharing groups cannot be estimated. The ritual feature complexes are also thought to have been accessed primarily by the interhousehold group during ritual and ceremonial observances. Such observances probably helped integrate the nuclear family units that constituted each interhousehold.

Because of their larger floor areas, Periman oversized pitstructures are thought to have served some supra-household organizations (corporate groups) as well as a resident interhousehold. The characteristics of the associated feature assemblages suggest that most oversized pitstructures served as habitation and work space

and as integrative loci for the interhousehold. It is suggested that, in addition, oversized pitstructures were accessed by more inclusive, higher-order corporate groups for managerially oriented ritual and ceremony. Such observances may have been attended by representatives of different interhouseholds residing in the same roomblock unit or in related roomblock units. These organizations are viewed as similar in structure and responsibilities to the corporate groups described by Hayden and Cannon (1982:132-158). The largest oversized pitstructures recorded by the DAP (Pitstructure 3 at McPhee Pueblo and Pitstructure 9 at Pueblo de las Golondrinas) did not contain domestic features or artifacts. These 2 structures are thought to have functioned strictly as locations for corporate group ritual and ceremony. Both pitstructures are associated with horseshoe-shaped roomblocks; this association is thought to be significant in terms of the managerial structure of large, Dolores-area communities (chap. 14).

Grass Mesa Subphase of the McPhee Phase (A.D. 870-910)

Grass Mesa Subphase architecture is aberrant when compared to recorded late Pueblo I or early Pueblo II patterns in the Mesa Verde Region. Specific architectural descriptions for the Grass Mesa Subphase are presented in the Grass Mesa (Site 5MT23) report (Lipe et al, 1985) and in the Rio Vista Village (Site 5MT2182) report (Wilshusen 1985, comp. 1985).

General Layout and Structure Populations

Grass Mesa Subphase layouts and population size are variable. In many instances, the Grass Mesa inhabitants reoccupied Periman Subphase structures and often remodeled the former surfaces to accommodate new arrangements of features and activity areas. In other instances, entirely new structures were built. Also, the Grass Mesa groups apparently resided side by side with traditional Periman groups, and probably participated in rituals and ceremonies held in the traditional locations (Lipe et al., 1985). Grass Mesa Subphase habitation sites, therefore, are characterized by continuation of the old Periman roomblock-plaza patterns, which have been rendered more complex by abandonment of some units and addition of others. Mean estimates of numbers of architectural units per habitation site are difficult to calculate because Grass Mesa Occupation have been recorded only at 2 sites: Grass Mesa Village and Rio Vista Village; both sites contain roomblock unit occupations assigned to this subphase. The general plan of a Grass Mesa settlement is depicted in figure 5.24.

Surface Structures

Grass Mesa surface rooms conform to the inferred pattern of relatively great architectural variability. In cases where Periman rooms were reused, former back storage rooms may have been modified into living or domestic rooms through addition of hearths and other features. Former front living rooms might have been reoccupied as open, ramada-like areas on the northern margins of plazas (Varien 1985:4.122). Areas where the Grass Mesa groups constructed new rooms have been recorded. These rooms usually are small (ca. 4 to 6 m^2 in area) and noncontiguous, similar to Tres Bobos and Sagehill rooms. No definitive characteristics are listed here for Grass Mesa rooms because of the variability in the data set.

Pitstructures

Grass Mesa pitstructures also are relatively variable when compared to those from other periods. Some apparently can be classified as protokivas, reflecting continuation of the old Dos Casas-Periman pattern of a dual function as domestic and integrative structures. Others (termed "pocket pitstructures") apparently served solely as living or economic activity locations and therefore can be termed "pithouses." These pithouses are characterized by their small size (from 6 to 15 m^2), expedient construction mode, and variability in feature complement and placement. For example, the structures are generally subrectangular with many irregularities in wall outlines; wingwalls may be present or absent; and the positions of mealing stations are variable, although they are usually west or south of the hearth. The standard four-post roof-support pattern is maintained in Grass Mesa pitstructures. Because of the inherent variability in the data set, no definitive characteristics of Grass Mesa Subphase pitstructures are described here. A plan view of a Grass Mesa "pocket pitstructure" is illustrated in figure 5.25.

A Grass Mesa Subphase oversized pitstructure (Pitstructure 32) was identified near the east end of the Grass Mesa site (Varien 1985:4.344-4.357). This structure has a total floor area of over 40 m^2 and an eight-post rather than the standard four-post support system. Unlike Periman oversized structures, Pitstructure 32 lacks a wingwall and vaults and consequently has a great expanse of unencumbered floor space. It thus could have accommodated mobile group activities such as dances. The structure is inferred to have functioned as a ritual-integrative facility for the resident Grass Mesa Subphase groups (Varien 1985:4.355-4.356).

Cline Subphase of the McPhee Phase (A.D. 920-1000)

Cline Subphase architecture in general is similar to early Pueblo II patterns described for the Mesa Verde Region (Morris 1939:33-35; Farmer 1977:31-64, 115-141, 176-227; Lister 1965, 1966). Specific descriptions of excavated Cline Subphase architectural units can be

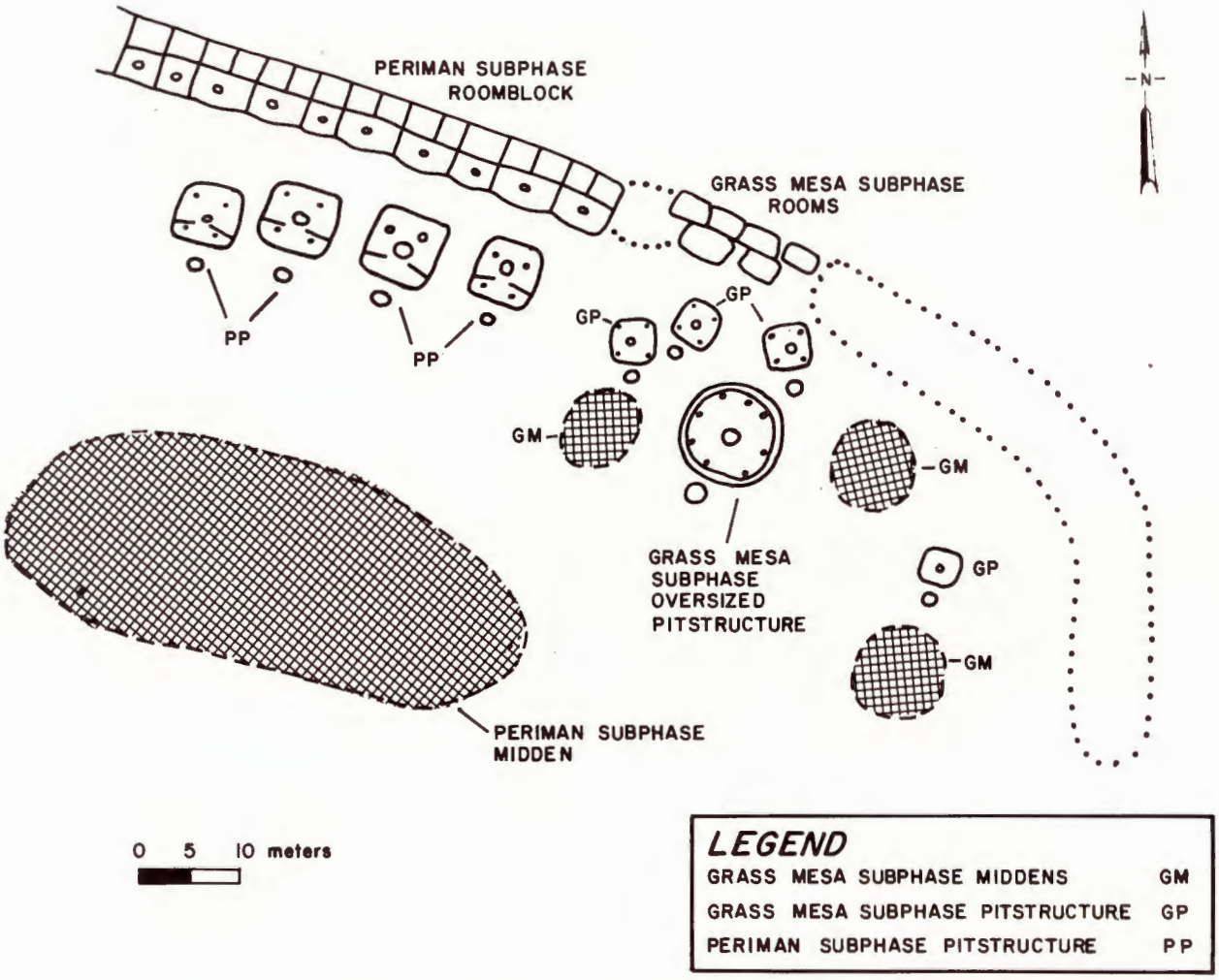

Figure 5.24 – Grass Mesa Subphase habitation site layout (adapted from Varien [1985:fig. 4.101]).

located in the DAP site reports for McPhee Pueblo (Site 5MT4475 [Brisbin et al. 1985]), Masa Negra (Site 5MT4477 [Kuckelman 1984a]), and Kin Tl'iish (Site 5MT2336 [Dohm and Gould 1985]).

General Layout and Structure Populations

Cline Subphase occupations generally are restricted to the Sagehen Flats and McPhee Community areas and to the southern portion of the river valley within the project area. A fairly substantial Cline Subphase occupation was recorded during field investigations at McPhee Village; Cline groups apparently reoccupied 5 or 6 of the roomblock units originally constructed and used during the earlier Periman Subphase. Cline Subphase roomblock units consist of masonry surface rooms and a plaza area containing pitstructures. Total populations of structures are less than during the previous Cline occupation; 2 of the Cline roomblock units contained over 20 rooms and 2 to 3 pitstructures each, while architecture at the other 3 to 4 roomblocks probably was limited to several rooms and 1 pitstructure. A plan of a Cline Subphase roomblock is depicted in figure 5.26.

Surface Structures

Cline Subphase surface rooms are generally similar in form and function to their Periman predecessors, although several differences are noted. Mealing areas seem to become more formalized and spatially distinctive, and some Cline Subphase rooms may have functioned primarily as mealing facilities. This change in surface room function is probably related to shifts in pitstructure function. With the shift from "protokiva" to "kiva" and the deletion of mealing locations from pitstructures, an accommodation was made in surface room architecture. Cline surface rooms are not easily grouped into domiciliary suites consisting of storage rooms and a living room; ambiguous wall alinements

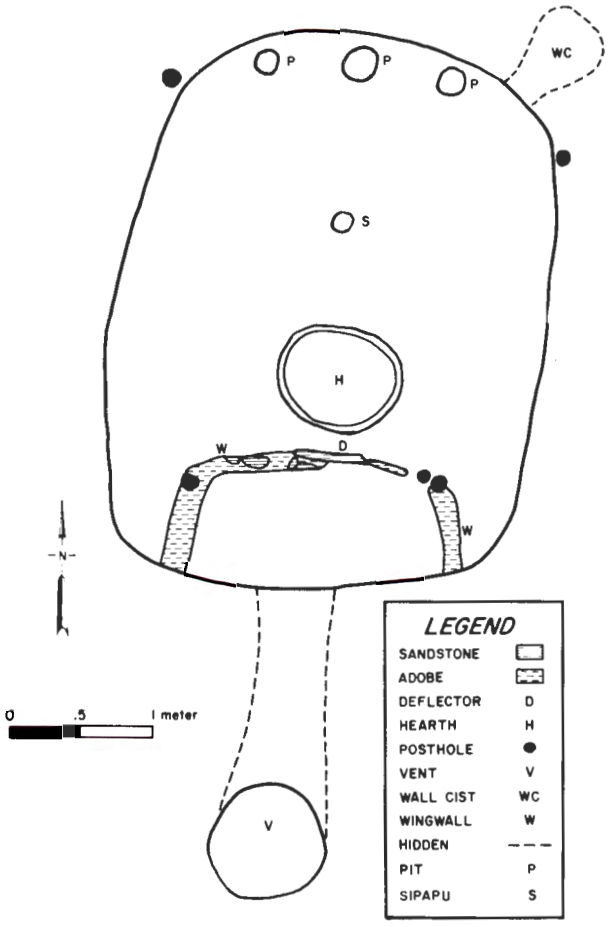

Figure 5.25 – Plan of a Grass Mesa Subphase pitstructure (adapted from Morris et al. [1985:fig. 6.15]).

do not allow a simple definition; however, domestic apartments are definable on the basis of minimum necessary facilities rather than on regular wall lines. This may reflect organizational changes in the composition of Cline domestic and economic groups. Cline surface rooms incorporate more horizontal masonry into their construction, and comparatively speaking, reflect a greater investment in materials and labor. Most Cline surface rooms are built over previously occupied Periman rooms and may incorporate portions of original Periman walls or surfaces in the new construction. Architectural characteristics of Cline Subphase surface rooms are listed below:

1. Shape. The structures are rectangular in plan.

2. Size. Two populations are discerned: small storage or processing rooms with a mean area of about 6 m², and large living rooms with a mean area of about 15 m² (Wilshusen 1985c:table 3).

3. Wall construction. Walls are constructed primarily of horizontally laid and mortared sandstone

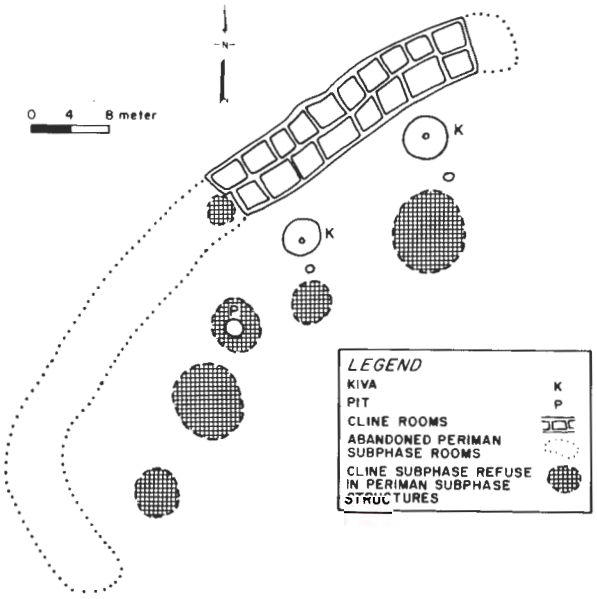

Figure 5.26 – Cline Subphase habitation site layout (adapted from Kuckelman [1984a:fig. 2]).

block masonry. The individual blocks are shaped by flaking, and they often have a "scabbled" appearance (Brisbin et al. 1985). Back room walls might have been constructed entirely of masonry, while front room walls probably had upper portions of jacal or turtleback daub.

4. Roof construction. Most rooms contain postholes in the 4 corners, suggesting that standard four-post construction was the dominant roofing pattern. Large front rooms may contain 2 additional post supports near the north-south axis of the structure.

5. Floor. Floors consist of the original surface of the excavation covered with a veneer of dried mud or sand.

6. Domestic and economic activity areas. Rooms can be functionally classified as storage, processing, or habitation rooms. Storage rooms contain few features and usually are small back rooms. Processing rooms contain grinding stations or sets of hearths and are small back or front rooms. Habitation rooms contain a complement of features (e.g., corner bins, central hearths, warming pits, mealing stations) used in the performance of day-to-day domestic tasks.

Pitstructures

Cline pitstructures exhibit marked changes in form and function when compared to their Dos Casas and Periman Subphase predecessors. One or several pitstructures are present per roomblock unit. Pitstructures

are generally circular rather than rectangular, and they usually have a bench. Pitstructures 4 and 5 at McPhee Pueblo are subrectangular; they incorporate portions of abandoned Periman Subphase pitstructure construction. Wingwalls are absent and domestic/economic activity areas are less common, suggesting increased use of the pitstructure as a location for ritual and for group integration. The form and function of Cline pitstructures approximates the descriptions of the true "kiva" as presented in the archaeological literature (Lancaster and Pinkley 1954:55; Gillespie 1976:85-98). Figure 5.27 depicts the plan of a Cline Subphase pitstructure. Specific architectural characteristics are as follows:

1. Shape. Cline Subphase pitstructures are generally round or oval, except when the builders expediently incorporated portions of Periman Subphase structures. This is in marked contrast to the rigid subrectangular plans of the previous Periman Subphase.

2. Size. Usable roofed areas (floor plus bench surfaces) for Cline Subphase pitstructures range from less than 10 m^2 to almost 30 m^2. If outliers in the size distribution are omitted, then most Cline pitstructures are between 10 m^2 and 20 m^2 in area; the mean roofed area is approximately 18 m^2 (Wilshusen 1985c:table 3). Pitstructures 1 and 2 at McPhee Pueblo (these are superimposed structures) are larger than the "normal" population (27.4 m^2 and 34.1 m^2, respectively) and may be equivalent to the "oversized" pitstructures of the Periman Subphase.

3. Depth. Depths for Cline Subphase pitstructures range from 1.3 to 1.7 m; mean depths are approximately 1.5 m (Wilshusen 1985c:table 2).

4. Roof construction. Four-post roof support patterns are common, although some structures apparently had roofs with the main beams footed on the tops of the walls, that is, at ground level. When present, the 4 main supports are footed in the bench in the northwest, northeast, southwest, and southeast corners. This style of construction would have increased the amount of unencumbered floor space in comparison with Periman pitstructures.

5. Bench. Presence or absence of a bench is variable in Cline pitstructures and may covary with size (large pitstructures incorporate a bench, small pitstructures usually do not). Pitstructure 5 at Masa Negra Pueblo (Kuckelman 1984a), near the small end of the size distribution, had a high bench. This feature may have served as reinforcement for the walls rather than as the more typical kiva bench. The "oversized" pitstructures at McPhee Pueblo (Pitstructures 1 and 2) contained benches. Pitstructure 8 at the same roomblock unit contained a partial bench on the west side.

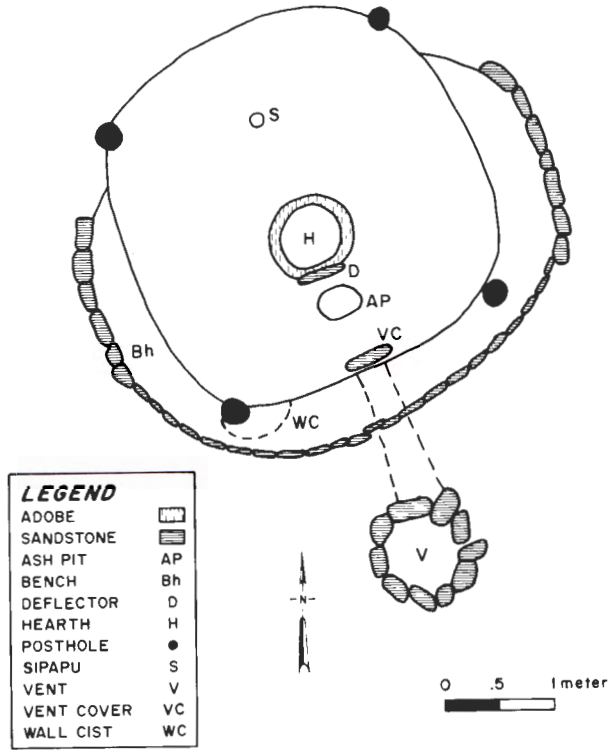

Figure 5.27 – Plan of a Cline Subphase pitstructure (adapted from Kuckelman [1984a:fig. 41]).

6. Wingwall. Wingwalls are absent in Cline Subphase pitstructures.

7. Bins. Bins are absent in Cline pitstructures.

8. Ventilation system. Cline Subphase pitstructures incorporate a standard ventilation system in the form of a horizontal tunnel and a vertical shaft, the former opening into the pitstructure at floor level from the south. Pitstructure 1 at McPhee Pueblo (Brisbin et al. 1985) has a subfloor ventilator tunnel with an opening just south of the central hearth.

9. Hearth and heating complex. Cline Subphase pitstructures incorporate a central hearth, usually accompanied by an ash pit to the south.

10. Domestic and economic activity areas. Feature and artifact populations indicative of domestic or economic tasks are variable in Cline Subphase pitstructures. Some pitstructures (Pitstructures 1 and 2 at McPhee Pueblo [Brisbin et al. 1985], Pitstructure 5 at Masa Negra Pueblo [Kuckelman

1984a], and Pitstructure 4 at Kin Tl'iish [Dohm and Gould 1985]) contained relatively sparse populations of features and artifacts, which suggests a use other than as living space. Others (most notably Pitstructures 4 and 8 at McPhee Pueblo) contain high densities of material items, including flaked stone tools, ground stone tools, ceramic fragments, and chipping waste. Some of this material may represent postabandonment disposal of refuse; however, some of the recovered materials probably reflect use of the structure. Even when high material densities are present, the items do not appear to be spatially arranged in any regular fashion. Formal mealing areas, which are commonly encountered in Periman pitstructures, are absent from Cline pitstructures.

11. Ritual activity areas. Cline Subphase pitstructures usually contain a simple, cylindrical sipapu on the north-south axis of the structure between the central hearth and the north wall. Pitstructure 5 at Masa Negra Pueblo (Kickelman 1984a:125-140) contains a capped basin-shaped pit which is similar in form and location to Periman Subphase complex sipapus (Wilshusen 1985b:11-14). The 2 "oversized" Cline pitstructures at McPhee Pueblo contained niches, possibly used for storage of ceremonial items, in the north wall on the north-south axis. Cline pitstructures do not contain complex assemblages of ritual features such as those described for Periman counterparts.

The feature and artifact data suggest that Cline pitstructures can morphologically and functionally be classified as kivas. They are generally round or oval in outline except when portions of abandoned Periman structures have been incorporated. They lack wingwalls, and the main support posts have been incorporated into the bench or outer walls, thus creating a relatively large expanse of unencumbered space. Cline Subphase pitstructures also lack the standard Periman domestic activity areas and features (mealing stations, tool storage areas, warming pits, etc.) and Periman-style complex ritual features. Again, the effect of the removal of most "furniture" associated with the structures would be to free up space, perhaps to facilitate mobile group activities. Thus, Cline Subphase pitstructures generally exhibit similar morphology to published descriptions of early "Mesa Verde" kivas and are probably functionally similar as well. Most domestic activities probably were relocated in the surface rooms. Pitstructures 4 and 8 at McPhee Pueblo may have been the locations of some domestic activities. However, a large portion of the "domestic" artifacts associated with these structures may be secondary refuse. The possible domestic activites do not appear to be patterned. The substitution of a simple sipapu in lieu of the complex Periman-style ritual feature assemblages suggests that the types of ritual-ceremonial observances and perhaps the composition of the groups participating in these observances also changed. Specifically, it is proposed that Cline ritual observances were more mobile than static, when compared to Dos Casas-Periman analogs.

Marshview Subphase of the Sundial Phase (A.D. 1000-1200)

Marshview Subphase structures identified and investigated by DAP field crews do not correspond to the published descriptions of Mesa Verde Region Pueblo II and Pueblo III architecture (e.g., Morris 1939; Hayes and Lancaster 1975; Rohn 1971). The uninvestigated sites in the vicinity of the Reservoir Village probably contain architectural patterns more similar to the published accounts. Specific descriptions of Marshview architecture are available in the following DAP reports: Marshview Hamlet (Site 5MT2235 [Wilshusen 1982b]), Paintbrush House (Site 5MT2729 [Kleidon 1984b]), Pinyon House (Site 5MT4751 [Kuckelman 1984b]), Southview House (Site 5MT2241 [Morris 1983]), Weasel Pueblo (Site 5MT5106 [Morris 1984]), and Beaver Trap Shelter (Site 5MT4654 [Hewitt and Harriman 1984]). The following discussion is limited to the Marshview occupations investigated by the field staff; these sites are generally in the middle and northern parts of the project area. The Reservoir Village area, on the southern fringe of the project, contains more typical Pueblo II – Pueblo III architecture, including masonry surface room-kiva complexes. The village also contains specialized architecture in the form of a two-story, rectangular roomblock similar in form to Escalante Ruin, a tri-walled structure (the Emerson Ruin) and a possible great kiva (fig. 5.4 and 5.5).

General Layout and Structure Populations

Marshview Subphase architectural sites are characterized by comparatively low structure populations and considerable variability in the proportions of structure types. Architectural sites with only 1 structure are common, and generally speaking, no more than a few structures are present. Marshview architectural sites may consist of a single pitstructure without surface rooms, a surface room without pitstructures, or a surface room-pitstructure complex with one or several surface rooms and a single pitstructure. Marshview architectural sites exhibit the typical Anasazi north-south axis alinement with surface rooms (when present) to the north, pitstructures in the center, and a midden or sheet refuse area to the south. These sites are very small (sites usually are less than 600 m² in total area). The small size, structure variability, and expedient, low-cost construction of Marshview sites suggest many were probably seasonal occupations rather than permanent settlements. A plan of Marshview Subphase architectural site is depicted in figure 5.28.

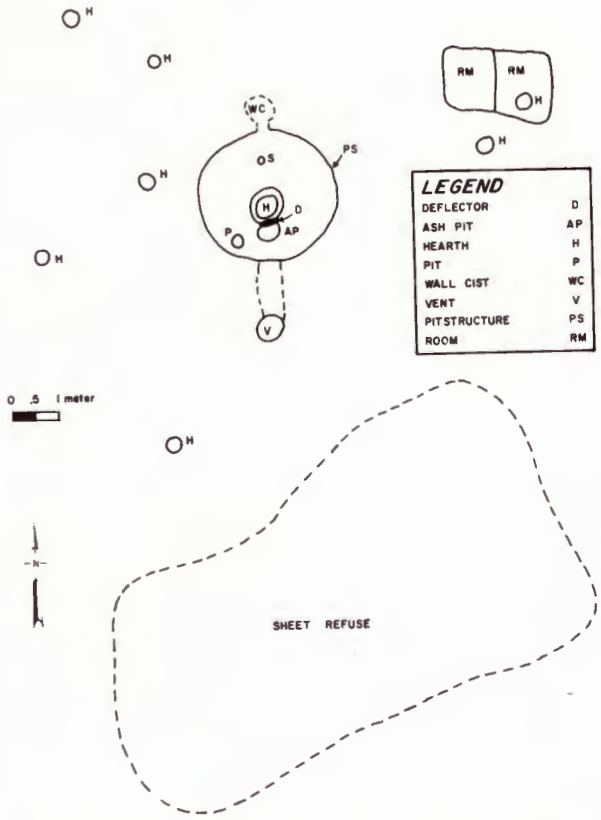

Figure 5.28 – Marshview Subphase habitation site layout (adapted from Wilshusen [1982b:figs. 12.9, 12.10]).

Surface Structures

Marshview surface structures are variable in form and construction. Several Marshview sites contain stone masonry surface rooms; these can be briefly described as follows: Beaver Trap Shelter contains a masonry roomblock with 4 contiguous structures; 1 of the structures possesses kiva-like construction and features. Pinyon House has a single masonry room thought to have been a storage facility. Southview House contains a single rectangular masonry room with walls that originally were over 2 m in height; the room apparently served as the location for a variety of activities. Singing Shelter (Site 5MT4683) contained a Marshview dry-laid masonry surface room that apparently functioned as a habitation; a central hearth and masses of soft vegetal materials interpreted as bedding were present in the structure. The Marshview component at Weasel Pueblo was marked by a round surface structure, which probably was part of a tower-kiva complex. Excavation of 2 Marshview sites without substantial surface architecture (Paintbrush House and Marshview Hamlet) yielded indications of jacal or brush ramada-like structures north of the pitstructures. However, because of postabandonment erosion and disturbance, the form and function of these structures could not be estimated.

Because of the variability within this data set, few generalizations are possible. Mean floor areas for Marshview structures are between 5 and 6 m^2, with a standard deviation of over 2 m^2 (Wilshusen 1985c:table 3).

Pitstructures

Marshview Subphase pitstructures are very small and shallow, and reflect less investment in materials and labor than their counterparts during previous subphases. Functionally, they probably can be considered pithouses rather than kivas or protokivas, as they lack evidence for ritual or ceremonial activity. Specific architectural characteristics are given in the following list:

1. Shape. Marshview pitstructures are round or oval.

2. Size. Floor areas of Marshview Subphase pitstructures range from 5.3 m^2 to over 14 m^2; the mean is about 7 m^2 (Wilshusen 1985c:table 2). Marshview pitstructures thus encompass less than half of the mean floor area when compared to pitstructures of other subphases.

3. Depth. The mean depth of Marshview Subphase pitstructures is about 1.0 m (Wilshusen 1985c:table 3); the pitstructures are very shallow when compared with pitstructures of other subphases.

4. Roof construction. Roof beams usually were footed at the top of the pit walls.

5. Bench. Benches are absent from Marshview pitstructures.

6. Wingwall. Wingwalls are absent from Marshview pitstructures.

7. Bins. Bins are absent from Marshview pitstructures.

8. Ventilation system. Marshview pitstructures incorporate a standard horizontal tunnel-vertical shaft ventilation system. A deflector is usually located on the south margin of the central hearth.

9. Hearth and heating complex. Marshview pitstructures contain a central hearth and sometimes an associated ash pit south of the hearth. The deflector is usually anchored in the southern clay lining of the hearth itself. Lateral warming pits are absent.

10. Domestic and economic activity areas. Features indicative of domestic or economic activities,

such as in situ metate stations or lapstones, are usually absent from Marshview pitstructures. Features indicative of storage, such as wall or floor cists and pot rests, are often present.

11. Ritual activity areas. Evidence for ritual activities in Marshview pitstructures is usually absent; a simple cylindrical sipapu may be located between the hearth and the north wall.

Because of their small sizes, their variability in and low cost of construction, and their lack of association with household surface roomsuites, Marshview Subphase pitstructures are interpreted to be habitation facilities. Because they are very small when compared to other project habitation structures (Tres Bobos pitstructures, for example, have a mean floor area of over 25 m^2, versus 7 m^2 for comparable Marshview structures), Marshview pitstructures may have been used only on a seasonal basis. Marshview pitstructures do not contain the set of formal morphological attributes (bench, plaster-footed roof, masonry wall lining, etc.) used to define Mesa Verde Region kivas (Lister 1966:77-87). Rather, Marshview pitstructures can be considered "least cost" in terms of labor expenditure and materials: they are small and shallow and have low feature populations, earthern walls, and roofs that are footed on the wall margins of the pit. This expedient style of construction reinforces the impression that these structures were used by small groups on a seasonal basis.

Escalante Subphase of the Sundial Phase (A.D. 1120-1180)

Because DAP excavations of Escalante Subphase architectural contexts were limited to 1 site (Sundance Hamlet [Site 5MT2215]; Harriman [1983]), no architectural summary is presented here. For architectural descriptions, refer to the general Escalante Subphase discussion in the first section of this report and the reports of site investigations undertaken by other institutions (Reed 1979; Hallasi 1979; Douthit 1984).

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PART IV

Chapter 6

MODELING DOLORES AREA CULTURAL DYNAMICS

William D. Lipe

INTRODUCTION

This chapter is devoted to the development of a general model of sociocultural change and to the identification of some implications of this model that can be tested against archaeological data from the Dolores area. After introductory comments about the nature of building and testing theoretical models, a major section is devoted to presenting a general model of a regional sociocultural system. This model is not specific to the Dolores area or to Anasazi culture, but is derived from theoretical considerations and substantive generalizations about how "Formative" level (Willey and Phillips 1958) sociocultural systems work. This general model is presented and discussed to identify variables and relationships potentially important in bringing about sociocultural change. Thus, it is intended as a survey of variables and relationships that might be considered in investigating specific instances of sociocultural change.

The next section of the chapter briefly discusses possible approaches to developing testable expectations from the general model. It is concluded that, short of a complex computer simulation beyond the capacity of the Dolores Archaeological Program, only selected expectations can be tested.

In the final section, selected variables and relationships are used to construct 2 specific processual models of change for evaluation against the Dolores archaeological data. The first assumes as primary an economic system that has stable economic goals and articulates population, material needs, and resources in a cost-efficient way. Sociopolitical development is seen as a necessary accompaniment to increased population density or to economic intensification brought about by resource supply/demand imbalances. The second model assumes that under any of a broad range of economic conditions, social variables can become primary, with status differentiation and competition promoting economic intensification, population growth, and sociopolitical development. Contrasting expectations are developed for these alternative specific models of systemic change. These expectations are examined, in light of several categories of data, in chapters 7 through 15. In some of these chapters, additional evaluations of relationships among variables taken from the general model are also attempted. Chapter 16 presents a synthesis of results. A number of the supporting studies that contributed data used in chapters 7 through 16 are published in Petersen and Orcutt (1985) and in Blinman et al. (1985).

Definition and General Requirements of Modeling

A model is a simplified or abstract representation of a real system, incorporating only the few variables and relationships believed to be most important in accounting for the variability in the real system (cf. Clarke 1968:32). Since a system is being modeled, relationships among the variables must be stated; i.e., how change in 1 variable is likely to result in change in others. If this change is repetitive and is maintained within a steady range of values, the relationships among these variables can be viewed as maintenance processes regulating the operation of the system. To the extent that the system as a whole or major subsystems within it undergo nonrepetitive or structural change, the relationships linking the sequent states may be viewed as evolutionary or change processes.

The model must be relevant to the system, i.e., the modeled variables must be thought to be present, important, and measurable (or at least capable of being estimated) in the real system. On the other hand, the variables and relationships chosen should be derivable from general sociocultural theory, and the results of testing propositions derived from the model against data should be able to contribute to general theory. Thus, the model will be powerful to the extent that it can both account for a variety of characteristics of the real system data and can also be related to general theory about the operation of systems of the kind under study.

Archaeological modeling operates under the burden of having to work with data derived from the archaeological record and hence somewhat removed from the sociocultural phenomena being modeled. The model must

not only incorporate theory about how sociocultural systems work, but must also use "middle-range theory" (Binford 1977) about how the sociocultural phenomena of interest are expressed in the archaeological record. These links are discussed in chapters 7 through 15 and in numerous supporting studies (Petersen and Orcutt [1985]; Blinman et al. [1985]).

Testing a model requires that researchers be able to develop from the model predictions or expectations about archaeological data that did not enter into the construction of the model itself, i.e., did not provide the basis for delineating the variables and their relationships. This is not a difficult constraint because the model presented is based on generalizations about sociocultural continuity and change and because expectations about the Dolores case are derivable from these general considerations, rather than from examination of specific Dolores archaeological data.

For the same reasons, however, the model itself is testable only in 2 rather indirect ways. In the first, and more direct way, propositions can be drawn from the model and compared to the Dolores area data. For example, we might posit that increased population density should be followed by increased social differentiation and by increased agricultural intensification. Should we find these expectations are **not** supported by the Dolores data, it would show that the posited relationships did not hold in this particular test, but would not demonstrate they were not **generally** present. These relationships have been found in numerous other cases, or at least it has been so argued (e.g., Plog 1974; Boserup 1965), and we would have added only one counterexample. The finding would, however, contribute to the literature on these propositions and might to some extent modify our evaluation of their worth as generalizations.

In the second, and less direct sense, the overall usefulness of the general model can be evaluated by asking "Did the general model assist in isolating variables and relationships that could be shown to account for aspects of Dolores area sociocultural continuity and change?" To the extent that this question can be answered affirmatively, the general model can be considered to have been supported by this application or "test." This does not mean, however, that some other general model might not have served better.

The view of testing presented here emphasizes the role of the general model in the DAP approach to Problem Domain 5 (Cultura Process) in the DAP general research design (Kane et al. 1983). The model serves to generate propositions whose applicability to Dolores prehistory can be tested. Thus, the focus is on determining what variables and relationships account for **Dolores area** continuity and change; the general considerations are useful and relevant to the extent they contribute to that goal.

Testing propositions derived from the model also requires that the tests be capable of being falsified; that is, some states of the variables could conceivably occur that would deny the predictions of the model. And, the archaeological data used in testing must be linked by credible warranting arguments to the variables employed in the propositions that are being tested.

A GENERAL MODEL OF SOCIOCULTURAL STABILITY AND CHANGE

This general model provides a selection of variables for examination, and a justification as to why these variables are potentially important in accounting for stability and change in regional sociocultural systems. It also indicates general directions of influence or effect among variables, what co-variance is to be expected and which variables are likely to change in response to change in others. The model is to be used as a framework for abstractly describing the state of a regional sociocultural system and for comparing the system at different points in time. It can also serve for describing and comparing different regional systems at the same or different times.

In figure 6.1, a number of variables are named and relationships among them shown by connecting arrows. The directions of the arrows indicate the direction of influence or effect. The variables and relationships are those thought to have the potential to affect sociocultural stability and change in a system of the kind found in the Dolores area during the period of interest. The individual variables and their probable relationships are discussed later.

Figure 6.1 and the discussions that follow present a very general model of a regional sociocultural system. The model also incorporates aspects of the natural environment and of adjacent sociocultural systems to the extent these may have had an effect on the regional system under study. Although most variables (e.g., population, resource demand) will play a part in the functioning of the system in any state it might assume, some of the variables (e.g., immigration, intersystem exchange) may not. All variables have the potential to change through time, but some may not in a particular case. For example, in the Dolores area, the supply of most raw materials for lithic tools appears inexhaustible and was probably not measurably depleted by use. On the other hand, the Dolores area population changed greatly through time. The strength of the relationships among variables may not vary through time. In the Dolores

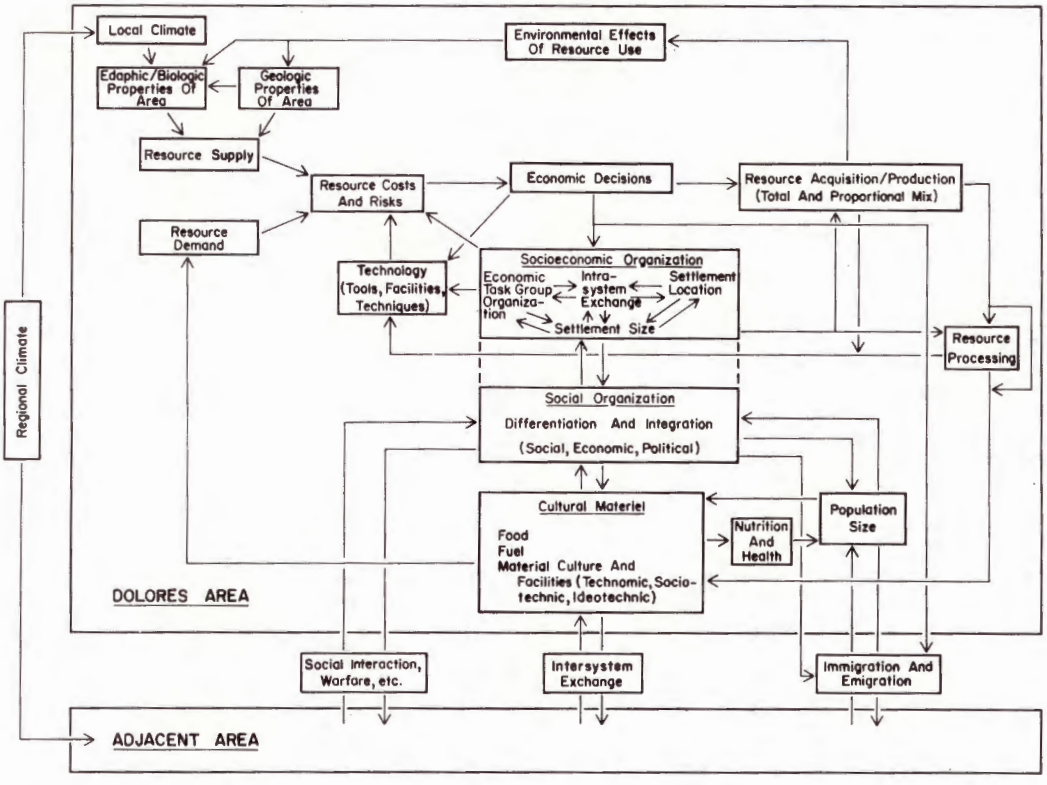

Figure 6.1 – A general model of sociocultural stability and change.

case, it seems likely that the technology of tool manufacture and use exerted a fairly constant effect on resource procurement and processing costs throughout the time period of interest (cf. chap. 11). On the other hand, immigration was probably a strong contributor to population size in some periods and not in others.

Some Basic Considerations

Homeostasis and Open Versus Closed Models

The system modeled here is assumed to have a tendency towards homeostasis, in that mechanisms exist to constrain variability within certain limits so that the states of a given variable oscillate around a (statistical) norm. Some of this variability may be viewed as stochastic, and some as a result of directional change processes interrupted by a cultural response that restores a previous state. Thus the progressive deterioration of facilities may be halted by repair or by the construction of new facilities, disparities in rates of accumulation of goods may be reduced by ritual distribution, and so forth. The degree to which the system's components are functionally interrelated can be seen as leading to homeostasis, if one assumes a certain amount of inertia or resistance to change within each of the components. The existence of homeostatic or deviation-damping (Flannery 1968) mechanisms does not imply the system cannot change or that it is always, or ever, in perfect equilibrium. Nonetheless, homeostatic mechanisms must operate to some extent if the system is to maintain an adequate amount of functional integration and coherence.

The system should not be viewed, however, as so successfully and thoroughly homeostatic that it remains in a state of equilibrium until a forceful enough disruption sends it oscillating toward a new equilibrium state. This view implies a kind of all-pervasive, well-oiled functional integration is the normal state, and further, that disruptions must come from outside the system. They could not come from inside if complete functional harmony is the rule (Jarvie 1965). An undue emphasis on homeostasis and integration leads us to view the system as closed and directs the search for change agents to the larger social or natural environment outside the system.

Wood and Matson (1973) have properly criticized this view and have proposed that, following Buckley (1968), sociocultural systems be viewed as open. The system is defined as a nexus of interacting variables; to the extent that variables affect one another, they are part of the system. This is very close to the view adopted; in this

proposed model, certain sociocultural and environmental forms (variable states) are seen as the product of a balance among interacting forces; a change in any or all of these forces may cause a change in the balance so that a new set of forms emerges. Rapidity of change is constrained by the effectiveness of functional integration and deviation-damping mechanisms. Change is also assumed to be constrained by a certain inertia, resulting from attachment to particular cultural solutions to the problems of life, due probably to the intellectual, affective, and neuromuscular investments required to learn particular patterns of behavioral response (Jochim 1981:27-28).

In keeping with the open system concept, the model presented (fig. 6.1) includes aspects of the local environment as well as variables that are sociocultural and demographic. The key element in the treatment of the environment is resource supply, which is considered to be those aspects of the environment recognized by the area's population as actual or potential resources. Although climate is likely to have affected resource supply both directly (e.g., by early killing frosts) and indirectly (e.g., by causing long-term shifts in vegetation community distributions), socioeconomic factors must have had substantial effects on resources as well. These would have included, for example, the results of land clearing and cultivation and of collecting wild plant and abiotic materials and animals. From this perspective, treating resource supply as a product of a coupled, but separate, environmental system would be unnecessarily awkward.

Geographic Boundaries of the Dolores Area

The Dolores area is coextensive with the Escalante Sector in the DAP spatial systematics (Kane 1983). The Escalante Sector was established to encompass the central impact area and project takeline and is based on the extent of the Anasazi settlement system centered on the Dolores River canyon. In the model diagram (fig. 6.1), the Dolores area is distinguished from adjacent areas, some of which were inhabited by other Anasazi populations. This spatial boundary is not necessarily (though at some times it has been) a "natural" one, i.e., one that represents a fall-off in population density or in amount of social interaction between settlements. It is a heuristic bounding that facilitates consistent investigation of the prehistory of the Dolores area; it is the area from which most of our available data come; it is large enough to include several Anasazi communities and their primary economic catchments during the time period of interest; and it has environmental variety, but not so much that it cannot be summarized by a small set of physiographic, biotic, climatic, and edaphic patterns. In keeping with the open systems assumption, relationships with sociocultural systems outside the Dolores area are included in the model because they have the potential to affect variable states within the region of primary interest.

During the A.D. 600-950 period, Anasazi populations were present at least part of the time in areas immediately south, west, and northwest of the Dolores area. To the east and northeast, the higher, forested areas seem not to have supported Anasazi settlements, at least not on a year-round basis, nor does any evidence show they were occupied at this time by non-Anasazi hunters and gatherers. Further afield, Anasazi populations in the Durango and Animas-La Plata areas, the San Juan Valley near Farmington, the Mesa Verde proper, the Montezuma Valley and McElmo drainage, and the Blanding-Bluff region of southeastern Utah may have had interactions with and effects on the Dolores area Anasazi.

It is assumed the non-Dolores systems can also be characterized by the general model – that all things being equal, they would respond to change in a given variable in much the same way as would the Dolores system. The credibility of this assumption may be increased by the fact that the populations likely to have been interacting with the Dolores Anasazi all participated in the Mesa Verde Anasazi Cultural Tradition, and thus probably had similar sets of cultural expectations and norms, had a generally similar level of sociopolitical complexity, and depended on generally similar economic resources. Of course, not all things were equal across southwestern Colorado and adjacent areas – population density, costs and risks of obtaining necessary resources, and degree of agricultural intensification – varied through both time and space, providing much of the impetus for economic, social, and demographic interactions among regions (cf. Braun and Plog 1982; Judge et al. 1981, Plog 1984).

The bounding of the Dolores area appears to be least arbitrary, in a demographic and sociological sense, during the A.D. 800's, when the Dolores River valley and some of the adjacent uplands were more heavily populated than were surrounding regions. The boundaries of the Escalante Sector probably passed through areas of relatively low population density and social interaction. Earlier, however, the small dispersed homesteads and hamlets that characterized the Dolores area in the A.D. 600's and 700's may well have been part of a larger distribution of such settlements that extended outside the area to the south and west. Their community boundaries may not necessarily have coincided with the edge of Escalante Sector.

Sources of Systemic Change in the General Model

In the following paragraphs, several groups of variables and relationships are described; each can be considered as a major component of the system and as a potential source of change.

Because the modeling studies are focused on the Dolores area, which has geographic boundaries, the first group of variables and relationships are referred to as "interareal," as extending outside the Dolores area. That is not meant to contradict the "open system" assumption described earlier but is the result of the adoption of a geographic focus. Social, economic, and demographic relationships that extend outside the Dolores area are not necessarily more or less important in determining sociocultural responses within the Dolores-based system than are its own economic, social, or demographic subsystems.

Interareal Relationships

In the model, the factors that extend beyond the Dolores area and that can bring about responses leading to change within the Dolores area are regional climate and relationships between the local system and adjacent sociocultural systems. Regional climatic variability can affect local climate, which in turn affects the supply of basic resources – in particular, the capability of Dolores area lands to yield agricultural products. The regional climate's effects on surrounding areas can also alter the **relative** attractiveness of the Dolores area vis-a-vis surrounding areas and hence can affect the attractiveness of emigration or immigration as solutions to economic or social problems in any of these areas.

Turning to sociocultural relationships, immigration to and emigration from the Dolores area are thought to have affected local population size and density, at least at times, although internal rates of growth and decline must also be considered. Population movement into and out of the Dolores area may have been strongly influenced by its economic costs, risks, and productivity **relative to** neighboring locales. Such movements may also have been constrained by the type and degree of leadership and social integration within each area and by the kinds of social interaction (including, for example, intermarriage and warfare) between groups in the different areas. Furthermore, though emigration might have solved economic or social problems for the individuals or group that moved, it might have caused other problems (e.g., a change in the ratio of food producers to consumers or a disruption of established cooperative hunting relationships) for the population that remained. Problems of social integration and access to resources and settlement space might also have been present in the area receiving the migrants.

An additional external relationship that may have affected the states of variables within the Dolores system was interareal exchange (cf. Braun and Plog 1982; Judge et al. 1981; Upham 1982; Plog 1983). Incoming items would have supplemented the inventory of resource raw materials or of finished cultural materiel available locally. This could have served to compensate for temporary insufficiencies (e.g., due to crop failure) in local supplies of resources and material. The movement out of the area of exchanged items would have increased demand for resources needed to furnish these items.

Movement of goods between areas can be accomplished by exchange or by one-way transfers (Pryor 1977). Of the 2 mechanisms, exchange seems the more likely for interareal relationships. Such external exchange may have effects on social and socioeconomic systems. Because the distances involved are relatively great and because social relationships must be established with members of "foreign" groups, external exchange probably takes a greater investment of time by the participants than does local exchange. Perhaps for this reason, external trade appears to have a greater potential for social manipulation, e.g., by restricting participation to only certain groups (Upham [1982]). To the extent that foreign products are widely desired or admired, the group in control of their acquisition through exchange can obtain an economic advantage and can use the products to display and validate its special status. I am not asserting that in the Dolores case mechanisms for external trade or transfer of goods went beyond trading partnerships among individuals (Snow 1981, Ellis 1981), but merely raising this possibility.

Resource Supply

Within the Dolores area, the local environment is considered to be part of the system under study because it furnishes resources of value to the local population. One of the most likely sources of variability that could have affected other components in the system is resource supply. The agricultural potential of soils in this area can be greatly affected by even small variations in local climate, notably in length of growing season (Shuster 1981; Petersen and Clay 1985); it is also affected to a lesser extent by amount and seasonal distribution of precipitation. Climatic variability could also have affected the area's vegetation types and distribution (Petersen 1981, 1985), with possible effects on wild plant and animal resources.

Furthermore, the effects of resource use on the environment must have had effects on resource supply by

decreasing the availability of some items (e.g., pinyon pine [*Pinus edulis*] as a result of land clearing for agriculture) and by increasing the supply of others (e.g., edible pioneer plants such as goosefoot [*Chenopodium* sp.], which thrive in disturbed areas, such as cleared fields) (Bye and Shuster 1984; Petersen et al. 1985). Such environmental effects would include those resulting from land clearing and cultivation, harvesting timber for building materials and fuels (Kohler et al. 1984; Kohler and Matthews 1984), hunting, exploiting clay and lithic resources, and so forth.

Population

Another powerful source of systemic response and, potentially, of structural change, is variability in population. In some theories of sociocultural change this is considered a prime mover (e.g., Boserup 1965), although in others it is considered as one of several factors that might place stress on the system and hence eventually promote structural change (e.g., Flannery 1972, Hassan 1981; Lightfoot 1984). This latter perspective is adopted here. In this model, it is assumed population change is likely to have had important effects on other aspects of the Dolores system in 2 main ways: first, through its effects on resource demand; and second, through its effects on population density with consequent effects on the social system.

In societies in which most economic activity is focused on providing small and relatively equal amounts of basic cultural materiel – food, shelter, clothing, fuel, and tools – for all members of the population, a major component of resource demand will vary directly with population. The demand for food – in terms of calories and basic nutrients – is likely to be most closely tied to population size. Demand for fuel and for material culture and facilities (and hence for the resources necessary to provide them) will also vary more or less directly with population, but will be conditioned as well by demands stemming from the character of the socioeconomic system and technology (e.g., degree of sedentism, importance of storage) and of the social system (e.g., the need for group assembly facilities, the need for imported goods to validate social status). If interareal exchange is substantial, this will also of course affect the directness of the relationship between change in population and change in resource supply and demand.

Change in population size within a given area of course changes population density, which likely affects the social system by changing the number and frequency of interactions among individuals and groups, and thus increasing the opportunities for conflict, including those arising from overlaps in role definition. Numerous studies have cited increasing population density as one of the preconditions for increasing social differentiation and for the development of sociocultural complexity in general (cf. Plog 1974; Blau 1975; Carneiro 1967). If density is the aspect of population size with the strongest effects on social relationships, these effects might be achieved by aggregation of a dispersed population into larger, high-density settlements, even in the absence of change in regional population size. The effects of increased density should be most pronounced when both regional population size and aggregation are increasing, as was true for the Dolores area in the A.D. 800's. If average community size stays the same, population growth in an area would then increase the density of communities (i.e., number of communities in a given area). Situations in which resources are localized or are scarce overall may lead to territorial conflicts among communities, which may have an effect on sociopolitical relationships between communities or on sociopolitical institutions within communities.

Some of the possible effects of population change on the social and economic subsystems have been discussed. But what brings about population change? The balance of births and deaths is controlled by factors intrinsic to the population (Palkovich [1980]; Wetterstrom [1976]), and population size may also be affected by immigration and emigration.

In the model presented, one of the most powerful determinants of immigration and emigration is assumed to be the difference in economic costs and risks among areas close to one another. This differential is likely to result from the effects of climatic conditions on areas having differences in factors such as elevation, physiography, and soils, as well as from differences among areas in population densities. For example, immigration into the Dolores area would occur when conditions for agriculture were substantially more favorable than in nearby areas, and emigration out of the Dolores area would be most common when other areas had become relatively more favorable.

Economic differentials should be most effective in triggering population movement when the receiving area has low population density. As population density increases, rates of immigration should increasingly be affected by social factors such as marriage and land tenure patterns, including the development of land ownership by kin or other corporate groups that regulate access to land (Hunter-Anderson 1980; Hayden and Cannon 1982). Also, a history of social relationships (e.g., trade, intermarriage) among adjacent areas would enhance the possibilities for population movement between them. Responses to immigration may vary, depending on the character and history of the social and economic systems. When economic integration is low, when small

groups are essentially independent economically, immigration should slow gradually as population increases and arable land becomes more scarce. With greater economic integration in the recipient area, one might also envision a scenario in which the adoption of labor-intensive forms of agriculture or the growing importance of local economic differentiation and exchange would favor some amount of immigration (Lightfoot 1984).

Lightfoot (1984) argues that even in relatively simple societies, the development of institutionalized leadership groups and the competition among leaders and their communities for followers may promote immigration to particular settlements or localities. He also notes that competition among leaders to achieve and maintain status may promote other developments, such as agricultural intensification, warfare, or increased trade, which may then attract population to an area. Braun and Plog (1982) discuss interregional economic intensification and integration through the development of exchange networks, and note that population may be attracted to the major nodes in such systems.

Factors likely to have affected intrinsic rates of population change include the general state of the population's nutrition and health (Frisch 1978; Wetterstrom 1976). The occurrence of nutritional and disease stresses can be inferred from skeletal material (Palkovich 1980). The relatively small number of burials from the Dolores area makes this approach of secondary usefulness, even though the existing materials do yield valuable information (Wiener 1984; Stodder 1985). Modeling of variation in food resource supply (primarily of agricultural yields) will have to be relied on for estimates of whether food shortages that could not be buffered by storage or other mechanisms are likely to have occurred.

Because most preindustrial societies have been characterized by very low rates of population increase (Cowgill 1975a, 1975b), and Malthusian controls appear seldom to have operated, it can be inferred that most prehistoric populations had some kind of cultural patterns resulting in population regulation well below the carrying capacity of their sustaining area and technology. This seems especially clear for hunter-gatherer societies (Hassan 1981:160). The adoption of an agriculture-based system, and particularly the development of attempts to intensify agriculture, apparently created in some times and places a demand for additional unskilled labor of the sort that could be provided by children. In such circumstances, larger families and population growth would be expected (Nardi 1981; Hassan 1981:223-224; Stuart and Gauthier 1981:23-24; Lightfoot 1984). This might lead to a positive feedback relationship in which population growth raised costs of meeting resource demand, which favored further intensification, and so forth.

In our situation, increases in population associated with agricultural intensification might be expected, provided it was of the type that would have made children's labor more valuable. It can also be argued that increasing social differentiation may create more statuses, or "niches," which then create a demand for a larger local population so these positions can be kept filled. Reference has already been made to situations in which competing leaders seek by various means to increase the population of their own faction, community, or tribe (Lightfoot 1984). Likewise, a decrease in population may make it difficult for a group to maintain complex kinship or ritual organization, or for leaders to retain political power, which would promote change in these aspects of culture.

Economic Subsystem

This subsystem, which plays a central role in the model, consists of the economic decision structure and the variables associated with it (resource supply, resource demand, resource costs and risks, technology, socioeconomic organization, exchange, resource acquisition/production, and resource processing). Resource supply has already been treated as part of a separate nexus of variables, but it is also considered as participating in the economic subsystem as well. The interaction of resource supply and resource demand is the most powerful determinant of resource costs, although technology, task group organization, and settlement size and location can also affect costs directly.

In developing this aspect of the model, several assumptions were made about: (1) economic goals; and (2) economic decision criteria. Because of the importance of these assumptions, they are discussed in detail in the following paragraphs. These assumptions properly apply to individuals, but, as is commonly done, are generalized to the whole system. In other words, economic goals are held by individuals, and decisions about how to allocate available means to meet these ends are also made by individuals. However, in the modeled system, we assume these goals and decision criteria are widely enough held as shared cultural norms that they can be considered in aggregate as properties of the system. This can be a dangerous assumption, because even in a relatively egalitarian, undifferentiated social and economic system, it is probably unlikely that individuals, roles, groups, and communities had **identical** economic norms. With the development of economic or political status differentiation, almost certainly differences among statuses or groups in economic goals and in access to economic resources, goods, or services would exist. In any case, the assumption of

identity can allow us to model responses expected under such a condition; disparities seen in actual findings may allow us to identify differences in economic behavior that may reflect different economic norms among communities or other social segments.

The goals of the economic subsystem are assumed to be the provision of enough cultural materiel (i.e., food, fuel, clothing, tools, and shelter) to meet predetermined needs. It is assumed land is not a commodity; hence, access to land is subsumed under settlement pattern as a component of the socioeconomic organization.

This assumption of a "satisficer" criterion in the decision-making process (Jochim 1976:6-7; Earle 1980:16) seems appropriate for a relatively undifferentiated society. Maximization as a goal appears to be likely only where economic differentiation and exchange are highly enough developed so that individuals or groups can turn surpluses into goods they did not themselves produce, and hence can raise their standard of living significantly. Upham et al. (1981) and Lightfoot and Feinman (1982) argue from several Southwestern cases that certain individuals or groups were involved in the differential accumulation of wealth as a means of enhancing status, political power, and undoubtedly, economic security. In their example, however, differentials seem quite small, and certainly are so by comparison with truly complex societies. In modeling, the satisficing assumption is used to develop expectations; its adoption does not preclude our finding evidence for economic maximization at some times or in some areas of Dolores Anasazi economics.

Under the satisficing assumption, then, demand for cultural materiel and hence for resources from the environment is presumed to spring from: (1) population size – the needs of the populace for adequate food, fuel, clothing, and shelter; (2) technology – the needs for tools and facilities to obtain and process food and fuel, and to make other material culture items; and (3) social organization – the requirements of the social and ideological systems for items associated with status differentiation, for ritual paraphernalia, and for facilities used for ritual or sociopolitical activities (above and beyond those used for basic housing and storage needs).

Demand can be estimated with aid from the archaeological record, population estimates, environmental reconstructions, and ethnographic analogy. The satisficing assumption implies the general level of use should indicate the general level of demand.

The archaeological record can often provide us with a relatively good list of what resource materials were actually used for food, fuel, material culture, and facilities by the prehistoric inhabitants. Environmental reconstructions and specific ethnographic analogy (from groups occupying closely similar environments) can help fill out the list of what resources were probably used. Estimation of amounts of resources used is more difficult. For imperishable materials (e.g., stone for building and for tools), the archaeological record may provide fairly direct measurements of total actual amounts used (though in calculating demand at any particular time for a given population size, allowance needs to be made for longevity of use and for reuse). For other materials, relative frequencies of use can sometimes be estimated for a series of resources having similar contexts of discard and deposition (e.g., animal bones in trash, charcoal in firepits). For broad classes of resources (e.g., plant foods, animal foods, fuel, wood for building), level of demand can be estimated from ethnographic analogy and from clues in the archaeological record. Proportional demand or desired resource mix can be estimated with the aid of uniform marginal cost analysis (refer to following discussion and to Earle 1980; Christenson 1980, 1981; Hastorf 1980), using the aforementioned list of "culturally acceptable" resources in conjunction with estimates of level of supply (from environmental reconstructions) and level of demand (from estimates of per capita demand and of population size).

The satisficing assumption does not mean that per capita demand for cultural materiel cannot change from time to time or differ from place to place. Rather, it implies that change does not come from a goal of economic maximization per se, but must be explained in a larger systemic context. For example, additional demand for raw materials for manufacture of tools or storage facilities might be engendered by intensification of agriculture in response to increasing costs or risks of farming. Additional demand for ritual paraphernalia or facilities might be generated by increased ceremonial activities, in turn related to agricultural intensification, to resolving stresses generated by higher population density, or to the use of ritual to validate increased status for powerful individuals or groups. Competition among individuals, groups, or societies for status and influence might also generate increased demand for goods to be used in "conspicuous consumption" or to be distributed at festivals designated to recruit supporters. General increases in standard of living and hence demand for resources might also follow technological changes resulting in either increased efficiency in production of food or material culture, or in increased productive capacity per capita or per unit of land.

Decisions about how to apply available means to meet economic goals are assumed to have generally followed a least cost or minimization of effort course (Earle 1980:14; Athens 1977:362) consistent with fulfilling

predetermined demand for resources and material. This strategy is characterized by Christenson (1982:424) as "minimization of input, with a constraint on output." In our model, cost is equated with labor, which is measured or estimated as time expended (Earle 1980:6). Actual energy expenditure would be more appropriate but much more difficult to measure or estimate, except as a conversion from time. Like the others, the least cost assumption is admittedly unrealistic, because the embedding of economic activities in larger social patterns in simple societies is well documented (Polanyi 1957). Nevertheless, the assumption can provide the basis for developing some expectations as to economic behavior, and other possible assumptions are equally if not more unrealistic.

It is also assumed culturally defined economic goals are general enough that several resources can potentially be substituted for one another in meeting these goals. Within a category such as subsistence, the goal will be to obtain adequate calories and nutrients, and a range of food resources will be considered culturally acceptable for meeting the goal. Consequently, different combinations of resources can potentially be used to satisfy the need. What foods were actually on the "culturally approved" list can be estimated from archaeological remains, and reconstructions of past environments can provide information on what was likely to have been available for selection.

The substitutability of resources within general domains (e.g., subsistence, fuel and building timbers, raw materials for stone tools, raw materials for ceramics) makes possible the further assumption that within a general class of resources, least cost decisions as to desired resource mixes can be modeled with the aid of marginal cost theory (Earle 1980; Christenson 1980, 1981). It can be assumed that a mix of resources was chosen so as to obtain the lowest possible uniform marginal cost of exploitation for the aggregate of resources. Marginal cost is the cost of obtaining the last unit of a resource, "the increase in total production cost (input) when output is increased by one unit" (Christenson 1982:421). Under this assumption, low cost resources are exploited until their marginal cost rises to equal the initial cost of exploiting the next most expensive resource, at which time the latter is added to the resource mix. The result is a resource mix in which the marginal costs of each resource used will be more or less equal or uniform across the aggregate of resources exploited to meet the demand for calories, building material, and so forth.

This set of assumptions places emphasis on estimating, in at least a rough way, the costs of obtaining resources from the environment to provide sufficient cultural materiel to meet economic demands, as set by predetermined economic goals. Changes in resource costs can have important effects on the whole sociocultural system through the effects they exert on the socioeconomic subsystem. As demand for resources rises in a given area, the per unit costs of obtaining them can be expected to increase, leading ultimately to the adoption of intensified strategies of resource procurement or production to satisfy demand. This may promote the development or adoption of new technology or new forms of social organization (cf. Earle 1980; Christenson 1980; Athens 1977).

Related to the least cost assumption is the assumption that, to the extent feasible, risk is also to be minimized in meeting economic goals. Risk can be defined as the probability that output from a given economic strategy will be insufficient (Christenson 1982:422-423). Risk derives from variability in the supply of natural resources and in the reliability of various techniques for obtaining these resources. In the Dolores case, the risks most important to the economic system were probably those associated with variability in farming success related to variability in local climate. In these terms, risk can be considered the probability that the caloric needs of a given group of people (ranging from a household to the population of the Dolores area, depending on the level of analysis being undertaken) will not be met by a given agricultural strategy.

As risks rise, farmers can be expected increasingly to employ buffering responses, such as planting increased acreage, diversifying field locations, intensifying their use of the least risky parcels of land, building more storage facilities, increasing their dependence on wild foods, increasing their involvement in exchange networks, or moving to a different but lower risk area. Most of these alternatives would appear to increase subsistence costs. Furthermore, the magnitude of risk (probability of not being able to satisfy basic demand) and the effects of risk on the economic system may increase with increasing resource costs. When costs (labor inputs) are already high, the individual farmer or aggregate of farmers may simply be unable to marshal the time, technology, or organizational arrangements to respond effectively to a change in risk, particularly if this has been brought about by a rapid change in the magnitude or frequency (Jorde 1977) of the resource fluctuations. Consequently, the level of demand relative to supply has an effect on risks because of its effect on costs, and vice versa. A given climatic fluctuation may introduce greater risks if demand for agricultural or other products relative to supply is high than if demand is low.

As Christenson (1982) notes, the complexity of the relationships among risks, costs, and subsistence strategies make the concept of risk a difficult one to isolate

and define operationally, and hence a difficult one to apply in economic modeling. He apparently prefers to treat assessment of risks as one of the factors contributing to determination of the target minimum (satisficing) level of resource output.

For example, if variability in yields per acre are high, more land will have to be planted to avoid risk than if variability is low. Also, higher cost resources may be substituted for lower cost ones if dependence on the former involves greater risk.

Our concern with risk is thus founded on the effects of resource supply fluctuation on basic subsistence demand. This also leads us to expect that the economic strategies for meeting a given level of demand might vary under differing conditions of fluctuation in resource supply. Under a high risk (high fluctuation) scenario, strategies incorporating storage, exchange, or diversification of field locations might be favored. Occasional surpluses would also be generated, which the system would have to discard.

Use of a least cost and low risk assumption in the model does not imply that the actual costs of obtaining resources will always be low or that risks will never be high in a given sociocultural system. When a subsistence economy is intensified, when more resource units are extracted per unit of space (Turner and Doolittle 1978:297), the labor costs per unit of resource are likely to rise (Earle 1980), and to the extent that intensification requires concentration on one or a few of the most productive resources (Christenson 1980, 1981), the system may be placed in greater risk from environmental fluctuation. That is not to say, however, that the resource mix chosen and the technology and organization used will not be the lowest cost, lowest risk ones possible consonant with obtaining or producing the amount of food required to meet demand. Athens (1977) and Stuart and Gauthier (1981) show how attempts to reduce risk in seasonally variable environments by generating food surpluses for storage can lead to demand for more labor to increase production, which in turn can cause population to increase, resulting in a need for more intensification and a trajectory of growth in system size and complexity at the same time the subsistence resource mix is being simplified or niche width (Christenson 1980) reduced. Even in low risk environments, population growth due to other factors (e.g., immigration) could set in motion the same trajectory of intensification and system differentiation; so could other processes that strongly increase resource demand in the face of constraints on supply.

Modeling economic decisions in the fashion just described also provides a way to view economic intensification (or lack of it) as the product of rational and situationally expedient decision making over time, rather than as a long-range system goal, or as the inevitable result of improvements in tools, or of the introduction of cultigens. It also provides a mechanism to account for socioeconomic change without invoking Malthusian scenarios; the perception that resource costs are increasing or decreasing can be seen as the proximate cause of change; this avoids the unrealistic and mechanistic assumption that malnutrition, starvation, or the complete exhaustion of nonsubsistence resources had to occur before change would be forced to take place. This modeling perspective also avoids assuming fuzzily defined "insight" or "foresight" as mechanisms for triggering change and instead provides a clear, if idealized, model of change as a rational response to tangible factors in the economy.

The discussion of the economic subsystem so far has emphasized how the assumed decision structure can produce change in resource mixes and associated acquisition and processing behavior by differential allocation of means to ends in response to cost factors, but it has not considered other ways in which change could originate in or be affected by the economic subsystem. In addition to attempting to achieve least costs in the use of available means, the economic decision structure should favor the invention or adoption (i.e., through cultural borrowing) of means that: (1) decrease costs at a given level of output; or (2) that enable output to be increased beyond levels achievable through existing means; or (3) that enable output to be increased at a rate of cost increase slower than if existing means were used. Christenson (1981) suggests the first type of change, which increases overall efficiency in the system, may occur whether or not change in resource supply/demand relationships occurs. On the other hand, his discussion implies the second and third types of change may only be likely to occur when increasing demand requires increased output. In this type of situation, a change that enables output to increase may be developed or adopted, even if it results in some decrease in total efficiency (i.e., results in an increase in costs per unit output). Changes that can have these effects can be made either in technology or in socioeconomic arrangements.

Turning first to technology, this is a variable in which innovation or borrowing can clearly affect costs in the economic subsystem. As defined here, technology includes: (1) tools and facilities; (2) techniques for acquiring resource materiels; (3) techniques for transforming them into cultural materiel; and (4) the technical information required to successfully use tools, facilities, and techniques to satisfy demand for cultural materiel. Some resource acquisition and processing (e.g., picking and eating raw fruit) does not require tools or facilities, but all resource acquisition and processing requires techniques and knowledge.

All 4 of these components of technology may be a source of technical change through innovation or borrowing. All 4 components of technology may have somewhat different functional interrelationships within the system and these differences may constrain the acceptance or integration of either a diffused or innovated technology. For example, the adoption of a storage technology may be affected if the new kinds of facilities required come into conflict with the existing allocation of space in a household cluster, this allocation being a function of social as well as economic factors. However, the degree to which a technological innovation or borrowing would help solve problems of economic costs or security would affect the likelihood of its overcoming resistance based on conflicts with existing functional relationships. It follows that if economic costs or risks are rising, the rate of trial and acceptance or the rate of technological borrowings or innovations should increase.

With respect to the socioeconomic area, the relationships of supply, demand, and costs can be profoundly affected by the structure of economic task groups, by settlement location, by settlement size, and by intrasystem exchange, both reciprocal and redistributive. Changes in any of these components may provide an effective response to economic needs to increase efficiency or to increase output. Furthermore, because these socioeconomic arrangements usually serve to solve social as well as economic problems, a change in response to social needs may have substantial effects on the economic system. For example, an increase in settlement size, if accomplished by aggregating small dispersed settlements, may substantially affect travel time to various resource loci and at the same time provide new opportunities for intracommunity exchange and for different structuring of task groups. Yet, the proximate cause of the aggregation may not have been these intended economic effects but may instead have been a response to intraregional and interregional hostilities or to problems of the social integration of the community. It is best to view the socioeconomic subsystem from the perspective of both the social and economic problems of the system as a whole.

Social Subsystem

The social subsystem of the model has at its core social organization; it also includes, and shares with the economic subsystem, the components that make up socioeconomic organization. The distinction between social organization on the one hand and socioeconomic organization on the other is heuristic rather than reflective of any "natural" separation. Because socioeconomic organization plays such an important role in this model and because the components included in this construct are likely to have **relatively** clear archaeological expression, this element of the model has received more detailed treatment than has social organization per se. Social organization as a whole is treated in terms of the abstract variables differentiation and integration. One of its **parts** – socioeconomic organization – is drawn out for treatment at a more concrete level of analysis.

Social organization is characterized along the dimensions of social differentiation and integration (Blau 1975). This conceptual structure is flexible enough to serve as framework for a number of kinds of measures of social complexity, and it is also compatible with a number of general theories of sociocultural change.

Differentiation, as the name implies, has to do with the division of society into differing parts – in this case, into roles and subgroups. These divisions have 2 main dimensions – horizontal and vertical (Tainter 1977:331). Horizontal differentiation refers to the numbers of roles and subgroups within a community or society. Proliferation of such divisions may be related to economic division of labor, to ethnic or associational memberships, to kinships or ceremonial structure, or to sociopolitical structures. Vertical differentiation has to do with the extent to which roles and subgroups can be ranked or arranged hierarchically in terms of their access to economic goods, to influence over individuals and groups, to ceremonial power or prerogatives, or to political authority. There is general agreement that change in social differentiation is one of the major processes of sociocultural change (Plog and Bates 1980:389-390). Aspects of social differentiation may be detected and measured with data from the archaeological record of a society in a number of ways; in particular, archaeologists have had success in recognizing differential status, as well as craft specialization and other forms of economic division of labor.

Integration has to do with mechanisms by which social cohesion is maintained, at whatever level, ranging from household through total society. To the extent that differentiation results in the appearance of roles and subgroups having goals different from one another, a potential is created for conflict or confusion. If a society, or a component social group within it, is to maintain a reasonable amount of internal order, or to take collective action, or to defend itself from outside threats, some mechanisms must exist to reinforce common concerns and values, to disseminate the information essential to the successful interaction of different social components, and to resolve conflicts. Such integrating mechanisms can range from informal methods for achieving consensus in small groups, to ceremonies that promulgate and reinforce integrative values and behavior, to formal political structures that allocate group decision-making authority and provide

for centralized conflict resolution and punishment of disruptive behavior.

Changes in social differentiation and integration can occur in response to changes in the economic sector, either because they affect socioeconomic arrangements such as settlement pattern or because of changes in economic security for particular groups or the society as a whole. In the latter case, if the economic system does not adequately buffer the effects of variability in resource supply, the decline in economic security may engender a number of stresses because of increased frequency of physical deprivation, uncertainty over future economic well-being, and trials of new behavior patterns. Such a situation should promote the development of more effective integrative mechanisms, as well as select for successful responses to these problems in the strictly economic sphere.

Another major source of change in social organization is change in population density, especially as it is expressed in the number and size of settlements in the region. As population density increases, the potential for role and intergroup conflict increases, leading to a need for stronger integrative structures; to the extent that these employ ceremonial or political specialists, this process also can contribute to further differentiation, as can the failure of integration and the onset of intergroup feuding or warfare.

Interregional relationships, including warfare, intermarriage, alliances, and external trade, can also affect the complexity of the social organization. Warfare may lead to the development of warrior and war chief roles, or the promotion of these roles to higher levels of status or authority. External trade may provide individuals or groups with a route by which they may escape economic insecurity, and in so doing become differentiated from the food-producing, essentially self sufficient majority.

Whether change in social differentiation and integration can occur as independent developments (from causes lying within the social organization itself) is an open question; this possibility is certainly not ruled out in the model. The more complex the society becomes, the more likely contradictions in the goals of component roles and subgroups will be a source of stresses that can lead to the development of new integrative forms or to further social differentiation. Furthermore, as Flannery (1972) has pointed out, if a role or subgroup is promoted in status to solve a problem, that component will tend to attempt to maintain its status even when the problem has been solved.

Lightfoot (1984) argues that a simple leadership/management hierarchy can develop even in very simple societies as a response to any of a variety of factors that increase the amount of information that must be processed in the society and that create conditions where the adoption of a reliable decision-making mechanism gives the society a selective advantage. These triggering or forcing factors can include population increase, sedentarism, localized highly productive subsistence resources, warfare, social or environmental circumscription, or dependence on exchange. Once leadership is established, a tendency for vertical status differentiation to increase will be promoted by a feedback cycle based on differential advantages that acrue to leaders. In an attempt to maintain or increase their standard of living, access to ceremonial and social perogatives, and so forth, leaders may accumulate and distribute economic surpluses, increase local population by recruiting followers, and initiate interregional exchange to acquire valued goods for redistribution. These processes themselves, in addition to competition engendered among aspiring leaders or between communities, create demands for additional centralized decision making and management and hence promote increased further vertical differentiation. To the extent that communities or societies having greater sociopolitical development can grow at the expense of less-developed societies, or are more effective at meeting external or internal threats to their continued integration, sociopolitical development has a selective advantage. Lightfoot (1984) points out, however, that operation of this developmental cycle often runs counter to "leveling devices" designed to counter status differentiation, and that it may create societal instability by overburdening some subgroups or by promoting overexploitation of resources. Consequently, sociopolitical development is often truncated before it results in major structural transformations of society.

Whatever their source, changes in social organization can result in additional constraints or demands being placed on other aspects of the system. For example, if defensive needs or the formation of larger cooperative work groups or increased intracommunity exchange lead to the formation of larger settlements, some of the costs of resource acquisition may increase because individuals will be residing farther from resource loci. This may have an effect on factors such as resource mix and storage technology which, in turn, might have still other effects on the organization of economic task groups.

In another familiar example, intensification of the subsistence economy, particularly if accomplished by higher labor inputs, may promote an increased or increasingly clear cut division of labor and the development of essential managerial roles even in the presence of strong social or cultural constraints on the development of vertical differentiation. These changes may generate demands for additional cultural materiel to be

used in signifying or validating new statuses; in providing facilities, equipment, or goods to be used by integrative activities or institutions needed to counter the effects of increased differentiation; and in providing goods and equipment for managerial or other integrative specialists no longer producing these items themselves. In addition, as specialization increases, and acquisition of cultural material no longer depends largely on one's own household production, a situation is created in which individuals or groups may improve their standard of living either by producing more of their particular speciality for exchange for a variety of other desired items or by gaining influence or control over the surplus production of others. All of these results lead to increased demands on the economy for the production of cultural materiel, which in turn may lead to further differentiation of society.

Summary of Variables

In the following section, each of the terms used in figure 6.1 is defined and its role in the model briefly indicated. These definitions and relationships are discussed more fully in the preceding text; this section is intended as a compact reference aid. The model's variables, or factors, are grouped in several categories, in accord with the relationships discussed under "Sources of Systemic Change in the General Model." The interareal relationships previously discussed are presented here along with the group of variables with which each is most closely related. An attempt is made to relate these general variables to the Dolores area, the subject of this investigation.

Resource Supply Variables

Resource supply. – Resource supply is determined by the quantities and kinds of resource materials obtainable from the environment. Resource supply is affected by the rates at which supply decreases with use and by the edaphic, biologic, and geological properties of the area, which may vary with climate and the effects of resource use. Resource supply and demand are the major variables affecting resource costs.

Regional climate. – Factors such as temperature and precipitation in the region, including seasonal, interannual, and long-term variability. In the Four Corners region of the Southwest, these types of variability affect the **relative** attractiveness of various areas, e.g., the Dolores area versus the Montezuma Valley versus the Durango area, for settlement or resource acquisition.

Local climate. – In the Dolores area, the most important components of local climate are temperature, precipitation, and patterns of cold air pooling and drainage. Diurnal, seasonal, interannual, and longterm variability of these factors must all be considered. In conjunction with other local environmental factors (e.g., geological properties such as elevation, exposure, slope; edaphic properties such as soil type), local climate affects relative resource potentials of loci within the Dolores area.

Edaphic/biologic properties of area. – Types and distributions of soils, plants, and animals within the Dolores area, with emphasis on the resource potential of these for farming, subsistence hunting and gathering, and acquisition of fuel and resources for material culture and facilities. Edaphic/biologic properties are affected by changes in local climate, by geologic variables including rates of geomorphic processes, and by the direct and indirect effects of human resource use (e.g., depletion, succession initiated by land clearing).

Geologic properties of area. – Bedrock and surficial deposits, physiography, ongoing geomorphic processes—principally erosion and sediment deposition. These properties directly determine supply of resources such as stone for tools and building, and clay and temper for pottery. They indirectly affect edaphic/biologic properties through relationships of the latter to factors such as elevation, slope, exposure, and substrate. In theory, geologic resource materials are subject to depletion; in actuality, most of the geologic raw materials used by prehistoric Dolores area inhabitants occur in quantities large enough so as to be inexhaustible.

Environmental effects of resource use. – Response of the edaphic, biologic, and geologic properties of the area to the direct and indirect effects of growing and collecting plants, hunting animals, and collecting geologic materials. The results of these activities may consist not only of depletion, but of changes in biotic communities or in soil characteristics in the wake of land clearance and timber harvesting.

Population Factors

Population size. – The number of people in the Dolores area at any given time. Changes in population size are determined by intrinsic rates of increase or decrease, as well as by rates of immigration and emigration. Affecting intrinsic rates is the population's state of nutrition and health, which is related to the ability of the economy to provide adequate food, fuel, material culture, and facilities. The economic system's demand for labor, especially for child labor, may also affect rates of population growth. Social differentiation may also have an effect on population size by providing additional roles; increased differentiation may create demands for more people to keep these roles filled. Development of leadership statuses having prospects for upward mobility may promote population growth

through recruitment of followers, especially if competition develops among factions, communities, or societies. Recruitment may include promoting intrinsic increase for a group, as well as encouraging immigration. Population size is an important determinant of demand for cultural materiel, which determines demand for resources.

Population density. – Population size is related, by definition, to population density; density affects the frequency of interpersonal and intergroup contacts and hence affects social organization. By ordering social relations, social organization also affects the population density that can be sustained in an area. Because agriculturalists spend most of their time in settlements, size and number of settlements in a region are important aspects of population density with respect to social organization. As population density increases, patterns of land tenure and access may also have major effects on social organization.

Immigration and emigration. – These factors are defined as the rates of movement into and out of the Dolores area. These rates are affected by conditions in the Dolores area relative to those in adjacent and nearby areas. Conditions thought to be relevant to decisions to emigrate/immigrate include relative economic potential, relative population size, and relative degree of social integration and differentiation in the current versus the considered area. Previous interareal social relationships (or lack of same) established through trade, intermarriage, and ceremonial affiliations, are probably also relevant.

Nutrition and health. – These factors determine the state of physical well-being of the population and are affected by the ability of the economy to provide adequate food, fuel, tools, clothing, and shelter. If nutrition and health fall below minimal levels, it will cause the population to decline, may contribute to the level of stress in society and hence affect social organization, and may contribute to decisions to move to another area, as well as to intrasystem economic change.

Economic Variables

Resource supply. – (Refer to discussion of resource supply variables).

Resource demand. – System requirements for raw materials from the environment are generated by demand for cultural materiel. Resource demand is one of the factors contributing to the determination of economic costs.

Economic costs. – This variable is determined by the costs (in person-days or person-hours as a substitute for actual energy expenditures) of obtaining resource materials and producing cultural material. It includes not only the direct costs of acquiring resources, but the costs of making and maintaining tools and facilities needed to obtain and store resources; costs of learning and transmitting economic and technical information and techniques; and costs of organizing and maintaining economic task groups and managerial personnel. Consequently, the main contributors to economic costs, in addition to resource supply and demand, are technology and socioeconomic organization.

Resource risks. – Risk can be defined as the probability that output from a given resource acquisition/production strategy will be insufficient to meet basic demand. Risk derives from variability through time and space in the supply of resources and, to a lesser extent, from variability in various techniques for obtaining these resources. Risk is related to costs in that the ability to meet demand in the face of a drop in supply may be more difficult if costs of obtaining needed resources are high than if they are low. The necessity to buffer risks may also require use of higher cost resources or organization than if average resource yields could always be relied upon.

Economic decisions. – This variable includes decisions about how much of what resources to acquire and process into cultural materiel, with what technology and what economic task groups. The model assumes decisions are made to select least cost alternatives after considering marginal costs of required acquisition or production and that, for a given producing unit, the goals of production are sufficient supplies of desired cultural material, rather than maximal production of goods to provide "buying power." Underlying these assumptions about economic goals are the expectations that aspirations for a rising standard of living are limited to a considerable degree by weakly developed social differentiation and convertibility of goods and services, and hence by the absence of pervasive use of markets or barter.

Resource acquisition/production. – These variables involve the total amounts of resources acquired (as in hunting and gathering) or produced (as in agriculture or husbandry), as well as the proportional mix of these resources. It is assumed economic decision making of the sort just described will cause the proportional mix of resources chosen to vary in response to variation in resource costs. In the absence of extensive exchange, substitution of resources can occur only within resource categories (e.g., plant foods, animal foods, fuels and building timbers, source materials for stone tools) that permit functional needs to be satisfied in a variety of ways (e.g., corn [*Zea mays*] to take the place of wild seeds as a nutrient source, juniper [*Juniperus* sp.] to

take the place of Douglas-fir [*Pseudotsuga menziesii*] as building material).

Resource processing. – Processing activities are needed to transform acquired or produced resource materials into cultural materiel. Some resource processing will require the organization of economic task groups, and much of it will require the use of tools or facilities, as well as techniques. Some resource material (e.g., fuel wood, some foods) may receive little or no processing before use; the act of producing or acquiring is sufficient to transform it into cultural materiel.

Technology. – This variable is represented by the tools, facilities, and techniques used to acquire and process resource materials into cultural materiel. Not all resource acquisition, production, and processing requires tools or facilities, but all require techniques. The costs of technology include the costs of obtaining materials for tools and facilities, making and maintaining these, and learning techniques. Technological costs are considered part of the resource costs of the system.

Socioeconomic organization. – Those aspects of social organization most directly related to the economy comprise this variable. For the purpose of this model, the components of socioeconomic organization are considered to be economic task group organization, intrasystem exchange, settlement size, and settlement location. The specific form of all these components is constrained by the organizational requirements of resolving social as well as economic problems. Settlement location is a function of social needs to facilitate interaction among social groups, as well as of the need to minimize costs of acquiring resources and of distributing cultural materiel. Socioeconomic organization is affected by economic decisions, and contributes to economic decisions through its effects on resource costs. As part of the total social organization, socioeconomic organization helps generate demands for cultural materiel that go beyond the amounts needed to maintain the population's minimum biological well-being.

Cultural materiel. – Food, fuel, material culture (e.g., clothing, containers, tools, ornaments), and facilities (e.g., houses, storage structures, community assembly structures) comprise the cultural materiel required by the system. The demand for cultural materiel generates demand for resources from the environment; the economy obtains resources and converts them into cultural materiel. In any adapted system, enough food, fuel, equipment, and facilities must be provided to ensure the population's biological survival and continuance; consequently, population size can be seen as setting a minimum level of demand for cultural materiel.

In all human societies, however, some demands that go beyond this abstract minimum are satisfied, and in some, the demand for and supply of cultural materiel goes far beyond the minimum. This permits an increased standard of living for some groups in the society, the support of an "overhead" level of personnel not involved with producing basic items such as food and fuel, and the widespread use of cultural materiel to signify social and ideological arrangements.

The evolution of rising demand for and supply of cultural materiel appears to involve complex relationships among adaptive success, social differentiation and integration, and exchange. For example, economic differentiation and the development of exchange in widely substitutable goods and services (with money providing the extreme example of a substitutable item) permits individuals and groups to increase their standard and security of living by producing more of particular goods and services and then exchanging them for a variety of other goods and services. Without specialization and exchange, their ability to increase their own standard of living would be less because they would have to satisfy their full range of demands by their own production.

Social Variables

Social organization. – Although socioeconomic organization is treated in more detail elsewhere in the model, social organization as a whole can be viewed abstractly along the dimensions of differentiation and integration. Horizontal differentiation refers to the numbers and kinds of social roles and groups present in the society; vertical differentiation refers to the extent to which these components can be ranked in terms of social privilege or access to economic, political, or ceremonial power. Integration refers to mechanisms by which interpersonal or intergroup conflicts are avoided or resolved, by which collective action is achieved, and by which a generally orderly working of social relations is maintained. Increased differentiation (and hence increased demand for integration) is thought to be promoted by economic intensification, including increased division of labor and the rise of economic managers; by increased population density, which increases opportunities for interrole and intergroup conflict and hence favors the emergence of integrative specialists; by increased immigration or exogamy, if this increases ethnic diversity within the society; by increased exchange, to the extent that this favors the emergence of specialists and the signification of social differences; and by some kinds of intersystem relationships, especially warfare. Any of these stresses may also trigger a feedback cycle by promoting establishment of leadership statuses. An emerging leader, in seeking to maintain or promote a privileged status, may engage in

activities that favor further status differentiation. Socioeconomic organization is, of course, a part of social organization but has been distinguished as a separate component in the model because of its role in the economy, its importance in the model, and the likelihood that it will have a greater archaeological expression than will some other aspects of social organization.

Intersystem exchange. – This factor is related to the economic system as well as to the social system because it involves the acquisition or disposition of cultural materiel. In systems of the sort modeled here, foreign exchange may in part or even largely result from demand for items used ceremonially (a probable relationship with social integration) or for use in symbolically validating ceremonial, economic, or political status or influence (a relationship with differentiation). Intersystem exchange may also serve more directly adaptive functions if it involves goods such as foods, tools, or raw materials (e.g., hides) that have clear economic as well as social significance. Intersystem exchange is likely also to function as a mediator and maintainer of intersystem social relationships such as trading partnerships, which can be called on for other purposes, e.g., when individuals or groups desire to travel outside their own territory, are seeking mates, wish to emigrate to a new area, or need food or other basic economic goods in times of adaptive stress. To the extent that the Dolores system was not a political entity and its boundaries were not clearly defined in prehistoric times, external trade is not likely to be sharply distinguished from internal exchange.

In any case, the greater the distances involved, the greater the cost of the exchange and the more likely it is that social rather than utilitarian economic relationships are emphasized in or signified by the exchange. The effect of external trade on social organization is probably proportional to its frequency and the amounts of goods involved. Because it involves more time per unit of goods moved, and has more logistic requirements than does most intrasystem exchange, foreign trade would appear to lend itself to being run by specialists if the amount and frequency of this exchange is high. On the other hand, low volumes of external exchange certainly would not require specialists; the extent to which exchange served to mediate other relationships would also militate against the development of specialization.

Intersystem interaction and warfare. – Movement to new areas by individuals, groups, or populations is a strategy often used to resolve adaptive or social problems. Individual and group travel outside home territories is also documented ethnographically for many groups, as is occasional recourse to neighboring villages or even other ethnic groups for provisions in times of adaptive stress. For these reasons, it is advantageous for individuals and communities to maintain knowledge of adjacent areas and relationships with their inhabitants. The role of exchange in such relationships has been discussed with the preceding variable; archaeological identification of external exchange may provide clues to these relationships, though not all are likely to have had exchange as a component. It also seems likely that feuding or warfare was a possible type of relationship among communities in adjacent areas, especially if population density was high over the whole region and resource supply was fluctuating. In the absence of well-developed polities, hostilities may have been most likely among adjacent settlements, whether or not they were inside or across area boundaries. In any case, warfare, if frequent, destructive, or sustained, is likely to have promoted differentiation of the role of warrior, and probably the aggregation of population. If defensive facilities were constructed, this would have placed additional demands on the economy. If war parties were large enough, or the threat to the whole group great enough, the status of war leaders would probably have increased, thereby amplifying the level of political integration during times of hostility and raising the possibility that such leaders would attempt to maintain their authority after the cessation of hostilities. Warfare may also have contributed to the elaboration of ritual and religious ideology, both because this could contribute to greater group integration and because hostilities would raise psychological stresses that ritual might be able to reduce.

OPERATIONALIZING THE MODEL: GENERAL CONSIDERATIONS

Two main problems, or groups of problems, occur with operationalizing any model of a sociocultural system. The first is how hypotheses or expectations about change and continuity are to be derived, given the multivariate, multirelational nature of the model. The second problem is how the model is to be linked with the archaeological record. What properties of the archaeological record represent the abstract variables modeled? What kinds of variation and covariation in the archaeological phenomena indicate significant variation and covariation in and among modeled variables?

The first problem is concerned with the ways in which expectations can be derived from the general model. How can we credibly predict the effects of changes in 1 variable on the states of other related variables? Even though the model is drastically simplified as compared with a real sociocultural system and its environmental context, the model nonetheless has many variables and many possible interrelationships. Therefore, the problem of equifinality (i.e., that the same result can be

produced in several ways, depending on complex chainings of interaction among the variables involved) is a large one. This obviously complicates the task of making predictions.

At least 4 ways of approaching the problem of deriving expectations are considered here. The first is the standard "linear" hypothesis – the "if. . .then" statement linking 2 or at most a few variables in an independent-dependent relationship. An example drawn from the model is "If resource demand increases, resource costs will rise." The model also tells us, however, that this should more properly be stated "If resource demand increases while resource supply, technology, and socioeconomic organization are held constant, resource costs will rise (provided supply is depleted under the level of increased demand that is anticipated)." Most, if not all, other examples that can be drawn from the model show the same characteristics – any given variable can be affected by, and can affect, several others.

This suggests that testing a large number of simple, univariate hypotheses will be very cumbersome and may not provide satisfactory results. This leads us to a second alternative for deriving expectations for testing against the Dolores area data – a computer simulation that could incorporate all or at least many of the model's variables. Although in theory this appears to be the most appropriate way to approach the problem, in practice it poses a number of problems. The first is the lack of other comparably large simulations of whole sociocultural systems, using archaeological data to investigate continuity and change. Examples of this kind of project that could be fairly readily adapted to our needs are lacking; consequently, we would have to pioneer such a large-scale simulation. Futhermore, the immense demands on staff and computer time that this project would entail proved to be beyond the resources of the DAP, given the many other contractually required analyses and reports that had to be produced.

A third alternative is to investigate relationships among domains of related variables. At a DAP modeling seminar held in 1982 (Dean 1983; Lipe et al. 1983) change in 7 major domains of variables was targeted for explanation, and each was assigned to a working group. The variable domains chosen were population size and growth, settlement behavior, exchange, resource mix, technology, resource costs, and social organization viewed as social differentiation and integration. Each of the target groups of variables was to be considered as a dependent variable, and effects on it of the other variables (at least, those indicated by the general model as affecting the target variable) were to be examined. The intent, then, was to use the Dolores area data to arrive at conclusions about the directionality of causation, or at least, influence, among a set of variables considered in highly abstract form. Although some progress was made toward this goal, and these efforts are reflected in some of the presentations in chapters 7 through 15, the time and data demands of this project also proved too great in relation to the many other obligations of the DAP staff. Futhermore, some of the DAP staff involved in this work became concerned that the focus was on the variables, rather than on the Dolores case itself. In other words, the Dolores data was to be disarticulated to better understand the relationships among the variables specific in the general model. The alternative was to focus on the specific trajectory of the Dolores Anasazi sociocultural system through time, and to concentrate work on those variables and relationships that seemed most promising for providing a processual understanding of the systemic changes reflected in the Dolores archaeological record.

Consequently, a fourth approach was considered and eventually adopted. This was to select 2 contrastive weightings of key variables and relationships, and to incorporate these into 2 alternative processual models, each of which might account for the observed trajectory of the Dolores system. Then, the archaeological data could be used to evaluate the 2 specific (as opposed to general) models. The first model assumes as primary an economic system that has stable economic goals, and that articulates population, demand for materiel, and resources in a cost-efficient way. Sociopolitical development is seen as a necessary accompaniment to increased population density and to economic intensification brought about by resource supply/demand imbalances. Climatic variation is seen as creating interregional variations in agricultural productivity and risk that lead to immigration into the Dolores area at certain times, and emigration at others. The second model assumes that under any of a broad range of climatic, economic, and demographic conditions, social variables can become primary in bringing about change. Hence, even low initial levels of status differentiation may bring about competition among individuals or groups, and promote economic intensification, population growth, and sociopolitical development. These models are more fully described in the following section of this chapter, and contrastive expectations are developed for evaluation in chapters 7 through 15.

This fourth approach does not fully resolve the problems of equifinality, but does so better than the first approach suggested – that of attempting to test a large number of specific hypotheses, considered one at a time. This approach is feasible under the time and funding available, which the second, or simulation, approach was not, and it places the emphasis on explaining the Dolores system trajectory in terms of the

interaction of selected variables, rather than the reverse, which characterized the third approach.

The second major problem of operationalization has to do with the relationships between the model, which is an abstract, simplified version of how a kind of sociocultural system is thought to work in general, and the archaeological record, which is composed of the debris and traces of specific acts of human behavior that took place in a specific sociocultural system. Most of this record has to do with the production, use, and discard of cultural materiel, including facilities; cultural materiel, of course, is only one of the many components of the model. The behaviors that produced the archaeological record can be linked to the abstract factors in the model only by chains of inference of varying lengths, but all of them long.

Furthermore, although the archaeological record was created in large part by past sociocultural behavior, it has been subject to geologic and other processes (including both prehistoric and recent human disturbance in some cases) that have removed portions of what was once there and that have altered spatial and quantitative relationships among what remains. We also know this record only from a sample of observations and collections, most of which have been made/acquired with methods of field recording, specimen collection, and specimen analysis that represent our best guess in 1978-1979 as to what data would be most generally useful.

These problems appear large because our modeling effort is ambitious, but they are not different in kind from the problems faced by any archaeologist who wishes to make statements about past culture from the evidence he has obtained from the ground and from the objects he has collected. Yet an increasingly explicit awareness of these problems appears to have stimulated, rather than crushed, the efforts of archaeologists to make sense of the past.

To investigate some of the variables and relationships outlined in the general model, a number of studies of aspects of the Dolores area archaeological record were undertaken in 1982 through 1984. These supporting studies are reported in Petersen and Orcutt (1985) and Blinman et al. (1985). The studies attempted (with varying success) to take into consideration the problems of relevance of the archaeological data to the abstract variables, the problems of sampling and variance introduced by modes of data collection, as well as problems of loss and locational change from postdepositional transformations. More abstract consideration of problems of data relevancy and linking arguments are provided in chapters 7 through 15.

TWO SPECIFIC MODELS OF SOCIOCULTURAL CHANGE IN THE DOLORES AREA, A.D. 600-980

As described in the previous section, 2 narrower, more focused models of change have been developed from the general model. One views economic responses to population and resource imbalances as the driving force in change, and the other sees sociopolitical development as predominant. For convenience of reference, the 2 models are labeled "the economic model" and "the social model." Of course, both areas are functionally interrelated; both economic and social factors are important in each model. The goal, however, is to construct the alternative models in such a way that the relative strength of the constrastive assumptions can be assessed. The approach is designed, therefore, to be a heuristic one that will help sort out the web of cause and effect present in an actual prehistoric sociocultural system.

Below, the basic assumptions and characteristics of each model are briefly described. Following this, some of the contrastive implications of each model that can potentially be examined in the archaeological record are discussed.

The Economic Model

The first model can be characterized as a least cost economic response model, hereafter referred to as the economic model (fig. 6.2). Its basic assumptions are that subsistence intensification and the development of leadership and management hierarchies are responses to economic stress brought on by imbalances between resource supply and population demand. The model also implies that if economic stress lessens or if constraints on lower cost options weaken, then the lower cost options will be pursued. These might include dispersal, subsistence "deintensification," abandonment of expensive facilities, or rejection of managerial superstructures. The subsistence response portion of the model derives largely from work by Earle (1980) and Christenson (1980), while the assumptions about organizational responses overlap somewhat with Stuart and Gauthier's (1981) notion of an "efficient" adaptation.

In this model, systemic change is promoted by population/resource imbalances brought on by an increase in population relative to population size. (Actually, resource demand is the critical factor, but because population is the primary source of resource demand in societies of the type treated here, population can be used directly.) Population increase may result from the movement of people into an area because of its low relative costs or risks, or it may occur as a result of in

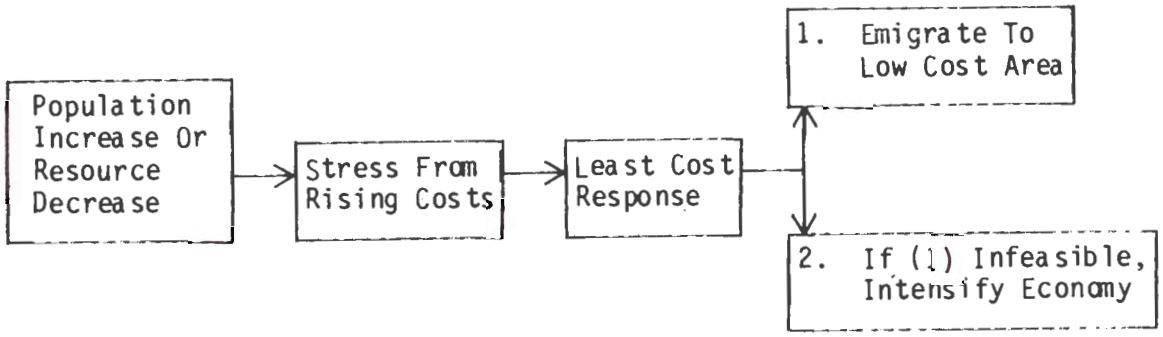

Figure 6.2 – Economic model, part 1.

situ population growth, which presumably would be enhanced by a period of low economic stress. A decrease in resource supply can be brought about by climatic change or by human activities that deplete resources and alter habitats. Increased risk due to greater variability in resource supply may have effects similar, though not identical, to those of decreased resource supply. The system will have to adapt to a greater frequency or magnitude of "bad years" and will have to increase buffering of seasonal or interannual shortfalls.

Given a relative increase in demand due to population increase, or to a decrease in resource supply, the economic model assumes that the population in question will seek a least cost solution to the imbalance. If adjacent areas have more favorable population/resource relationships, i.e., lower resources costs, then the favored or "least cost" solution may be movement. If movement is **not** economically attractive, or is constrained for sociopolitical reasons, the solution will be to intensify the local economy – to meet increased demand by extracting more resources from the local area. For the subsistence economy, this can be modeled with the aid of uniform marginal cost theory, as described by Earle and Christenson (1980).

In the Dolores area, and probably for the Four Corners area in general, subsistence intensification by Anasazi groups will ordinarily mean increased dependence on cultigens, often in combination with pioneer plants that grow in cultivated or abandoned fields (Shuster 1981). The marginal costs for increasing the output of such resources will ordinarily rise much more gradually than will costs for increased harvests of wild plants or animals from the same area.

Agricultural intensification promotes a number of other changes in the sociocultural system (fig. 6.3). Technological responses include greater investment in processing of subsistence resources for cooking and storage, as well as in construction of storage facilities. The tool and container assemblage therefore can be expected to show increased emphasis on production or on processing of cultigens, and on construction of storage and other facilities. Organizational responses to agricultural intensification include decreased mobility, increased interareal exchange, and greater scheduling and management of economic task groups. Assuming that population density also has increased, greater number of people in combination with agricultural intensification will promote greater regulation of access to land and perhaps to other key resources. This may contribute to community aggregation, which reduces conflicts due to overlapping of small catchments and facilitates land use regulation at a community or large kin group level.

These responses create conditions favorable for the growth of more effective leadership and management roles. In this situation, statuses are likely to be reinforced by increased ceremonial validation and by interregional trade in valuable items that serve as status indicators. These processes create an "overhead" cost that might seem incompatible with a "least cost" model. For example, aggregation increases costs by increasing travel time to fields and other resource locations, while the activities associated with maintaining leadership statuses also add costs. On the other hand, the alternatives are presumably even more costly crop failures due to poor scheduling or social conflicts due to increased population density and competition for land or other resources. The model does predict, however, that status elaboration will be minimal and will decline if economic stress and agricultural intensification decline. Even though sociopolitical development is promoted by ecological stress, the relatively low level of investment in this area may make the society vulnerable to adaptive failure in the face of major environmental problems or of competition from a more highly organized society.

The Social Model

The second model can be characterized as a sociopolitical development model, hereafter referred to as the social model (fig. 6.4). It proceeds from different assumptions and implies a different trajectory of change.

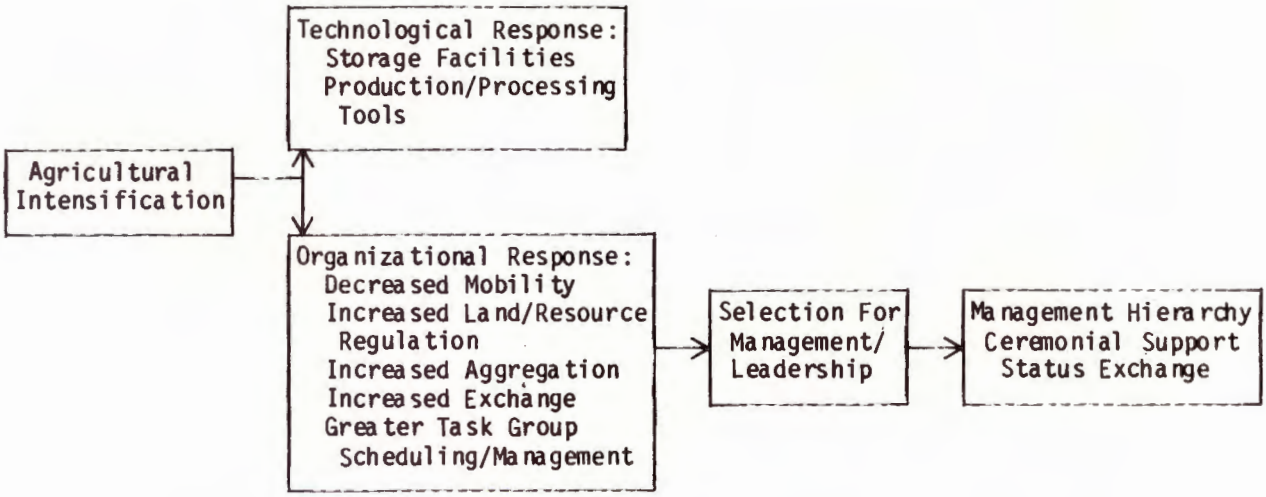

Figure 6.3 - Economic model, part 2.

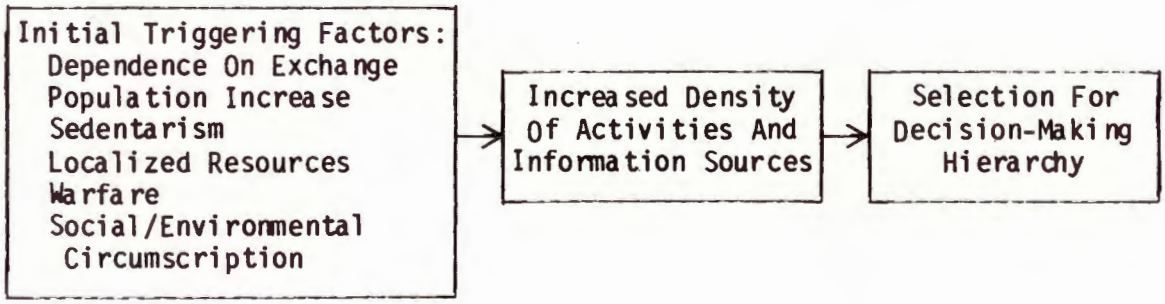

Figure 6.4 - Social model, part 1.

This model is derived largely from recent work by Lightfoot (1984) and has similiarities to the "power" model proposed by Stuart and Gauthier (1981).

Lightfoot offers a model of sociopolitical development that has at its core a feedback cycle that can be initiated in even very simple societies once a simple decision-making hierarchy has emerged. Several conditions can select for such leadership development. These include population increase, sedentarism, warfare, and others. What these conditions have in common is that they increase the density of activities and information in the society and hence select for effective decision making as an alternative to inaction, confusion, or conflict.

Once a simple decision hierarchy appears, a feedback cycle is set in motion (fig. 6.5). To maintain or enhance their positions, leaders recruit followers,and as part of this effort may foster subsistence intensification and the amassing and distribution of surplus foodstuffs. Leadership statuses can also be validated by interregional trade in valuable items and by hosting or promoting certain ceremonies. Competition among potential leaders may intensify these developments. Overall, they lead to higher levels of population density, activity, and information flow, which in turn select for additional management and leadership. Futhermore, groups that successfully attract population and that have the organizational capacity to respond effectively to problems are likely to expand at the expense of neighboring groups. As regional population density increases, this is likely to promote intergroup competition that selects for further sociopolitical development within specific groups.

The model does not assume that societies exist in an economic vacuum, but that one of the results of leadership development is to create surpluses and to increase the flow of energy through the system. Consequently, these groups tend to be fairly well buffered against environmental variability. Nevertheless, because resources play an important role at several points in the feedback cycle (e.g., support of increased populations), the development process should be most

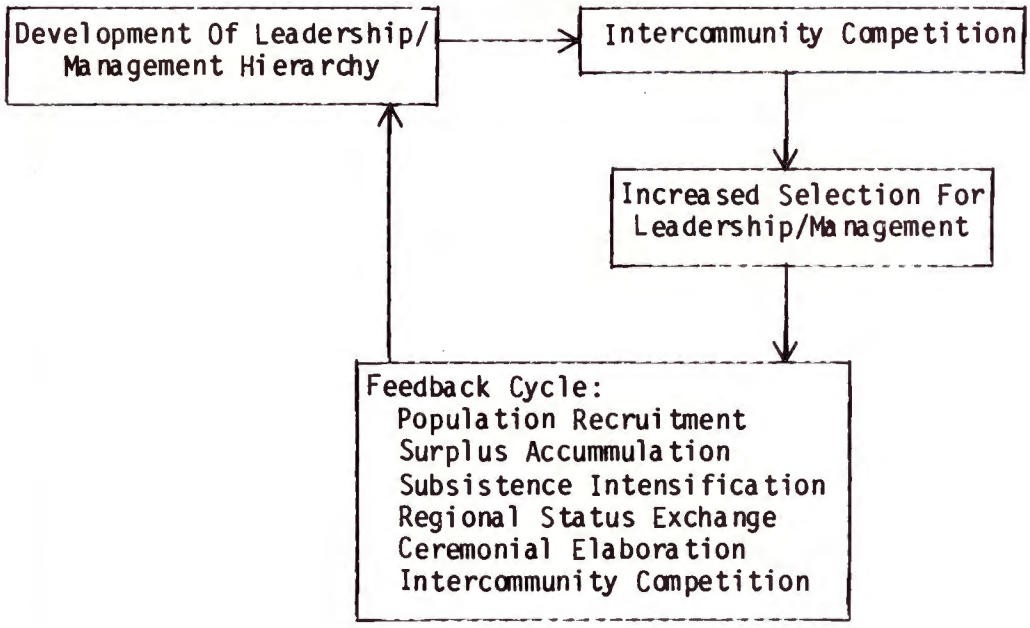

Figure 6.5 – Social model, part 2.

successful in times and places of relative resource abundance and stability. Groups with well-developed managerial hierarchies should also be able to respond effectively to environmental problems. Because of intragroup competition for leadership statuses, however, the hierarchy may be inherently unstable, and prolonged or severe economic problems may exacerbate weaknesses and lead to collapse of the relatively "expensive" superstructure.

Summary

In sum, both the economic and social models account for the development of agricultural intensification and managerial hierarchies, but to different degrees and by different pathways. In the following section, some of the contrasting implications of the 2 models are discussed. A number of these contrasts are only partial; for example, if aggregation **precedes** area-wide population increase and agricultural intensification, this lends support to the social model, but if aggregation **accompanies** population growth and intensification, it could result from either social or economic factors. The set of implications discussed in the following section should provide a basis for assessing the differential success of the models in accounting for Dolores Anasazi sociocultural change.

Implications of the Models

Population Distribution

The economic model implies that population should be distributed so that subsistence **costs** are similar over both the Dolores area and the larger Mesa Verde area of which it is a part. Population density should be **higher** in the more productive parts of the area and **lower** in the more marginal parts (figs. 6.6). Because agriculture appears to have been quantitatively the most important contributor to subsistence during the period of interest, it is assumed that relative agricultural productivity and costs will be a good predictor of relative population density across the area.

The social model implies that sociopolitical mechanisms are strong enough to generate surpluses and foster subsistence intensification within broad ranges of resource productivity. Within the zone of agricultural feasibility (referred to as "the dry-farming belt" by Petersen in the environmental studies chapter of this volume [chap. 4]), relative population densities should have more to do with the success of communities in attracting followers and in absorbing competing settlements than with variations in the agricultural productivity of their catchments (fig. 6.6). For the region as a whole, there should be a great variability in economic costs, with the sociopolitically more developed centers having substantially higher subsistence costs because of their higher population densities, greater degree of aggregation, and higher rates of surplus accumulation and conversion.

Population Movement

Under both models, population movement should conform to the general principles of population distribution (fig. 6.7). The economic model predicts that

Population Distribution	
Economic Model	Social Model
Correlates With Agricultural Productivity And Cost Variation	Within Agricultural Zone, Little Correlation With Agricultural Productivity Or Cost Variation

Figure 6.6 – Population distribution.

Population Movement	
Economic Model	Social Model
Immigration When Dolores Area Has Lower Costs Than Adjacent Areas	Immigration When Dolores Area Has Greater Sociopolitical Development Than Adjacent Areas
Emigration When Dolores Area Has Higher Costs/ Risks Than Adjacent Areas	Emigration With Adaptive Or Sociopolitical Failure In Dolores Area, Or With Greater Sociopolitical Development In Adjacent Area

Figure 6.7 – Population movement.

population movement should equalize the cost and risk differentials among areas – people should move from high cost or high risk areas to lower cost or lower risk areas – although some constraint on movement will be due to investment in facilities and in social relationships. The social model, on the other hand, indicates that within the general zone of adaptive feasibility, population movement should be from areas or communities having a lower degree of sociopolitical development to those having a higher degree. Because larger settlements ordinarily will have higher subsistence costs, this implies that movement will often be from low cost to high cost situations.

Settlement Pattern

Within a given area, the general characteristics of settlement pattern are predicted by the previously discussed principles. Under the economic model, community size should vary with catchment productivity, as should community spacing (fig. 6.8). Settlements and communities will be distributed so as to at least roughly even out subsistence costs over the area, with larger and more closely spaced communities in the more productive areas and smaller, less closely spaced communities in the more marginal areas. The social model, on the other hand, implies that within the zone suitable for agriculture, relative community sizes should fit a hierarchy determined by degree of sociopolitical development and that there should be regular spacing among communities that occupy central roles in competing sociopolitical systems (fig. 6.8).

Aggregation

Because aggregation generally increases the costs of subsistence by increasing travel time to fields and other resource locations, the economic model predicts the system will "attempt" to maintain a dispersed settlement pattern under most conditions of low population density (fig. 6.9). Exceptions might occur if several critical resources have spatially uncorrelated locations. With increasing population density, aggregation may be favored as a solution to conflicts created by catchment overlap and access to resources distant from the settlement. Aggregation may also be a component in systems of increased social control, and hence may be favored

Settlement Pattern	
Economic Model	**Social Model**
Community Size Varies With Catchment Productivity (Uniform Costs Among Communities)	Community Size Hierarchy Within Agricultural Zone; Size Not Predictable From Catchment Productivity Costs
Community Spacing A Function Of Agriculutural Resource Distribution	Community Spacing Regular; Based On Competition

Figure 6.8 – Settlement pattern.

Aggregation	
Economic Model	**Social Model**
Correlates With Population Density, Agricultural Intensification, High Costs/Risks In Time And Space	Correlates With Leadership Development; May Precede Increased Population Density And Agricultural Intensification

Figure 6.9 – Aggregation.

by the need for greater organization and conflict resolution fostered by increased population density, agricultural intensification, and high subsistence costs or risks. In the Dolores area, where both land and water are relatively abundant and widely distributed, we would expect the system to aggregate "reluctantly" and only in association with or following substantial increases in population, agricultural intensification, and economic costs and risks.

Under the social model, aggregation is an aspect of the successful development of leadership and recruitment of followers (fig. 6.9). Consequently, it may precede, or at least be uncorrelated with, the rate of population increase and the degree of agricultural intensification.

Sociopolitical Development

In both models, sociopolitical development should be expressed archaeologically by the development of settlement size hierarchies within the sphere of influence of a particular sociopolitical unit (fig. 6.10). Architectural differentiation should also demarcate ceremonial, administrative, or residential locations associated with leadership and management functions. Under the economic model, the expression of settlement hierarchies should be more influenced by local resource relationships than under the social model.

The economic model would also lead us to expect an ethic of egalitarianism would be maintained as long as possible even when some form of greater managerial control was adopted. This would be consistent with keeping "overhead" costs low and probably with maintenance of individual options to solve economic or social problems by relocating. Consequently, both settlement and architectural expressions of hierarchy should be more weakly expressed if the assumptions of the economic model apply rather than those of the social model. The economic model therefore implies that leaders would be likely to exercise control indirectly, perhaps through manipulating ceremonial sanctions, and that leaders might be expected to eschew higher standards of living and visible trappings of status.

The social model, on the other hand, implies the development of more direct and overt forms of leadership. If the assumptions of this model apply, administrative facilities are more likely to appear, and leaders would be more likely to possess large residences and to control exotic manufactured or imported goods. Another contrasting implication of the 2 models is that under the

Sociopolitical Development	
Economic Model	Social Model
Expressed In Community Size Hierarchy And Intracommunity Architectural Differentiation	Expressed In Community Size Hierarchy And Intracommunity Architectural Differentiation
Leadership Status Poorly Marked; Few Status Indicators	Leadership Status Well Marked; Abundant Status Indicators
Accompanies Or Follows Increased Population Density, Aggregation, Agricultural Intensification	Precedes Or Accompanies Increased Population Density, Aggregation, Agricultural Intensification

Figure 6.10 – Sociopolitical development.

economic model, archaeological expression of increased managerial hierarchy should accompany or follow increases in population density, aggregation, agricultural intensification, and economic costs and risks. However, the social model implies these expressions of sociopolitical development should precede or accompany the appearance of some of these factors. They might also be more strongly expressed in the absence of severe economic uncertainty or risk.

Agricultural Intensification

This refers to the use of agriculture to increase the output of food from a given area. Above rather low levels of demand, the costs of increasing food output by agriculture can be expected to rise less rapidly than the costs of increasing the exploitation of wild plants and animals. Consequently, as output continues to increase, agriculture should contribute an increasingly larger proportion of the diet. As the subsistence system's marginal costs rise, however, additional types of wild plants and animals heretofore too "expensive" to exploit may be added to the subsistence mix. Therefore, the number of food sources used may increase, even though nonagricultural elements comprise an increasingly small proportion of the diet. Provision of essential nutrients and a desire for taste variety may also contribute to the maintenance of subsistence variety.

The economic model implies that agricultural intensification will correlate closely with both population change and with the costs of exploiting wild food sources (fig. 6.11). Agricultural intensification should also increase with aggregation because wild plant and animal sources should be rapidly depleted in the vicinity of large settlements. Intensified agriculture will ordinarily require increased management and scheduling and it may also promote aggregation to the extent that this is associated with development of a higher order of social control.

The social model implies that agricultural intensification will be undertaken as a way of developing a reliable surplus that can be controlled by leaders and as a way of supporting community growth (fig. 6.11). It should thus correlate with aggregation and with evidence of growth in leadership hierarchies. It will not necessarily correlate with regional population density or with the costs of wild foods.

Storage

Under the economic model, increased storage is to be expected as agriculture is intensified, so that the seasonal surplus can be distributed across other seasons (fig. 6.12). Increased storage can also serve to buffer climatic variability that affects crop production. Consequently, storage should increase in times or places of high agricultural risk or when costs vary substantially from one year to the next. Storage should be managed by agricultural production units (ordinarily households or small groups of households) and little variability in storage within or between communities should occur, except as predicted by the distribution of agricultural intensification and subsistence risk.

The social model implies that storage increase is associated with the creation of food surpluses for disposition by leaders (fig. 6.12). This can serve to increase buffering of climatic variability, but also plays a role in competition for followers among emerging leaders

Agricultural Intensification	
Economic Model	Social Model
Correlates With Population Increase Or Resource Decrease (Rising Costs Of Nonagricultural Resources)	Correlates With Socio-Political Development; May Be Independent Of Population/Resource Relationships

Figure 6.11 – Agricultural intensification.

Storage	
Economic Model	Social Model
Correlates With Agricultural Intensification And With Times/Places Of High Costs And Risks	Correlates With Socio-political Development; Related To Surplus Accummulation; May Be Enhanced By Times/Places Of Low Costs/Risks

Figure 6.12 – Storage.

within a community or between communities. Consequently, storage volume should be greatest at the leading settlements within a sociopolitical sphere and should also be highest within the communities at residences, administrative facilities, or ceremonial facilities associated with leaders. Storage volume should not vary directly with the level of agricultural intensification and risks, and storage volume may actually be greatest in times of low costs and risks when abundant crops facilitate surplus accumulation.

Exchange

The economic model implies that exchange serves to even out variability in the distribution of useful commodities within and between regions (fig. 6.13). Furthermore, it functions to establish and maintain networks of social relationships adaptive because they play a role in providing mates and may furnish individuals or groups with economic support or even a place to resettle during times of hardship. If we also assume that egalitarian organization, or at least the appearance of egalitarianism, is low cost, then the economic model implies that exchange needs will be met largely by a network of trading partnerships manned by individuals at the same status or sociopolitical level. This should result in a relatively uniform distribution of exchanged goods within and among communities. It also implies that there will be relatively little traffic in exotic items for use as status markers and that these will be rare and not differentially distributed in the archaeological record.

The social model implies that exchange will be used as a path to leadership, so that both commodity and status exchange will tend to come under control of a leadership hierarchy or will be used by competing leaders (fig. 6.13). The model also implies that overt status differentiation is likely to emerge early in the process of sociopolitical development and hence that exotic items will be relatively abundant. It also implies that these should be differentially distributed in the archaeological record, possibly in high-status residences or in ceremonial contexts that function to enhance leadership. Such goods should certainly demarcate the burials of high-status individuals.

Exchange	
Economic Model	**Social Model**
Varies With Agricultural Intensification And Subsistence Risks	Varies With Sociopolitical Development
Relatively Uniform Distribution Of Trade Items Within and Among Communities	Relatively Nonuniform Distribution Of Trade Items Within And Among Communities
Exotic Items Rare: Randomly Distributed Or Associated With Ceremonial Contexts	Exotic Items Abundant In Leadership Burials/Residences Or Ceremonial Contexts

Figure 6.13 – Exchange.

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Chapter 7

RESOURCE STUDIES

Kenneth Lee Petersen

INTRODUCTION[1]

During the main Anasazi occupation of the Dolores River valley (A.D. 600 to sometime after A.D. 950), changes in settlement types and patterns, in facilities, in artifact types, and in regional population size occurred. One goal of the DAP is to describe and explain these social-cultural patterns.

Archaeological investigations by the DAP were guided by a general research design (Kane et al. 1983). The 5 problem domains outlined in the general research design include a number of specific questions concerning prehistoric adaptations and social organization during specific time periods in the Dolores Project area. Problem Domain 5 (Cultural Process) is designed to examine the subject matter of all the other domains in a dynamic framework (i.e., to examine change through time).

To address Problem Domain 5, a model of cultural change and continuity in the project area has been proposed (chap. 6). This model incorporates a systems approach in which only the variables most relevant to understanding and charting change in the area are included. These variables constitute only a small proportion of the total number of variables involved in a natural system (cf. Odum 1971). In a system such as the one modeled here, changes in one variable may cause changes in other variables that show the pathways by which variables interact. From this network, expectations can be generated about the relationship between changes in individual variables (or components) and changes in the rest of the system.

The DAP model proposed by Lipe (chap. 6) emphasizes 4 classes of variables related to resource supply, population, economy, and the social system. Resource supply is modeled as being dependent on regional climate, local climate, edaphic/biologic properties of the area, geologic properties of the area, and environmental effects of resource use. In addition to its dependent role, resource supply is also one of the factors affecting economic variables, including economic cost (direct relationship), economic decisions (indirect relationship through cost), and resource acquisition (indirect relationship through decisions).

Region-wide environmental and social changes, as well as changes initiated within the Dolores area proper, could have affected the Dolores Anasazi system through the movement of population or resources into or out of the area. Such influences could change relationships among variables within the Dolores system itself. As the DAP modeling studies progressed, they have focused increasingly on the economic and social subsystems as well as on interregional relationships as sources of change in the Dolores system.

From the general model, 2 narrower, more focused submodels of the source of change have been developed: the economic submodel and the sociopolitical submodel. The economic submodel views economic response to population demands and resource imbalance as the driving force in change, while the sociopolitical submodel views sociopolitical development as predominant (chap. 6). Both undoubtedly are interrelated, but these submodels have been developed to assess the relative strengths of these 2 sources of change. The focus of this chapter is the analysis of change in resource supply and resource mix in light of the economic submodel.

RESOURCE SUPPLY AND DEMAND

Modeling prehistoric resource supply provides a means of organizing the various components envisioned or detected in the paleoenvironmental system. Anasazi resource supply can be reconstructed on 2 different levels (Dean 1978): at the systemic level, resource supply is reconstructed through knowledge of the components of

[1]Portions of this chapter first appeared in a paper delivered at the 50th Annual Meeting of the Society for American Archaeology, Denver (Neusius and Matthews 1985).

the present-day ecosystem and of the relationships between those components; at the analytic level, it is reconstructed by examining the archaeological and fossil records to obtain information about the various components of the paleo-ecosystem and their interactions.

In the reconstruction of resource supply, it is assumed that the prevailing environmental conditions limit the number of people that can be sustained by a corn agriculture subsistence system. Therefore, reconstruction of past environmental conditions is important in understanding the effects of resource supply on the system, as outlined in the DAP general model (chap. 6). Pollen analysis of Sagehen Flats marsh sediments (located near the center of the project area) dating to the early A.D. 600's indicates that corn agriculture was underway and that the vegetational mosaic of pinyon-juniper-oak-sagebrush was indistinguishable from that of the early A.D. 1900's (Petersen 1985a). Regional reconstruction based on pollen records from the La Plata Mountains shows that the climate from about A.D. 800 to 1000 was drier than at present, which fostered a slight expansion of sagebrush at the expense of other woodland species (pinyon, juniper, and oak) (Petersen 1984a, 1985a, 1985b, 1985c, and chap. 4, sect. 6). Resource supply for the Dolores Anasazi may have been affected only minimally by large-scale climatic and vegetational change, since the kinds of plants and animals would have remained the same, although their distributions might have shifted. Native flora and fauna may have been influenced more dramatically by cultural factors affecting the environment than by changes in the climate (Petersen et al. 1985).

The demand for corn and other crops is strongly related to population size. As the population grows, more natural vegetation must be cleared for the planting of domestic crops. Agriculture disrupts the natural climax vegetation through clearing, and the cultivated area is opened to invasion by weedy plant species. The greater the agricultural activity, the more widespread the disturbance to the natural ecosystem. Beginning in the early to middle A.D. 800's, the human population in the project area appears to have dramatically increased, and in the A.D. 870's, population growth peaked (Schlanger 1983, and chap. 8). The presence of village complexes indicates the population was aggregating within defined communities (Kane 1984). One response to the increase in population and aggregation was adoption of an economic strategy of agricultural intensification to meet the increased energy needs of the growing population (Lipe 1983, Orcutt 1985a, 1985b).

During the late A.D. 800's to the early A.D. 900's, the project area came under increasingly severe climatic stress in the form of periodic, consecutive seasons of shortened frost-free period and decreased precipitation (Orcutt 1985a; Petersen 1984b, 1985d, and chap. 4, sect. 6). Although the prehistoric population appears to have decreased during this time and never again increased in the project area (Schlanger, chap. 8), agricultural intensification is believed to have remained the major economic strategy, but was used for the production of surplus foodstuffs that were stored as a buffer against low-yield harvests (Orcutt 1985b).

RESOURCE MIX

Against the general framework of changing population and changing climate, modeling changes in resource supply and demand and then testing for changes in resource mix by examining the floral and faunal remains recovered through excavation is possible. The mix of food resources used by the Dolores Anasazi has been estimated from the analysis of large quantities of floral and faunal remains collected from project area sites. These data also provide some basis for evaluating the general model and the economic and sociopolitical submodels. Specifically, the economic submodel assumes that least-cost decisionmaking guided the use of resources, while the sociopolitical submodel expects the fit between resource mix and cost to be less than perfect because of social factors. The goal in this section is to begin the process of evaluating the Dolores floral and faunal data in terms of the economic submodel.

One prediction of least-cost models, similar to predictions of the economic submodel presented by Lipe in chapter 6, is that agricultural intensification will occur in response to population growth and aggregation because intensification is an efficient way to meet the increased demand for food (e.g., Christenson 1980). Given the marked changes in population size and aggregation discussed by Schlanger (chap. 8), the degree of agricultural intensification is expected to vary at different times during the Dolores sequence. The temporal and spatial variability in resource supply outlined by Petersen (chap. 4, sect. 6) and Kohler et al. (chap. 9) also should reflect agricultural intensification if the economic submodel is essentially correct. On the other hand, social causes should be sought when the reconstructions of supply and demand are not sufficient explanations for the variability in this aspect of resource mix.

In the following sections, the assumptions regarding and the expectations for agricultural intensification will be discussed. Next, the evidence for use of animals and plants will be presented, and finally, the extent to which the data fit the predictions will be discussed.

Definitions, Assumptions, and Expectations

The subsistence economy of the Dolores Anasazi is conceived as having 3 general components (fig. 7.1): agriculture, wild plant gathering, and game procurement. This kind of mixed economy is well documented in the Southwest (Plog 1979; Cordell 1979), and is suggested in the Dolores record for the entire Anasazi sequence. Change in the relative importance of these 3 components is expected to be associated with agricultural intensification.

Agricultural strategies in the prehistoric Southwest generally involved more than the cultivation of corn, beans, and squash (Ford 1984; Shuster 1981; Bye and Shuster 1984; Winter 1974; Wetterstrom 1976). Pioneer plants, which in climax communities occur in low numbers and in scattered populations, can maintain dense stands in an agricultural field either actively being cultivated or in the early stages of fallow (Ford 1984:128). Encouraging and harvesting pioneer plant populations in agricultural fields increases the primary productivity of a field under cultivation, increases the predictability of yield, and enhances the nutritional basis of agriculturalists (Ford 1984:137). Thus, use of pioneer plants is viewed as part of the agricultural system.

Documenting this secondary aspect of the agricultural system is difficult, because the pioneer species recovered through excavation might have been collected from areas other than gardens or might have occurred in agricultural fields but were not intentionally harvested (Leonard 1985). However, given what can be learned from the ethnographic record (e.g., Ford 1968), it seems unwise to limit the definition of agriculture to the cultivation of non-native domesticates (Matthews 1985a, 1985b, 1985c).

Garden hunting, i.e., the harvesting of the animal biomass in the vicinity of fields and gardens (Emslie 1981; Linares 1976; Neusius 1984; Seme' 1984), also might be considered 1 component of an "agricultural complex." This has been suggested by some authors (Bye and Shuster 1984). However, if agriculture is defined to include faunal procurement, the floral and faunal data would have to be summarized into a single measure for agricultural production. Deriving such a measure would be difficult, because of the vastly different sampling strategies used to collect floral and faunal materials, and because of problems in deriving caloric estimates. Thus, in the present study, garden hunting is viewed as a type of game procurement strategy that is a separate entity embedded in agricultural strategies, rather than as an agricultural strategy per se. All other game procurement strategies, including large game procurement, are considered together in this chapter.

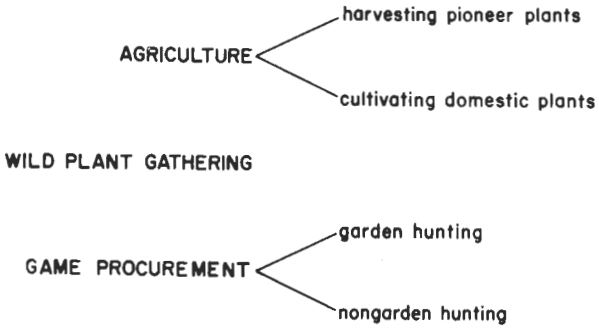

Figure 7.1 – The three primary components of Anasazi food sources and their subsets.

Although wild plant gathering could include collection of wood resources as well as of edible wild plants, wood resources are not considered in the analyses presented in this chapter (however, they are discussed in Kohler et al. [1984], and in chap. 4, sect. 2). The wild plants considered here do not benefit from disturbance, and most are perennials rather than annuals. All of them are sources of food.

Relative reliance on agriculture can be measured against wild plant gathering or against game procurement, and it is assumed that relative reliance mirrors intensification. Here, agricultural intensification refers to practices that increase expenditure of labor on crop maintenance, such as shortening the fallow, planting larger areas, and planting or exploiting a greater variety of plants. Because a greater expenditure of energy is required on agricultural production, it is assumed that the returns are higher and that this will be reflected in an increase in agricultural subsistence remains as compared to wild plant and faunal remains. Thus, this relative reliance can be used as a proxy measure of agricultural intensification.

The study presented here concentrates primarily on temporal variability in agricultural intensification. With a few exceptions, changes in resource supply and population are not evaluated for the project area for each time period, but a brief outline of these variables is provided. It is assumed that resource supply generally was abundant and conditions for agriculture generally were favorable throughout the Dolores sequence until approximately A.D. 880. At this time (Period 5), a combination of drought followed by a shortening of the growing season impacted resource supply. One critical resource during this period is arable land (Petersen, chap. 4, sect. 5); this and more subtle issues, such as the Anasazi impact on the landscape (Petersen et al. 1985), are not considered here. With regard to change in population, the project area was sparsely inhabited during Period 1 (A.D. 600-720). During Period 2 (A.D. 720-800) more sites were present and they covered a

larger portion of the project area, but sites remained small. Population continued to grow through Period 3 (A.D. 800-840), with a sharp increase during Period 4 (A.D. 840-880). Population began to decline during Period 5 (A.D. 880-920), and by Period 6 (A.D. 920-980) it was very low.

The specific expectations derived from this background and that provided in the other chapters in this volume are summarized in figure 7.2. Although a single line is shown for the relative reliance measures in figure 7.2, the measure is not a combined measure but represents each resource separately (i.e., wild plants or nongarden game). Generally, the degree of reliance on agricultural strategies and on garden hunting is believed to have been dependent on population size. Reliance goes up as population increases, and goes down as population decreases. Period 5 is expected to represent something of an exception, with energy expended on agricultural strategies decreasing somewhat, but niche breadth expanding in response to the increased risk involved in agriculture. Such a buffering strategy might involve producing and storing surplus agricultural products; thus, the agricultural and garden hunting curve is not lowered as sharply as might be expected from the population curve (Orcutt 1985a, 1985b, 1985c).

An inverse relationship between reliance on agriculture and garden hunting and reliance on wild plants and nongarden game procurement is predicted. However, once again Period 5 is an exception, with both wild plant gathering and nongarden game procurement rebounding rapidly due to the need to buffer agricultural production. The curves for Period 5 have been constructed to demonstrate this complexity. However, the relative reliance scale in this graph must be interpreted very loosely – it really is not a scale at all, and percentage contribution is not intended. It is simply a graphic presentation of expectation derived for this study.

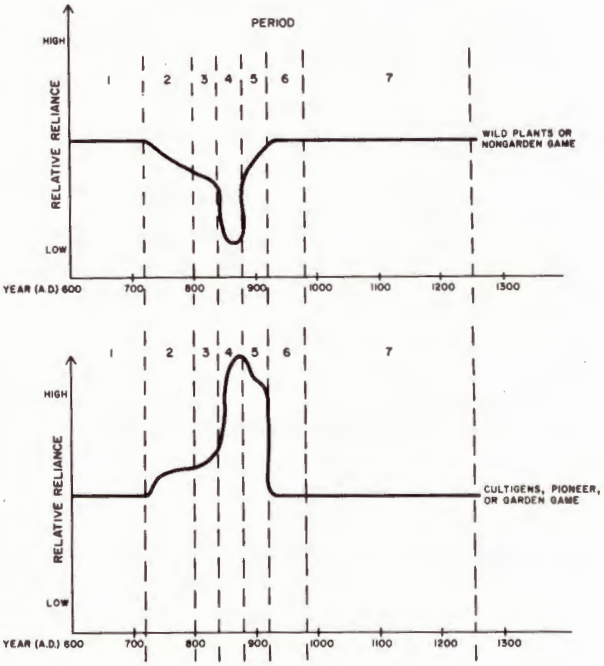

Figure 7.2 – Expectations regarding relative reliance of Dolores Anasazi on two classes of resources through time.

The Evidence for Resource Mix and for Agricultural Intensification

This section summarizes the authors' current understanding of the evidence for some of the expectations outlined above. The data were investigated by plotting the ubiquity of all game, garden game, cultigens, pioneers, and wild plants, by period. These plots provide one means of evaluating the validity of the expectations, even as they raise a variety of additional questions.

Faunal Evidence

Consideration of the faunal data for this chapter centers on 2 questions. First, does the overall role of game procurement appear to have changed; and second, to what extent can any change be attributed to more or less reliance on garden hunting as opposed to other types of game procurement?

Before proceeding, the extent to which different sampling methods and sample size might be biasing the indicators must be considered. With regard to sampling methods, only a small part of the total DAP faunal collection was recovered through flotation or fine water screening, and the data from this assemblage (the microfaunal assemblage) parallel the data from the assemblage recovered in the course of routine excavation, without special sampling or techniques (the macrofaunal assemblage).[2] Therefore, the microfaunal assemblages can be deleted from consideration. This results in at least gross comparability in sampling method, with few repercussions within the data base (for discussion of the representatives of collections obtained through various recovery techniques, see chap. 4, sect. 4, and to Neusius and Gould [1985]).

Ubiquity measures were more difficult to construct for the faunal data than for the botanical data because of the small sample size for some contexts. A straightforward measurement of abundance such as MNI (minimum number of individuals), calculated without regard

[2]For a more thorough discussion of the 2 types of faunal assemblages, refer to chapter 4, section 4.

for the total number of contexts dating to a particular period, does not provide reliable estimates of change in the relative importance of animals if more contexts dating to one period were excavated than contexts dating to other periods. Because of these potential problems with the indiscriminate use of MNI (cf., Grayson 1973, 1978, 1979, 1984), MNI measures were calibrated against general artifact abundance. This approach was chosen because the bones that make up the macrofaunal assemblage usually were collected during the course of excavation, in a manner similar to that used to collect other types of artifacts. Thus, even though the amount of excavation effort varied for the different periods, one can contrast the amount of bone recovered to the amount of artifacts recovered. Gray ware sherds are used here as the measure of artifact abundance because these sherds are both abundant and ubiquitous in Dolores sites. Gray wares also are assumed to be utilitarian in nature and are least likely to be spatially segregated in a manner different from bone. Additionally, if the rate of ceramic breakage and disposal for each person remained relatively constant through time, the rate would provide a relatively stable measure against which faunal MNI might be compared.[3]

Figure 7.3 is a plot of the ratio of bone (MNI) to gray ware sherds. The ratios were obtained by combining the data from all individual elements or episodes that could be assigned to a particular modeling period. Periods 6 and 7 are combined in this analysis because the numbers of elements and episodes assigned to these periods are particularly small. Elements and episodes not assigned to a specific single period were not used except for those with a combined assignment to Periods 6 or 7.

At the onset, it was anticipated that fauna, in relation to overall resource mix, might contribute relatively less during those periods of high population and agricultural intensification. The opposite trend appears to be true in figure 7.3. In addition, the very high contribution of fauna to the resource mix in Period 5 was unexpected.

Faunal MNI in figure 7.3 represent total fauna: no distinction is made between garden game and nongarden game. In figure 7.2, it was predicted nongarden game

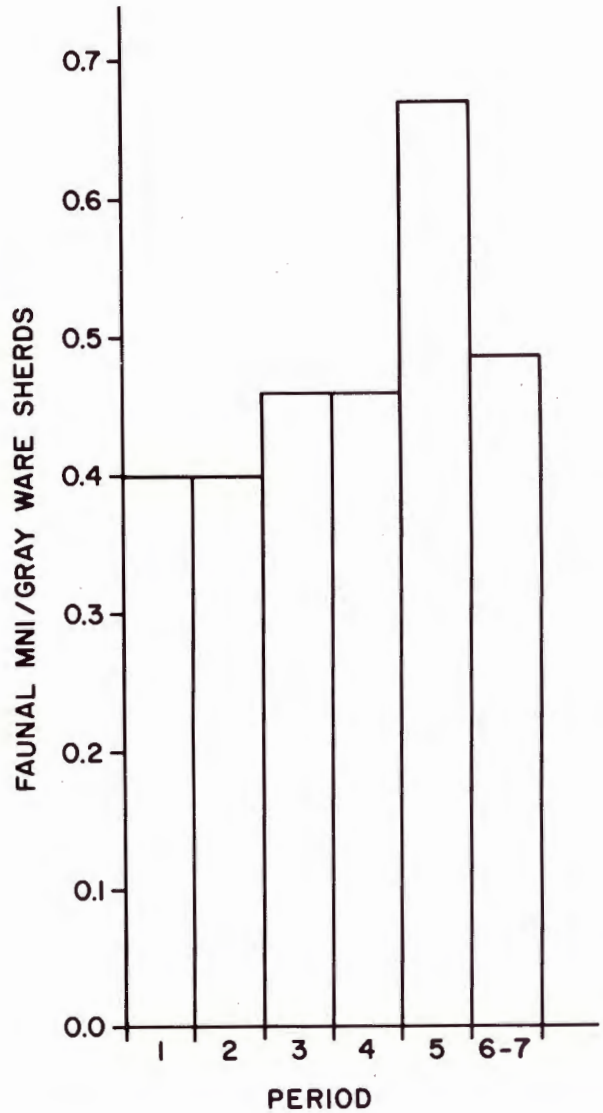

Figure 7.3 – Ratio of bone (MNI) to number of gray ware sherds. Differences between Periods 1, 2, 3, 4, and 6-7 are not significant.

would contribute relatively low amounts to the resource mix in Period 4, while garden game would contribute relatively high amounts. The relative contributions in Period 4 from both garden and nongarden game may balance one another out, and thus the combined contribution of game from both types of hunting strategies to the resource mix might not have changed or might have been slightly lower, as will be discussed later.

During Period 5 the contribution to the resource mix of garden game was modeled as remaining relatively high as the contribution of nongarden game increased (fig. 7.2). This would result in an overall relative increase in the proportion of game in the resource mix.

[3]After the faunal study was completed, it was realized that the argument for using gray ware sherds is valid only if gray ware vessels served the same functions through time and constituted a consistent proportion of the daily-use assemblage. If these conditions are not met (for example, if there was an increased use of decorated wares for some purposes), then bias could be introduced. Therefore, when the botanical study was undertaken, total sherds was used as the ceramic measure. The resulting larger sample size is believed to be more stable, if the assumption that rates of breakage and discard remained relatively constant through time is correct.

As judged by the results in figure 7.3, the high ratio of faunal MNI to gray ware sherds in Period 5 supports this interpretation; however, the relative proportions of garden game and nongarden game may have remained relatively stable from Period 1 through Period 7. This will be discussed in more detail later in this chapter.

These results are dependent on the crucial assumption that gray ware breakage and disposal practices remained relatively stable throughout the time of occupation. To calculate the individual ratios, an SPSS (Statistical Package for the Social Sciences) (Nie et al. 1975), regression program was used to calculate regression lines. The points used to derive each line represent individual temporal elements or episodes at DAP sites. Figure 7.4 shows the regression lines that summarize these relationships. Log-log scales were used to aid in plotting the widely ranging sample sizes. The correlation between MNI and gray ware sherds is significant for all periods, with r values ranging from 0.67659 to 0.87067. Probability levels range from 0.00000 to 0.01143. However, analysis of the residuals and scattergrams suggests the linear fit is less than perfect.

A BMDP (Biomedical Computer Programs, P-Series) (Dixon and Brown 1979) one-way analysis of variance and covariance program was used to compare the intercepts and slopes of these lines. The results tend to confirm the visual impression that the slopes for Periods 1, 2, 3, 4, and 6-7 do not differ significantly (overall $F = 1.4390$; probability $> F < 0.2147$). However, the difference for Period 5 as compared with the others is significant. The slope is derived from the ratio between faunal MNI and gray ware sherds, which is plotted in figure 7.3. Thus, for all periods except Period 5 the slopes are quite similar. Unless evidence suggests breakage and disposal practices for gray wares changed during Period 5, the relative increase in faunal MNI in Period 5 (figure 7.3) could be judged as both real and significant.

However, the high ratio (fig. 7.3) and steep slope (fig. 7.4) for Period 5 might be the result of having combined elements and episodes with very different catchments. Specifically, the Grass Mesa Locality at the northern end of the project area should have been most severely impacted by the climatic deterioration reconstructed for this period, because arable land was in shorter supply here than elsewhere (Orcutt 1985b). The biomass of nongarden game in this locality also might have been higher than elsewhere within the project area. As a result, it might be predicted that there should be a greater reliance on wild plants and nongarden game at sites in this locality.

Therefore, the regression analysis was rerun separating Period 5 elements and episodes into Grass Mesa Locality versus non-Grass Mesa Locality. Somewhat surprisingly, both new regression lines have a reasonably steep slope and both have negative Y-intercepts. Furthermore, the non-Grass Mesa Locality elements and episodes show heavier use of total game than do the Grass Mesa locality elements and episodes. If figure 7.2 is used as the game procurement model, it may be that garden game is the major contributor to fauna in the resource mix during Period 5 at non-Grass Mesa Localities, although this possibility is not explored here. Blinman (chap. 12) found a slight relative increase throughout the project area in the proportions of garden game in well-dated Period 5 contexts interpreted to be refuse. This trend will be discussed more later.

Differences in the Y-intercept of the regression lines in figure 7.4 can be interpreted as relative differences in faunal MNI density. The higher the Y-intercept in figure 7.4, the more faunal individuals represented in relation to gray ware sherds. This Y-intercept does not take into consideration the amount of time represented by the periods. Periods 1, 2, and 6-7 are much longer (i.e., 120, 80, and 330 years, respectively) than Periods 3, 4, and 5 (i.e., 40 years each). The longer the period, the more likely the accumulation of faunal MNI and gray ware sherds. Again, this is dependent on a relatively constant rate of breakage and disposal of gray wares/person. If this was the case, then the effects of changing population and length of time represented in a period are minimized through this measure.

In figure 7.4, the Y-intercepts of the lines do differ significantly between periods ($F = 4.0925$; probability $> F < 0.0017$). Student's t-tests also indicate Period 6-7 differs most significantly from the others in terms of intercept, although the similar difference in the intercept of Periods 1 and 2 as contrasted with the remaining intercepts also would be significant at the 0.10 level.

The differences in both slope and Y-intercept among Periods 1 through 4 are minor (fig. 7.4). Based on the expectation that intensification would be highest in Period 4, it was assumed Period 4 would contrast with the earlier periods by having an even lower Y-intercept as well as a different slope. When the analysis was rerun for 3 gross time periods – pre-A.D. 840, A.D.840-880, and post-A.D. 880 – the middle period, which corresponds to Period 4, has the lowest Y-intercept, which supports the predicted decreases in game use. However, the analysis of variance does not consider either the intercept or the slope of these 3 lines to be significantly different. Nevertheless, the results of earlier community-specific studies (Neusius 1985; Neusius and Gould 1985) also support a drop in the overall use of game during Period 4 when compared to earlier and later periods.

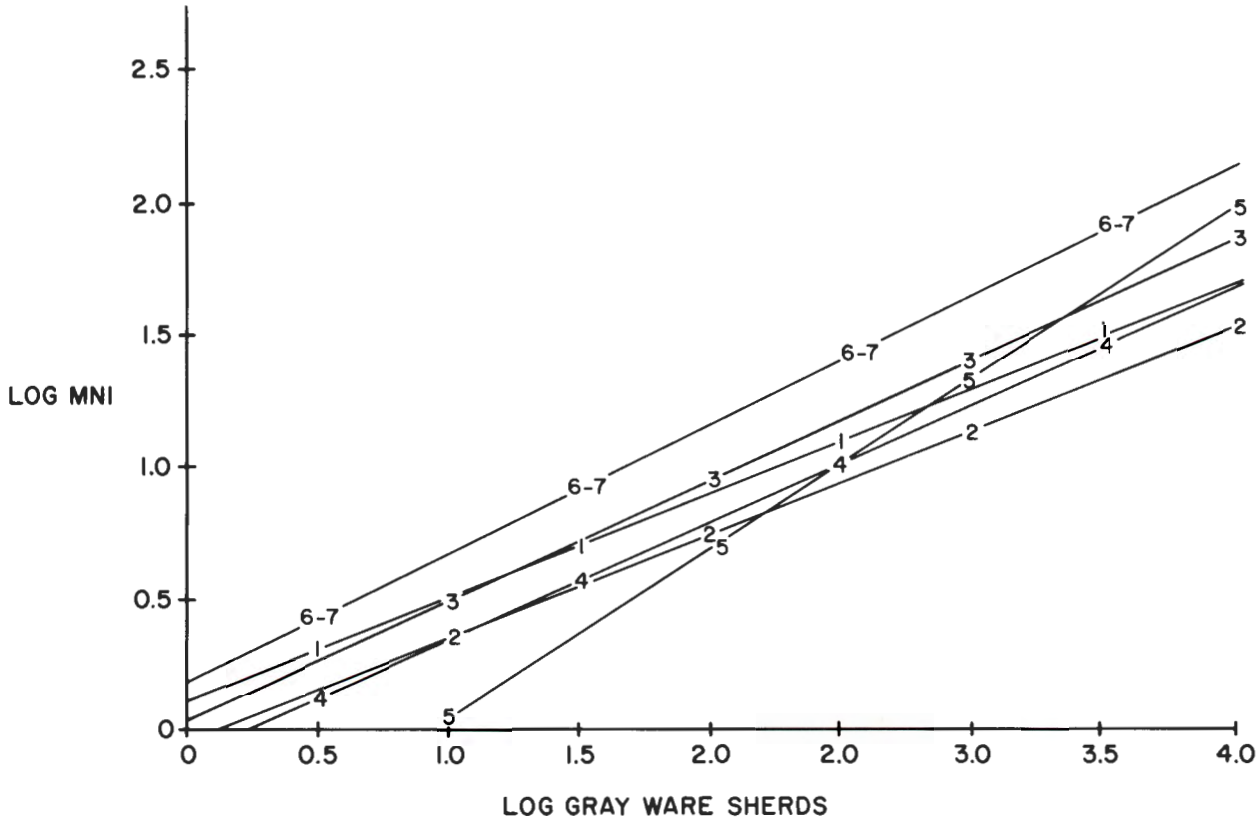

Figure 7.4 – Regression lines resulting from plots of faunal MNI against gray ware sherds for different modeling periods (indicated by numbers 1 through 7). Because of the wide range of sample sizes, plots were done with log scales.

Because of the complexity of figure 7.4, figure 7.5 is provided to show the plot of the Y-intercept against each period. The relative absolute density of faunal MNI when portrayed this way does not take into account the differences in the length of time for each period. In figure 7.5 a steady decline in the relative absolute amount of faunal MNI in relation to gray ware sherds from Periods 1 through 5 seems to occur, and then an increase in Period 6-7. Because Periods 3, 4, and 5 each represent the same length of time, it might be easier to compare these periods and detect any real differences in the Y-intercept (i.e., relative faunal MNI density). But first, the problem of the steeper slope for the Period 5 regression line in figure 7.4 must be addressed.

The rate of breakage and disposal of gray ware sherds/person can be demonstrated to be relatively constant for all periods. If the same rate is accepted, especially for Periods 3, 4, and 5, then an estimate of the relative absolute number of faunal MNI (i.e., the Y-intercept) can be made for Period 5 by determining the coefficient that faunal MNI must be multiplied by to produce a slope equivalent to Periods 3 and 4. In this case, the coefficient is 0.67. Thus, the faunal MNI accumulation rate as compared to sherd deposition in Period 5 is 1.475 (the reciprocal of 0.67) times as rapid as that in Periods 3 and 4 and thus, during Period 5, 1.475 times as many bones should accumulate for every sherd deposited as during Periods 3 and 4. Taking this adjustment into consideration, an estimated Y-intercept can be plotted for Period 5, as shown in figure 7.6. Of course, if evidence showed the rate of sherd deposition per person or per household during Period 5 differed from that during Periods 3 and 4, this approach could be invalidated.

The pattern in figure 7.6 does agree with the expected reduction in faunal MNI between Periods 3 and 4 and with the expected increase between Periods 4 and 5. The changes in Periods 3, 4, and 5 are for periods of equal time lengths. Because these changes in Y-intercepts were measured against gray ware sherd frequency, this approach should avoid the problem of changing population during these times as long as the rate of ceramic breakage and disposal per person did not significantly change during Periods 3, 4, and 5. However, even though the direction of change seems to fit the model presented earlier, the magnitude of change between periods may not be significant.

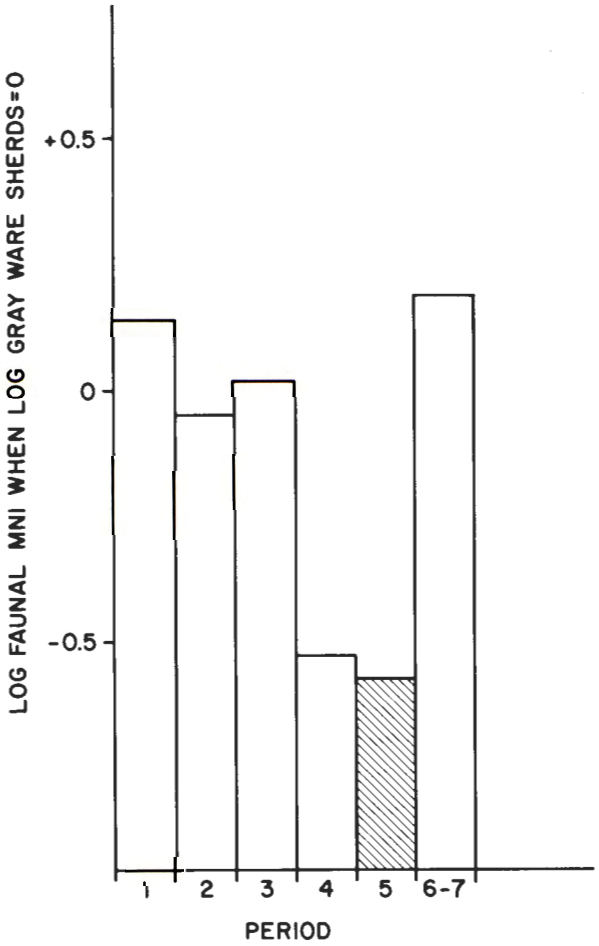

Figure 7.5 – Plot of Y-intercept against modeling period, as shown in figure 7.4. Provides a relative measure of absolute number of bones at sites within a given period. Because Period 5 has a different slope, it is not strictly comparable to the other periods and so is marked by hatching.

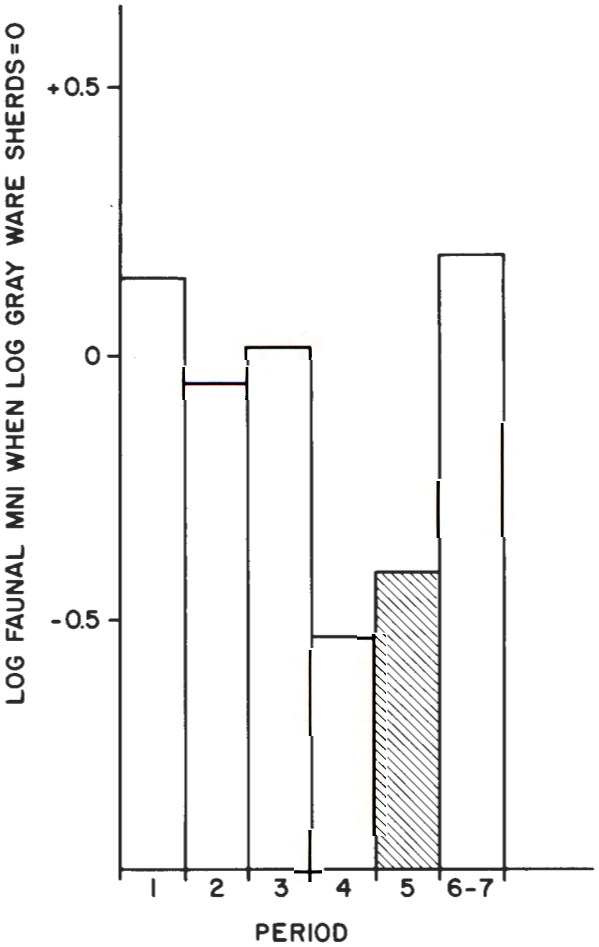

Figure 7.6 – Plot of Y-intercept against modeling period, with an adjustment made for Period 5 (hatched) to make it comparable to the other periods. Provides a relative measure of absolute numbers of bones at sites within a given period.

The types of game procurement strategies employed will not be explored in detail here. However, in earlier studies of Dolores Anasazi communities (Neusius 1985; Neusius and Gould 1985) and in the project-wide faunal data base, the proportion of MNI's from taxa that might represent a garden hunting strategy remains relatively uniform (fig. 7.7). The 96 percent confidence intervals for these proportions overlap in all instances (1 = 0.303 to 0.451; 2 = 0.388 to 0.482; 3 = 0.353 to 0.439; 4 = 0.284 to 0.418; 5 = 0.305 to 0.375; 6 = 0.407 to 0.501; 7 = 0.355 to 0.477). The same can be said for proportions of large mammals.

Using another approach to detect a change in the proportion of meat in the Anasazi diet, Blinman (chap. 12) uses the ratios of nonhuman bone to cooking jar sherds from well-dated, screened refuse collections. Blinman uses cooking jar sherds because he believes that boiling in ceramic vessels would encompass much of the preparation of both meat and cultigens, and therefore the cooking jar breakage and discard rate should produce a relatively stable index in relation to food preparation. If the index is not stable, then Blinman believes the direction of the bias within the index should tend to improve the contrast between cooking jar sherds and animal bones as an index of the reliance on cultigens.

Blinman plots the ratios of nonhuman bone to gray ware cooking jar sherds from screened refuse collections for Periods 1 through 6 (chap. 12, fig. 12.2). Although he uses numbers of bones or bone fragments, rather than MNI, Blinman does calculate the relative contribution of animal size classes (i.e., small mammal and bird, medium mammal, and large mammal), which

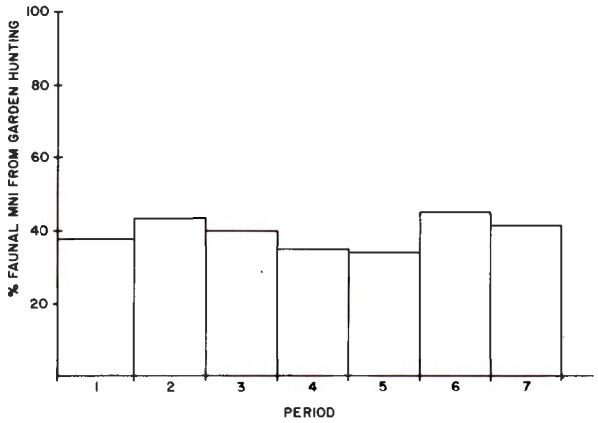

Figure 7.7 – Percentage of garden-type fauna as a proportion of total MNI.

should allow some comparison with figure 7.7 (for instance, the slight peaks in Periods 2 and 6 in figure 7.7 are also evident for small animals in figure 12.2). Refuse collections were chosen to minimize variance within ceramic material from uncontrolled contexts. Also, Blinman believes that vessel form proportions in refuse are most likely to approximate the intensity of vessel use. Screened proveniences were chosen to minimize recovery bias toward either bones or sherds.

Blinman (chap. 12, fig. 12.2) found that the highest bone/sherd ratio occurs in the Period 2 collection, due primarily to the extremely large contribution of small animal bones. The bone/sherd ratio declines in Period 3, with small animal bones continuing to contribute the largest proportion. The bone/sherd ratio declines to the lowest level in Period 4, with small, medium, and large animals contributing roughly equal proportions. An increase in the bone/sherd ratio occurs in Period 5 resulting in a ratio not as high as that for Period 3. The contribution of large mammal bones to the total in Period 5 is slightly less than for the other 2 animal bone groups, which might indicate a renewed emphasis on garden hunting. The bone/sherd ratio for Period 6 is higher than that for Period 5, and the proportion of large mammal peaks.

Blinman (chap. 12) concludes these results are consistent with the interpretation that dietary change accompanied human population increase in the Dolores area. He believes that if cooking jar sherds can be used as a stable proxy of total food consumption, then the reduction in the relative meat protein contribution to the diet during Period 4 is dramatic. This reduction in meat is presumed to be accompanied by an increased consumption of cultigens. However, Blinman notes bias could result in overestimation of the relative decrease in meat consumption. Boiling and soaking associated with cultigen preparation in ceramic vessels is expected to be positively correlated to have no correlation with cultigen preparation, rather than to be negatively correlated. This bias would tend to increase utility of the use of cooking jar sherds as an index of relative reliance on cultigens.

Evidence seems to indicate a change in the relative overall importance of game during the Dolores sequence. A regression analysis was done between faunal MNI and gray ware sherds for different periods. When the bone/sherd ratio (regression slope) is evaluated, only Period 5 is significantly different. This can be interpreted as indicating a greater accumulation of faunal remains (and hence greater relative reliance on animals) during Period 5 than during any of the other periods, or alternatively, that the rate of gray ware sherd deposition was significantly reduced during Period 5.

Differences in the Y-intercept of the regression of bone against sherds can be interpreted as relative differences in the number of faunal MNI in relation to gray ware sherds. Periods 4 and 5 have a much lower relative number of faunal MNI, which seems to support the expectation that a decrease in reliance in total fauna occurred during these periods. However, the difference in the length of each period could affect the MNI count, because more fauna remains could have accumulated during longer periods. On the other hand, the difference between Periods 3 and 4 is marked, even though Periods 3, 4, and 5 are all 40 years in length, which suggests an explanation other than period length must be applied.

The evidence for garden hunting during Periods 4 and 5 is slight or nonexistent. The only clear evidence for a heavy reliance on small animals is for Period 2, based on Blinman's (chap. 12, fig. 12.2) comparison of number of individual specimens of bones and gray ware cooking jars from well-dated, screened refuse collections. Blinman's study of refuse collections also provides the clearest evidence for a shift to a greater reliance on large game during Period 6 (he did not examine Period 7). Such evidence was not found in the present study when examining that portion of the total DAP faunal assemblage that could be assigned to period, possibly because too many different types of contexts were used.

Macrobotanical Evidence

With respect to interpreting the botanical remains, only charred reproductive parts of each taxon, including seeds, fruits, cotyledons,and the cobs, glumes, and cupules of corn, have been considered. The cultigen groups, unless otherwise specified, includes 4 taxa: corn (*Zea mays*), beans (*Phaseolus vulgaris*), squash (*Cucurbita* spp., *C. Pepo*), and gourd (*Lagenaria siceraria*). The

pioneer group includes 21 different taxa, notably pigweed (*Amaranthus* sp.), goosefoot (*Chenopodium* sp.), purslane (*Portulaca* sp.), tansymustard (*Descurainia* sp.), and groundcherry (*Physalis* sp.). The wild plant group includes 23 different taxa representing a variety of berries and seeds (table 7.1).

The poor preservation potential of beans and squash has affected both the composition and the size of the cultigen component in the DAP macrobotanical assemblage. Consumption of many wild plants raw also could have resulted in their low visibility in the archaeological record. These potential problems should be noted but cannot be remedied.

A second set of problems has to do with botanical sampling at the DAP. Large-scale vegetal remains were collected during routine excavation, when condition or quantity suggested to the excavator that collection was warranted; no special excavation techniques or sampling strategies were employed. Small-scale remains were collected through bulk soil, or flotation, sampling. The floatation sampling strategy (Litzinger 1979) emphasized collection of samples from undisturbed feature fills, living surfaces, and midden deposits. The focus on fire-related features in this study stems partly from the fact that both large-scale vegetal remains and small-scale remains were recovered from them.

The combination of sampling strategies also has resulted in an uneven representation among periods, with Period 5 having a substantially larger total sample (tables 7.2, 7.3, and 7.4). Two ways of dealing with this problem have been explored: use of ubiquity indices and comparisons of taxon abundance with total abundance using rank order correlation. Only the ubiquity information will be presented here.

A ubiquity index records the proportions of all samples or contexts in which a given taxon is present. Thus, it records the pervasiveness of a taxon rather than its relative abundance. Highly ubiquitous taxa are assumed to have been relatively important; rare taxa are assumed to have been less important.

Relative reliance on cultigens can be estimated by examining the ubiquity of cultigens in fire-related features. Figure 7.8 shows the percentage of these features that contain cultigens. Ubiquity of cultigens is lowest during Period 1 at 30 percent and quite high during Periods 2 through 6, with the percentage being highest during Period 4 (83.9). During Period 7 only 35.5 percent of these features contain cultigens, which suggests less use of these plants once again. The high ubiquity of cultigens in Period 2 is surprising, but the fact that the cultigens are most pervasive in Periods 4 and 5 is consistent with the expectations generated in this study.

Evidence for the use of pioneer plants parallels that for the cultigen group (fig. 7.9). The ubiquity of pioneers is lowest during Period 1 (35.0 percent), increases during Periods 2 and 3, and is quite high during Periods 4 and 5 (74.2 and 74.8 percent, respectively). Once again, some drop in ubiquity occurs in the Period 6 record, followed by a low in Period 7 early equal to that in Period 1.

When examining the occurrence of wild plants (fig. 7.10), ubiquity indices again indicate relative rarity early in the sequence and an overall increase through time (although Period 2 has a somewhat higher ubiquity index than Period 3), with Periods 4, 5, and 6 having the highest percentage of fire-related features containing wild plants (64.5, 67.9, and 66.7 percent).

The trends in ubiquity are believed to represent real trends in the reliance on these 3 groups of plants. Although not discussed here, the abundance and the diversity measures for each of these groups suggest quite similar trends, and preliminary attempts at rank order comparisons have indicated sample size is not responsible (sample size will be treated in detail later). Studies of community-specific macrobotanical records also support these observations (Matthews 1985a, 1985b, 1985c). Thus, evidence for change in the use of botanical resources exists within the Dolores Anasazi sequence.

In a general sense, use of plants appears to have been relatively low in Period 1, to have increased rather dramatically in Period 2, and to have reached a high or near high in Period 4. In Period 5 the ubiquity of cultigens drops off, while the ubiquity of both pioneer and wild plants remains high. Then, in Period 6, the ubiquity of pioneer plants drops, while wild plant ubiquity remains high. Finally, all reach a low in Period 7 that is about as low as in Period 1. The ubiquity of wild plants does not entirely follow the expected pattern (fig. 7.2). Instead of decreasing in relative importance in Periods 2, 3, and 4, the ubiquity of wild plants increases. However, during Periods 5 and 6 wild plants seem to take on greater relative importance when compared to the decreasing ubiquity of cultigens. The pattern of cultigens does seem to mirror that predicted for reliance on agriculture and garden game hunting. The overall use of plants appears to have been highest during those periods that other evidence suggests would have had the highest demand (Period 4) (Schlanger, chap. 8) and the greatest risk (Period 5) (Petersen, chap. 4, sect. 6).

Changes in wild plant ubiquity through Period 4 generally follow the pattern evident for cultigens and pioneer plants. This is in contradiction to the expectation that wild plant gathering was an alternative strategy

Table 7.1 – Taxa in each general plant group

Cultigen		Pioneer		Wild	
Scientific name	Common name	Scientific name	Common name	Scientific name	Common name
Cucurbitaceae	Gourd family	*Amaranthus* sp.	Pigweed	*Allium* sp.	Wild onion
Cucurbita spp.	Squash	*Chenopodium* sp.	Goosefoot	*Amelanchier* sp.	Serviceberry
C. pepo	Summer Squash	Cheno-am	*Chenopodium-Amaranthus* indistinguishable	Cactaceae	Cactus family
Langenaria siceraria	Gourd			*Cordylanthus* sp.	Birdbeak
		Cleome serrulata	Beeweed	Cyperaceae	Sedge family
Phaseolus vulgaris	Common bean	Compositae	Composite family	*Ephedra* sp.	Mormon tea
Zea mays	Corn	Cruciferae	Mustard family	*Iva* sp.	Sumpweed
		Datura sp.	Datura		
		Descurainia sp.	Tansymustard	Leguminosae	Pea family
		Gramineae	Grass family	Liliaceae	Lily family
		Helianthus sp.	Sunflower	*Opuntia* sp.	Pricklypear
		Malvaceae	Mallow family	*Penstemon* sp.	Penstemon
		Mentzelia albicaulis	Blazing star	*Phragmites* sp.	Reed
		Nicotiana attenuata	Tobacco		
		Oryzopsis hymenoides	Indian ricegrass		
				Asciepias	Milkweed
		Physalis sp.	Groundcherry	Chenopodiaceae	Goosefoot family
		Polygonaceae	Buckwheat family	Ranunculaceae	Buttercup family
		Polygonum sp.	Knotweed	*Rubus* sp.	Raspberry/
		Portulaca sp.	Purslane	*Rumex* sp.	thimbleberry
		Sphaeralcea sp.	Globemallow	*Scirpus* sp.	Dock
		Solanaceae	Nightshade family	*Scutellaria* sp.	Bulrush
		Solanum sp.	Nightshade	*Typha* sp.	Skull cap
				Verbena	Cattail
				Yucca sp.	Verbena sp.
				Y. baccata	Yucca
					Datil yucca

Table 7.2 – Type and number of selected provenience units from which macrobotanical remains were analyzed, by modeling period*

Provenience unit	Period								Total
	1	2	3	4	5	6	7	Other†	
Study units	53	100	118	135	208	47	44	216	921
Total features	51	137	174	222	429	48	42	56	1159
Flotation samples§	48	146	544	202	450	61	47	135	1633
Fire-related features**	20	51	47	62	131	27	31	23	392

* Numbers of proveniences are tallied according to the modeling period to which the macrobotanical materials recovered from the proveniences have been assigned. The proveniences themselves might not be assigned to the same modeling periods as the macrobotanical remains, because the latter may represent cultural activity earlier than or later than the use of the provenience.

† Other-not assigned to period.

§ Upper and lower control samples not included.

** The feature types included in this category are hearth, fireplace, ash pit, warming pit, and pit (not futher specified) with burning.

Table 7.3 – Abundance of selected charred cultigen taxa in the macrobotanical assemblage, by modeling period*

Period	*Zea mays*, kernels (g)	*Zea mays*, not kernels (N)	*Phaseolus*† (N)	*Cucurbita* (N)	*Lagenaria*§ (N)
1	628	833	384	4	0
2	554	828	45	1	0
3	1 161	1 127	1570	4	0
4	1 058	1 315	48	11	0
5	10 426	8 736	227	32	0
6	430	720	11	0	0
7	8	109	1	0	0
Other**	391	231	20	2	1
Total	14 656	13 899	2306	54	1

* *Zea mays* kernels are weighed; all other plant remains are counted. Fragments not included in counts. Remains from upper and lower control samples not considered.
† Includes *Phaseolus* spp. and *Phaseolus vulgaris*.
§ Includes Cucurbitaceae, *Cucurbita* spp., and *Cucurbita pepo*.
** Other-not assigned to period.

Table 7.4 – Abundance of selected charred pioneer and wild plant taxa in the macrobotanical assemblage, by modeling period*

Period	Pioneer (N)	Wild (N)
1	93	38
2	1 386	24
3	1 215	23
4	582	48
5	8 217	2108
6	744	14
7	243	11
Other†	690	46
Total	13 170	2312

* Fragments and remains from upper and lower control samples not included. Only reproductive parts considered.
† Other-not assigned to period.

that would have become less important as more and more energy was put into agricultural strategies. It can only be concluded that the importance of wild plant gathering in the system is misunderstood at this time. Perhaps more detailed examination of the particular resources involved will provide further insights.

Finally, some subtle but important differences exist in the trends for cultigens versus pioneer plants. Specifically, the relative importance of cultigens appears to be greater than expected for Period 2. Heaviest use of pioneer plants clearly is confined to Periods 4 and 5. The heavier use of pioneers in Periods 4 and 5 possibly is evidence for intensification of agriculture. For the Dolores Anasazi, harvesting of pioneers and use of multiple cropping strategies were a means of increasing the productivity of agricultural strategies. As predicted, this sort of intensification might have been a response to high demand for food in Period 4. During Period 5, when shortened growing seasons made the cultivation of maize, beans, and squash risky, these pioneer annuals could have provided an important buffer (Matthews 1985a, 1985b, 1985c).

The amounts of beans and squash shown in table 7.3 are smaller for Period 6. Matthews (1985a) suggests a similar reduction noted at the McPhee Community is best explained by the less favorable climate for cultigens in the project area late in Period 5 and continuing into Period 6. Pioneer plant taxa are not as sensitive to the climatic changes that would affect cultigens, and this might explain why the ubiquity of pioneer taxa remains relatively high in Period 5 before dropping off somewhat in Period 6. Pollen data from the project area also suggest Period 6 experienced a shift to less reliance on farming in the Dolores project area due to the greater risk of corn farming after A.D. 900 (Petersen, chap. 4, sect. 3). The pollen data will be discussed more later.

As shown in table 7.3, the amount of corn remains varied between periods, with Period 5 showing the highest amount. This large amount could simply be a function of the greater number of contexts dating to Period

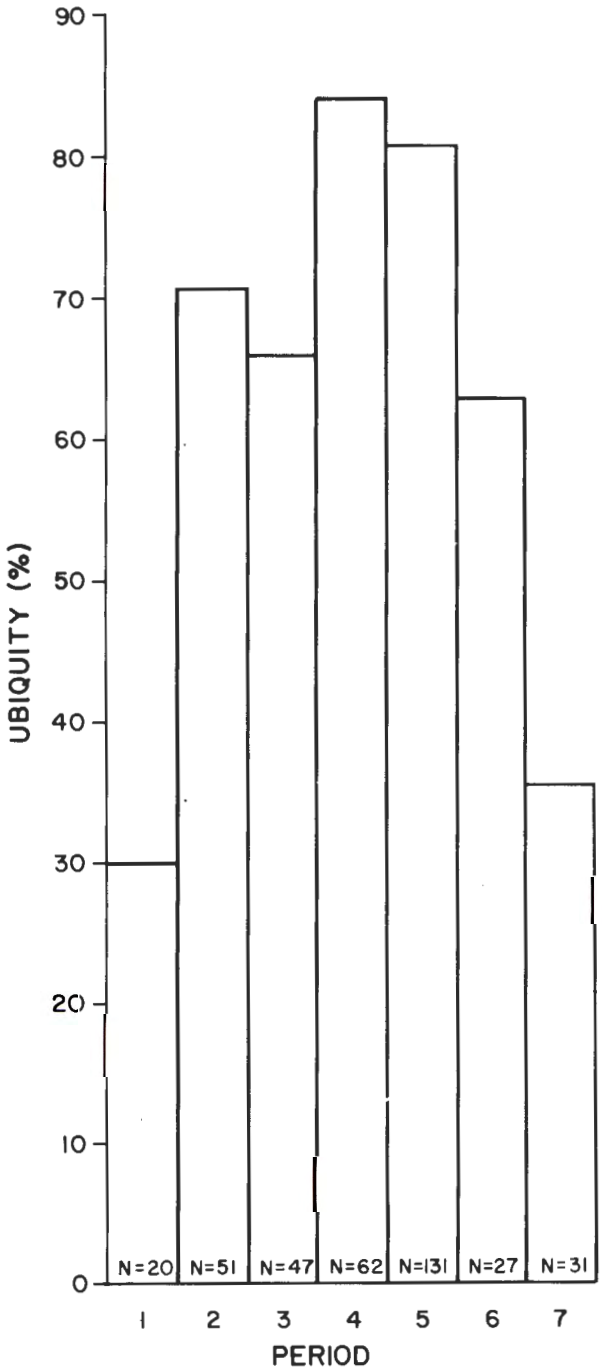

Figure 7.8 – Ubiquity of cultigen taxa in selected fire-related features, by modeling period. Ubiquity is calculated by N/T, where N = the number of fire-related features from which charred cultigen taxa (reproductive parts only) were identified, and T = the number of fire-related features yielding macrobotanical materials that were analyzed and could be assigned to modeling period. Feature types included are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. Remains from upper and lower control samples are excluded. Macrobotanical materials are considered whether or not related to the use of the feature.

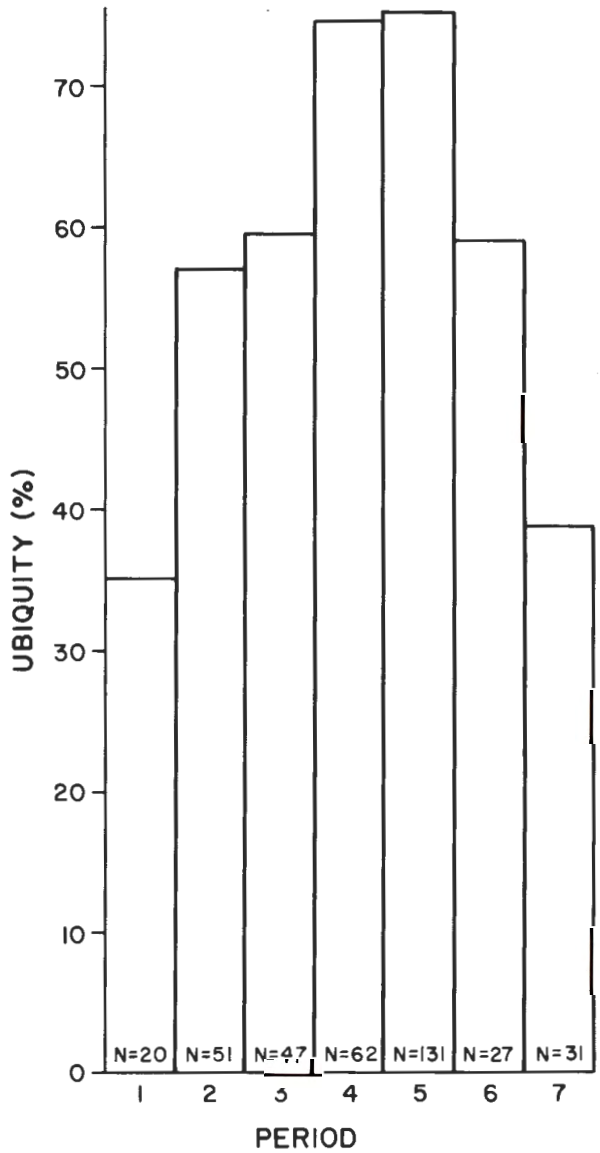

Figure 7.9 – Ubiquity of pioneer plant taxa in selected fire-related features, by modeling period. Ubiquity is calculated by N/T, where N = the number of fire-related features from which charred pioneer plant taxa were identified, and T = the number of fire-related features yielding macrobotanical materials that were analyzed and could be assigned to modeling period. Feature types included are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. Remains from upper and lower control samples are excluded. Macrobotanical materials are considered whether or not related to the use of the feature.

5 that were excavated. A control for this would be to measure the amount of corn recovered against some other artifact category. As was done in the faunal remains study, sherds were selected because they are both abundant and ubiquitous. Total sherds for the project area for each period were selected over gray ware

sherds, because it was thought that total sherds would be the most stable indicator of excavation intensity.[4] Weighed corn kernels (table 7.3) were selected as being representative of the changes in corn remains between periods. As argued in the discussion of the faunal evidence, if it can be assumed that the rate of ceramic breakage and discard of sherds remained relatively constant through time, then changes in the amount of corn remains may be compared between periods, and the effects of the varying lengths of the periods and the number of contexts excavated are minimized. Table 7.5 lists the corn kernel weights and the total number of sherds recovered from the project area. Nearly twice as many sherds were recovered from Period 5 contexts as were recovered from Period 4 contexts, which is an indication that many more Period 5 contexts were excavated.

To determine whether the increase in corn remains might simply be a function of the greater number of Period 5 contexts excavated, the amount of corn kernels was divided by the number of total ceramics. The ratio is plotted in figure 7.11. Even though more ceramics were recovered from Period 5 contexts, the amount of corn still is relatively much greater than during any other period. For instance, the corn/sherd ratio for Period 5 is nearly 5 times greater than that for Period 4. If one applies the same arguments presented in the faunal discussion to the results of the corn study, the high corn/sherd ratio during Period 5 could be interpreted in 2 ways: it could reflect a greater accumulation of corn remains (and hence, greater relative reliance on corn) during Period 5 than during any of the other periods, or it could reflect a significantly reduced rate of total sherd deposition during Period 5.

Trends in corn remains are discussed in greater depth in chapter 4, section 2. In that discussion, an increase in 10-row variety corn is documented for Period 5, an increase that might be the result of cultural selection. The 10-row corn might have been a higher-yield flour type, similar to the modern Pima/Papago variety, resulting from a cross between 8- and 12-row varieties. If this assessment is correct, then agricultural intensification may be manifested not only in the amount of corn remains but also in the varieties present.

In table 7.4, the relative abundance of pioneer and wild plant remains are presented. Just as was done with the corn kernels, these counts can be divided by the total sherds recovered from the project area for each period. In table 7.6, all the ratios of the wild plants are less than 0.0144, while ratios of pioneer plants range from 0.0063 up to 0.0563. The range of pioneer plant ratios from lowest to highest is characterized by roughly a nine-fold increase, and the highest ratio is nearly 4 times that of wild plant remains. These ratios are plotted in figures 7.12 and 7.13 using the same scale.

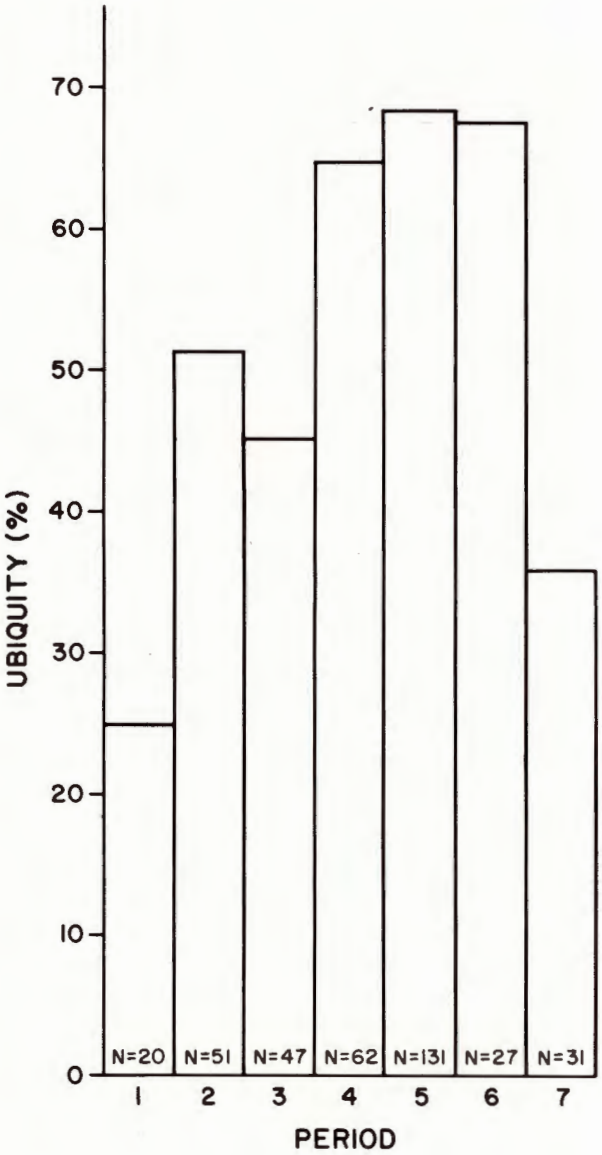

Figure 7.10 – Ubiquity of wild plant taxa in selected fire-related features, by modeling period. Ubiquity is calculated by N/T, where N = the number of fire-related features from which charred wild plant taxa (reproductive parts only) were identified, and T = the number of fire-related features yielding macrobotanical materials that were analyzed and could be assigned to modeling period. Feature types included are hearth, fireplace, ash pit, warming pit, and pit (not further specified) with burning. Remains from upper and lower control samples are excluded. Macrobotanical materials are considered whether or not related to the use of the feature.

[4]Refer to footnote 3.

Table 7.5 – Grams of *Zea mays* kernels and numbers of total sherds, by modeling period

Period	*Zea mays* kernels (g)	Sherds (N)
1	629.6	14 837
2	506.8	35 335
3	1 141.0	52 534
4	1 012.8	70 532
5	10 216.9	146 032
6	430.7	27 903
7	8.9	7 728
Other*	638.3	141 483
Total	14 585.0	496 384

* Other-not assigned to period.

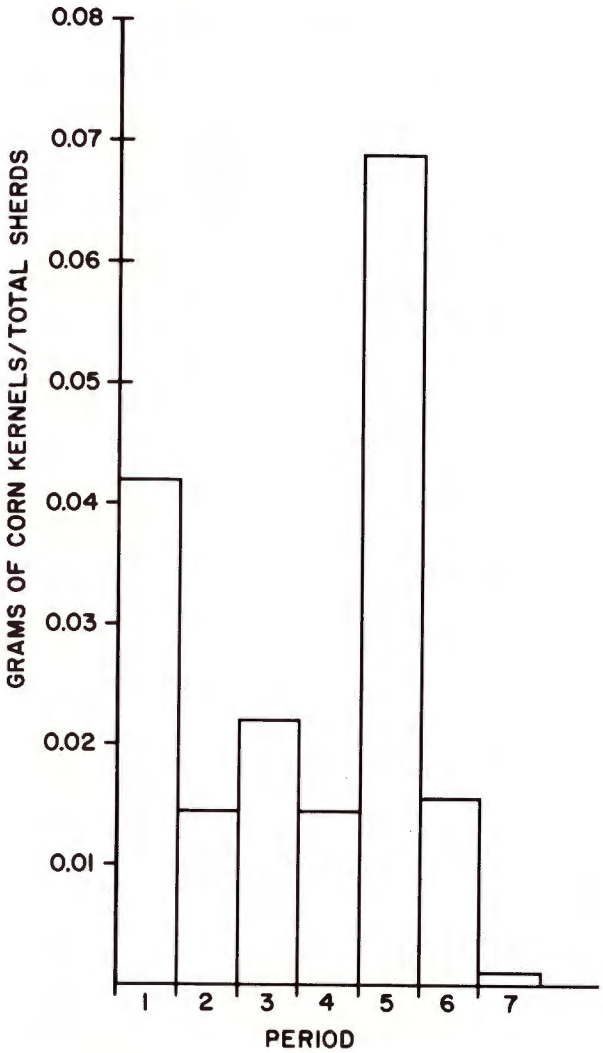

Figure 7.11 – Ratio of grams of corn kernels to total number of sherds, by modeling period.

Table 7.6 – Abundance of selected charred pioneer and wild plant remains and the ratio of each to total sherds, by modeling period*

Period	Pioneer		Wild	
	Count	Ratio†	Count	Ratio†
1	93	0.0063	38	0.0026
2	1 386	.0392	24	.0007
3	1 215	.0231	23	.0004
4	582	.0083	48	.0007
5	8 217	.0563	2108	.0144
6	744	.0267	14	.0005
7	243	.0314	11	.0014
Other§	690	.0049	46	.0003
Total	13 170	.0265	2312	.0047

* Fragments and remains from upper and lower control samples not included. Only reproductive parts considered.

† Number of plant remains divided by total sherds shown in table 7.5.

§ Other-not assigned to period.

Figure 7.12 shows that the highest ratio of pioneer plants to total ceramics occurs in Period 5, which is the period with the highest ubiquity index of pioneer plants in fire-related features (fig. 7.10). Period 4 having the second-to-lowest ratio (fig. 7.12) was unexpected. The fact that the ratios following Period 5 remain higher than the ratios for any other period (except Period 2) suggests that pioneer plants were still important in the economic subsystem in Periods 6 and 7.

A comparison of the ratio of wild plants (fig. 7.13) to pioneer plants (fig. 7.12) shows the importance of wild plants remained relatively minor. Period 1 has a relatively high wild plant/sherd ratio, as was anticipated, but the very high wild plant ratio in Period 5 was unexpected. Even in Period 6, when it was thought that wild plant use might be relatively high (similar to its ubiquity measure [fig. 7.10]), the ratio is relatively low. The slight increase in Period 7 was predicted.

The number of total sherds was used as an index against which the abundance of plant remains could be measured. Because the ubiquity measure used here only addresses the presence or absence of a taxon in fire-related features and not total abundance, it was hoped that the ratio with total sherds would reflect relative amounts. However, the most consistent patterns discerned using the ratio are the very high Period 5 ratios, and these could be a function of a lower rate of ceramic breakage and discard. This possibility will be treated in greater detail in the discussion section.

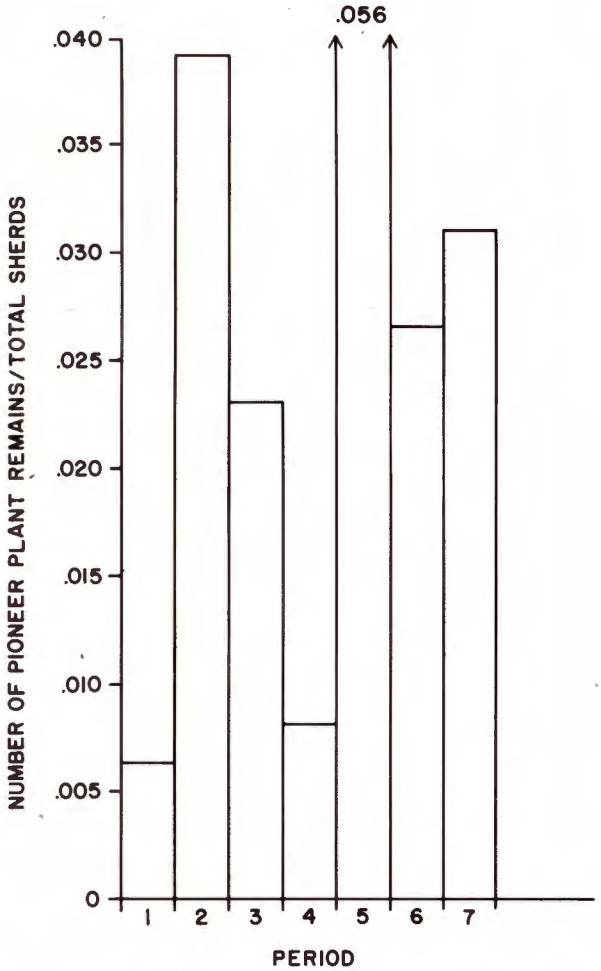

Figure 7.12 – Ratio of number of pioneer plant remains to total number of sherds, by modeling period.

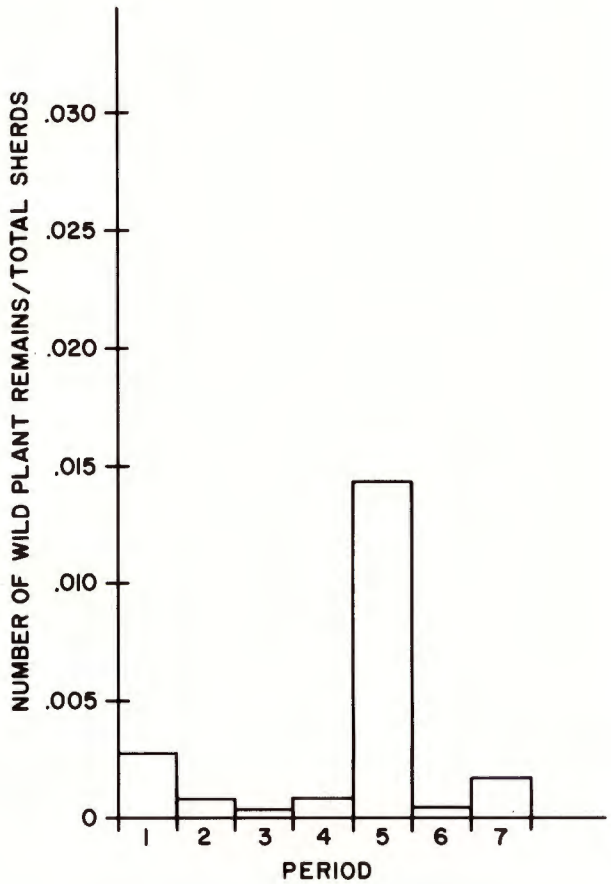

Figure 7.13 – Ratio of number of wild plant remains to total number of sherds, by modeling period.

Pollen Evidence

Petersen (chap. 4, sect. 3) reviews the pollen evidence for *Zea* and *Cleome* during the Anasazi occupation of the project area. One of the conclusions drawn by Petersen is that a slight reduction in the ubiquity of *Zea* pollen in the Cline Subphase may occur as compared to the Periman and Grass Mesa Subphases. Such a change could have had a bearing on the reconstruction of resource supply and demand.

Pollen cannot be routinely identified to the same taxonomic level as macrobotanical remains. However, the pollen of *Zea* and *Cleome* (beeweed) can be easily identified. *Zea* is an obvious cultigen, and *Cleome* is a commonly used pioneer plant that might have been encouraged by the Anasazi. *Cleome* pollen is extremely rare in nonarchaeological sediments (Martin and Byers 1965; Petersen and Scott 1985); thus, its presence at an archaeological site probably indicates the source plant also was at the site, just as the presence of *Zea* pollen at a site indicates the past presence of corn. Several important implications can be derived from these observations.

Within the DAP collections, 594 pollen samples had sufficient pollen to allow analysis. Of these, 473 could be assigned to a modeling period. In chapter 4, section 3, Petersen examines the percent occurrence of *Zea* and *Cleome* pollen using the DAP phase/subphase scheme; in this chapter, the same data are examined using modeling period assignments. When the data are grouped by modeling period, the average ubiquity of *Cleome* (i.e., the percent of the time it is present) for all periods is 84.4 percent. Figure 7.14 shows that, except for Period 7, *Cleome* is present in about 4 of every 5 pollen samples. Because *Cleome* pollen is extremely rare in the natural pollen rain – no *Cleome* pollen was found in the modern DAP surface samples (Petersen and Scott 1985) – the presence of *Cleome* in DAP pollen samples may act as a clear marker of archaeological sediments.[5]

[5]*Cleome* is relatively rare in the natural vegetation, and its mechanism for pollination probably is a combination of insect and wind dispersal (Martin and Byers 1965). This may account for the absence of *Cleome* pollen in the modern DAP surface samples.

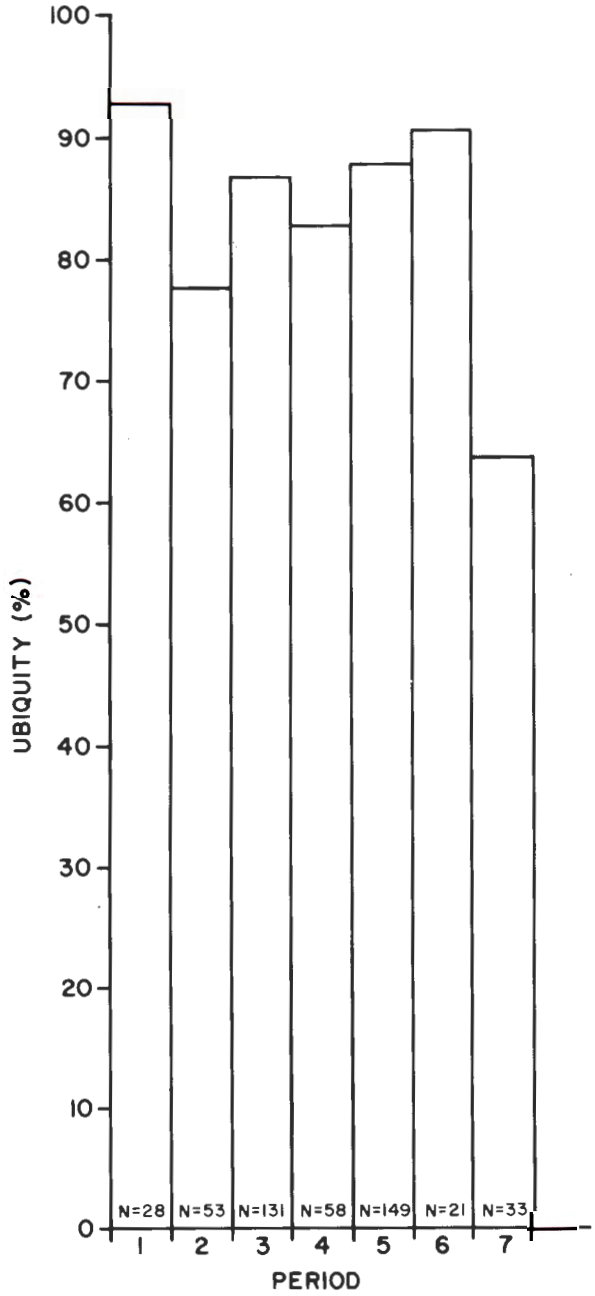

Figure 7.14 – Ubiquity of *Cleome* pollen in samples with sufficient pollen for analysis, by modeling period. Ubiquity is calculated by N/T, where N = the number of pollen samples in which *Cleome* pollen was tallied or observed, and T = the number of pollen samples with sufficient pollen.

The conspicuously high ubiquity of *Cleome* in archaeological sediments may be the result of *Cleome* with flowers most often having been brought into an archaeological site, or the result of *Cleome* having been allowed to grow in the disturbed ground within a site. Under these circumstances, *Cleome* pollen is likely to be disseminated in large enough quantities to be detectable in archaeological pollen samples.

The highest ubiquity of *Cleome* occurred in Period 1, with 92.9 percent; the lowest occurred in Period 7 with 63.6 percent. A 2×2 chi-square test that contrasted samples with and without *Cleome* for adjacent periods revealed that only the difference between Periods 6 and 7 was significant at the 0.05 level of probability (chi-square = 4.8139; probability > chi-square < 0.0282).

Little question exists among pollen analysts that the presence of *Zea* pollen in an archaeological site means that corn was used at the site, because the *Zea* pollen grain is very large and its dispersal is limited, even in modern corn fields (Martin 1963:50). The average *Zea* ubiquity for all modeling periods was 44.6 percent. The highest was 57.1 percent in Period 1; the lowest was 27.3 percent in Peirod 7 (fig. 7.15). A chi-squre test also demonstrates that the only significant difference is between Periods 3 and 4 (chi-square = 7.0637; probability > chi-square < 0.0079), which suggests the amount of change in the ubiquity of *Zea* pollen between Periods 3 and 4 could be statistically accounted for by chance alone in only 1 out of 100 cases.

The low ubiquity of *Zea* pollen in Period 4 may be the result of small sample size; however, 58 samples seems adequate, especially when 4 other periods have fewer samples. Another possibility is that a greater number of samples were from noncultural sediments (e.g., noncultural fill, sterile lower control samples). It is assumed here that the occurrence of *Cleome* pollen can act as a check for this bias, because of the relatively common occurrence of *Cleome* in DAP pollen samples from cultural sediments. For instance, the reason Period 7 has both the lowest *Zea* and *Cleome* ubiquity is that it probably has a larger proportion of samples from noncultural sediments. On the other hand, Period 4, which has the second-lowest ubiquity of *Zea*, does not have a concomitant low ubiquity of *Cleome*. This suggests Period 4 samples may reflect a real decrease in the ubiquity of *Zea* pollen. The drop in ubiquity between Periods 3 and 4 is in direct contrast with the expected trend in relative reliance of the Dolores Anasazi on cultigens (including corn) as modeled in figure 7.2. The possible reasons for this discrepancy will be explored in the next section. It is sufficient to indicate here that the drop in *Zea* pollen ubiquity between Period 3 and Period 4 appears to be both real and significant.

DISCUSSION

Within the framework of changing population and changing climate, it is possible to model changes in Dolores Anasazi resource supply and demand and then

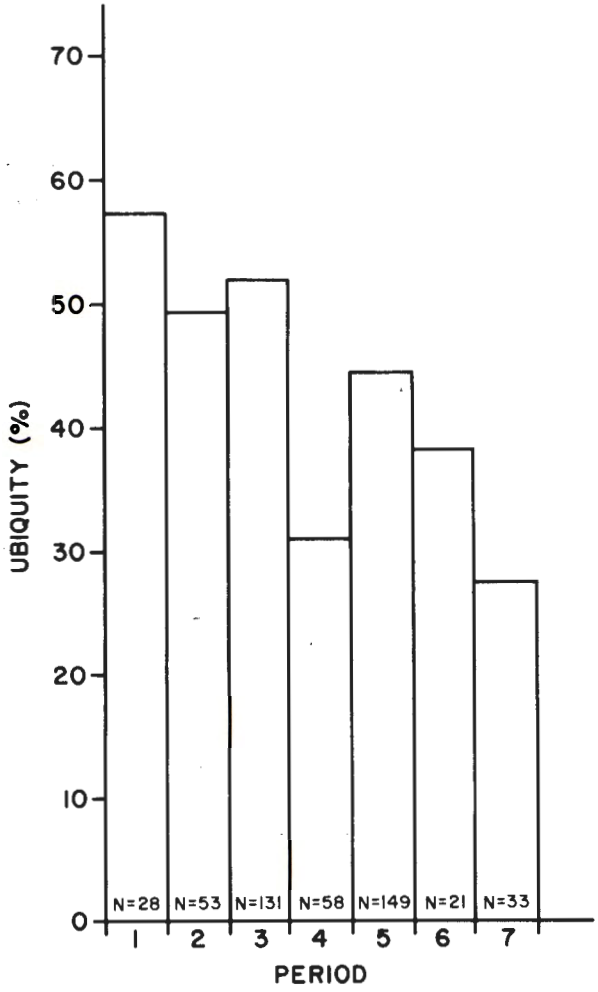

Figure 7.15 – Ubiquity of *Zea* pollen in samples with sufficient pollen for analysis, by modeling period. Ubiquity is calculated by N/T, where N = the number of pollen samples in which *Zea* pollen was tallied or observed, and T = the number of pollen samples with sufficient pollen.

test for changes in resource mix by examining faunal and floral remains recovered in the DAP area. Increasing demand due to increasing population is expected to result in agricultural intensification, or an increase in the expenditure of labor on crop maintenance (e.g., shortening fallow, planting larger areas, and planting or exploiting a greater variety of plants). Figure 7.2 depicts the expectations when a positive relationship exists between increasing population and the reliance on agriculture, pioneer plants, and garden hunting, and an inverse relationship between population and reliance on wild plants and nongarden game. A key test of these expectations rests on the relative changes of various resources in Period 4 (when population peaks), as contrasted with the immediately preceding and succeeding periods.

Two measures were used as possible indicators of the relative importance of faunal and botanical resources during each of the 7 modeling periods. Ubiquity (i.e., the percent of time a resource is present) was used for both macrobotanical remains and pollen, but was not considered here for faunal remains. Ubiquity gives presence or absence information, but no indication of the relative amounts involved. The second measure was the ratio of a resource against either gray ware sherds or total sherds. It was hoped that the ratios of resources to sherds would indicate the relative amounts of the resources used.

Based on the results of the macrobotanical ubiquity measures, Period 1 is characterized by low ubiquity for cultigen, pioneer, and wild plant taxa in fire-related features. In Period 2, a marked increase occurs in all 3 ubiquity indices; in Period 4, the indices rise to a high or near high. In Period 5, the ubiquity of cultigens drops off slightly, while the ubiquity of both pioneer and wild plants remains high. The ubiquity of pioneer plants drops in Period 6, although that of wild plants remains high. Finally, all ubiquity indices reach a low in Period 7 that is about as low as that for Period 1. The ubiquity of wild plants does not follow the expected pattern for Periods 2, 3, and 4; it increases instead of decreases. On the other hand, during Period 5, the ubiquity of pioneer and wild plants remains high, while the ubiquity of cultigens decreases. During Period 6, the ubiquity of wild plants remains high, while that of pioneers and cultigens.

The foregoing evidence may be interpreted as indicating the basic subsistence regime was established by Period 2 and changed little through Period 4. Even the slight peaks or near peaks in Period 4 (as contrasted with Period 3) do not give a clear signature that can be interpreted as indicating an increase in agricultural intensification specifically in Periods 4 and 5 coincident with the highest population level and demand. With the decrease in population in Period 6, there does seem to be a signature of "de-intensification" of agriculture with a detectable shift to a greater relative reliance on pioneer and wild plants in Periods 5 and 6. This could be due in part to the greater risk involved in growing cultigens after A.D. 900, because of the greater frequency of short growing seasons within the project area.

The next test of agricultural intensification in Periods 4 and 5 was the use of a ratio of a specific resource to sherds. Using this measure, possible evidence of agricultural intensification is indicated for Period 5, where the highest ratio of corn to ceramics occurs. However, it appears that Period 5 contexts produce more perishable items than any other period, when the ratios of faunal MNI/gray ware sherds, grams of corn kernels/total sherds, pioneer plants/total sherds, and wild

plants/total sherds are compared. This suggests the overall rate of ceramic deposition was relatively lower during Period 5 than during the other periods, which would partially account for the high ratios. The clearest suggestions that Period 5 might be aberrant are the faunal MNI/gray ware sherd ratio (fig. 7.3) and the wild plant/total sherd ratio (fig. 7.13), in which only the Period 5 ratios differ significantly from those of the other periods.

The higher frequency of perishable material during Period 5 may result from a slightly different history for Period 5 than for the other periods. The project area was largely abandoned near the end of Period 5. The increase in perishable items in relation to sherds could have resulted from the fact that, on abandoning the area, the inhabitants might have carried as much material away with them or might have had opportunities to scavenge sites. If ceramic vessels were one of the primary items carried away, this would certainly bias the ratio of resource remains to sherds during Period 5.

Whatever the actual cause of the biased ratios in Period 5, Blinman (chap. 12) may have circumvented the bias in his study, in which a ratio of nonhuman bone to cooking jar sherds from well-dated, screened refuse collections is examined. Blinman chose sherds collected from refuse because he felt that vessel form proportions based on broken and discarded vessels would most likely approximate the intensity of vessel use. In addition, this approach would minimize the variance within ceramic assemblages introduced by collection of materials from uncontrolled contexts (e.g., whole vessels on structure floors).

Blinman (chap. 12, fig. 12.2) found the highest and most significant bone/sherd ratio occurred in the Period 2 collections. This is due primarily to the extremely large contribution of small mammal and bird bones. A similar, but slight and not significant, peak occurs in garden-type fauna as a proportion of total MNI (fig. 7.7). Blinman's results possibly indicate a strong shift between Periods 1 and 2 in the reliance on garden hunting coincident with the shift to a strong reliance on agriculture in Period 2 as judged by the three macrobotanical ubiquity measures.

Blinman (chap. 12, fig. 12.2) shows a marked decrease in the proportion of all faunal types during Period 4. This would agree with the model that less dependence on fauna should occur during Period 4 coincident with the population peak. This same decrease is evident in figures 7.5 and 7.6, which show the relative measure of the absolute number of faunal MNI for each period. If this decrease in dependence on fauna was offset by an increase in the use of cultigens (as argued by Blinman), then this decrease may be the strongest evidence of agricultural intensification during Period 4. Because of the bias, Period 5 ratios involving ceramics in this chapter were largely ignored.

Except for Period 1 (and, of course, Period 5), the ratio of grams of corn kernels to total ceramics (fig. 7.11) is very similar between periods and therefore much like the relatively stable ratio of bone (MNI) to gray ware sherds for all but Period 5 (fig. 7.3). This particular use of ratios does not seem to lend itself to testing changes in the actual amount of corn or bone through time.

However, the ratio of pioneer plants to total sherds (fig. 7.12) does change. The increase in Period 2 reinforces the interpretation that Period 2 was characterized by a greater reliance on agriculture, garden hunting, and the exploitation of pioneer plants than was Period 1. Because the ratio of pioneer plants to sherds tends to decrease from Period 2 to a near low in Period 4, it is acting in a manner opposite than predicted in figure 7.2. If Period 5 is ignored, then Periods 6 and 7 show increases which again are in the opposite direction than predicted.

The ubiquity of cultigens (fig. 7.8) reaches a high in Period 4, and somewhat follows the expected curve shown in figure 7.2. Therefore, the cultigen ubiquity measure may reflect changes in agricultural intensification. With the peak in Period 2, it has been demonstrated that there was increased exploitation of both garden game and pioneer plants. This was also predicted to have occurred in Period 4. However, based on the ceramic ratios with pioneer plants (fig. 7.12) and nonhuman bone (fig. 12.2), this was not the case, because during Period 4 these ratios were near the lowest of any period. However, in Period 5, Blinman (chap. 12, fig. 12.2) found a slight increase in small animals in relation to cooking jar sherds, which could be interpreted as a renewed emphasis on garden hunting. The macrobotanical ubiquity measures also show a greater relative reliance on pioneer and wild plants during Periods 5 and 6. Rather than being indicators of agricultural intensification in Period 5, garden hunting and the exploitation of pioneer plants may be measures of "de-intensification" and expansion of the resource base. Blinman indicates a greater reliance on large game in Period 6, which would be consistent with figure 7.2.

The significant reduction in the ubiquity of *Zea* pollen between Periods 3 and 4, followed by an increased ubiquity in Period 5 (fig. 7.15), is puzzling. This anomaly interrupts an otherwise overall decreasing trend from

Period 1 through Period 7. The unexpectedly low Period 4 ratio possibly results from sampling bias.

Population pressure alone may not have been enough to bring about sufficient stress to the subsistence system in Period 4 to require increased exploitation of pioneers and garden fauna. However, with deteriorating climate in Period 5 (droughts early in the period and short growing seasons later [chap. 4, sect. 6]), which continued into Period 6 (short growing seasons), the evidence suggests that in Period 5 agriculture was supplemented by broadening the resource base. But the steps taken by the Anasazi early in Period 5 were not totally adequate, and the project area was largely abandoned late in Period 5 (early A.D. 900's) (chaps. 8 and 10). When the area was again occupied during Period 6 (A.D. 920-980), wild plants and big game were relatively more important than during the immediately preceding periods.

SUMMARY

The data suggest the assumption that changes in supply and demand will be good predictors of changes in the resource mix is heuristically useful. This does not mean that factors in the sociopolitical model (chap. 6) should be ignored, but with respect to this aspect of resource mix, an economic model seems adequate to explain some changes in the archaeological record.

At Dolores, the case for agricultural intensification as a response to population growth and a corresponding greater demand for resource supply is not as strong as expected and is mixed. Population growth peaked during Period 4 (A.D. 840 to 880), and the clearest case for agricultural intensification is found during that period. However, the case for intensification is based on a decrease in faunal remains and the assumption that this decrease is offset by an increased dependence on cultigens.

The evidence does suggest it might have been wrong to construct the predictions in this chapter around the contrast between agricultural versus nonagricultural resources. In response to changing supply and demand, plant use tends to increase and then decrease again, while animal use tends to decrease and then increase again. It was found that instead of being opposed, at times they changed together or changed at times not originally predicted. Possibly the specific strategies of interest are not being recognized in the archaeological record. Alternatively, the relative attractiveness of strategies or the boundaries of strategy types most meaningful among the Dolores Anasazi are not being understood. These issues deserve further attention.

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Chapter 8

POPULATION STUDIES

Sarah H. Schlanger

INTRODUCTION TO POPULATION STUDIES

The primary question addressed in this chapter is "What caused the pattern of population change observed in the Dolores area record?" The aspects of population change of particular concern are population size and growth rate, population density, inter-area population movement (immigration and emigration), and population health. The phrasing of the question "What caused the pattern of population change. . . ?," places emphasis on the role of population as a dependent variable in a model of general adaptation in the Dolores area.

The phrase "Dolores area" refers to that area falling within the Dolores Project takeline, an area of approximately 65.5 km^2 along the Dolores River, just downstream from the town of Dolores, Colorado. This area is the focus of most of the modeling work undertaken by the DAP. Because the population changes in the Dolores area appear to be linked to changes within the surrounding region, and in particular within the area known as the "Great Sage-plain" (Newberry 1876:84), which extends to the south and west of the Dolores area, the studies reported here often have a broader regional focus. Because the population trends appear to be part of a larger system, the temporal boundaries for the population studies have been extended to match the occupation span of the larger region; the time period addressed by these studies extends from A.D. 600 to 1250, about 300 years longer than that used for most of the modeling studies.

This chapter begins with a discussion of the role of population and population variables in the general model of Dolores area adaptations described by Lipe in chapter 2. This is followed by definitions of the variables that appear to be the primary links between population and the rest of the system and those that make up the population section of the model. Each of the studies carried out with population variables as the primary focus is then described. Finally, the results of the studies are given.

The Role of Population in the General Model

The general model for studying the Dolores area sociocultural system between A.D. 600 and 950 consists of 5 major subareas: (1) relationships between the Dolores area and surrounding areas, determined primarily through the effects of regional climate on population location and movement; (2) the supply of food and other vital resources, determined primarily by the effects of climate and human behavior on the agricultural potential of the Dolores area; (3) human population; (4) the economic system which supplies the population with cultural materials; and (5) the social system, which orders interaction between members of the population. Although population variables such as size, level of nutrition and health, and interareal movement are illustrated as occupying a small corner of the general model (chap. 2), the human population subarea might be better conceived of as central to the model as a whole. The central position of population becomes clear when the various aspects of the subarea (population size, population density, inter-area movement, and nutrition and health) are examined in terms of their relationships to the remaining 4 subareas.

The link between population and inter-area relationships is regional climate. The location of population within the greater region that includes the Dolores area and the uplands to the south and west, is determined by the regional climate.

The Dolores area is at the northeastern edge of the Sage-plain, a slightly tilted, eroded plain with a bedrock of Dakota Sandstone extending west from Cortez to Monticello and from the edge of the Dolores River canyon south to the entrenched canyons draining to McElmo Canyon and the San Juan River. Elevation in the Sage-plain ranges from just below 6000 ft (1830 m) up to 7800 ft (2379 m), with rainfall averaging about 10 to 12 in (25.4 to 30.5 cm) per year at the lower elevations and 18 in (45.7 cm) per year at the higher elevations. Growing season ranges from about 140 days at the lower elevations to 110 days at the upper elevations. Crop insurance is not currently sold for lands below

6000 ft (1830 m) in elevation (Petersen 1985:6); the short growing season at the upper elevations is also at the edge of what has been considered adequate for aboriginal corn agriculture (Hack 1942; Carter 1945; Schoenwetter and Eddy 1964). Past changes in rainfall and the average growing season length would shift the arable portion of the Sage-plain area from its current location and affect the ability of agricultural populations to maintain themselves in the region.

While it is unlikely the entire region was normally unfarmable, the Dolores area, which is at the northeast margin of the region, may at times have been more or less attractive as farmland than other sections of the region. As attractiveness rose and waned, population would have moved from one area to another in the region. Rates of movement also may have been linked to the relative agricultural attractiveness of the various sections of the region.

Population is connected to resource supply in 2 ways. First, it is a dependent variable, where resource supply determines population size and rates of change in population size through the intermediate variables of nutrition and health. Second, population is connected to resource supply as an independent variable. Resource supply is dependent on population levels because population levels affect the local environment and resource levels. Land clearing and cultivation, timber harvesting, hunting, and rock and mineral quarrying would all have affected local levels of certain resources, leading to shortfalls in some resources, but enhancement of others (Kohler et al. 1984; Bye and Shuster 1981). To the extent that population levels affected local resources, resource supply may be considered to be dependent on population, although resource supply is largely determined by climate. This latter relationship between population and resource supply is not addressed in this volume.

The primary connection between population variables and the economic subsystem is through the variable of resource demand. Because the Dolores system is not thought to have been characterized by wealth differentation and the accumulation of excess goods by individual members or by communities within the area, the link between population and resource demand is fairly straightforward; population size sets the level of resource demand directly. How the demand is met is not of concern here.

Population density is seen as a major determinant of the social structure subsystem. Population density levels determine, to a large extent, the frequency of interaction among individuals, and thus the need for some social mechanism for regulating the interactions between individuals. As population density increases through population growth, through the aggregation of population, or both, social differentiation and social complexity increase. In the studies reported here, population density is ordinarily equivalent to population size because the area under consideration for the Dolores population is the same throughout the period under study.

Dependent and Independent Variable Relationships

The connections between population movement and regional climate, population size and resource demand, population size and resource supply, and population density and social organization seem relatively clear. The following studies focus on the dependent variables of population size (and density), population movement, and rates of growth and movement.

Independent Variables Affecting Population Size, Density, Movement, and Growth Rates

Four variables are considered to be the most important determinants of change in population size, movement into and out of the Dolores area, and growth rates within the Dolores area: (1) the relative attractiveness of the Dolores area for small-scale horticulturalists; (2) the supply of local resources, primarily foodstuffs, agricultural lands, building supplies, and fuel; (3) social organizational opportunity, or the social niches available locally; and (4) socioeconomic opportunity, or the availability of work. Only the first 2 variables are examined in detail in this chapter.

Relative Attractiveness of the Dolores Area

The attractiveness of an area may be determined by a large number of factors including aesthetic values; proximity to water, fuel, food, and manufacturing resources such as clay and tool stone; the availability of arable land; and the degree to which the area is currently occupied. This research concentrates on the arable land aspect of relative attractiveness, with relative attractiveness defined as the suitability of the Dolores area for dry farming corn relative to other portions of the Sageplain region. Suitabilities determined through 2 measures: (1) the past patterns of potential crop failure as a result of short growing seasons or inadequate rainfall in the Dolores area and elsewhere in the region; and (2) the location of the Dolores area with respect to the position of the farmbelt within the region at any point in time.

Resource Supply Within the Dolores Area

The critical resources for the Dolores area population include agricultural crops, wild foods (vegetal and animal), building supplies, fuel, and manufacturing supplies such as clay and stone. This research concentrates

on the availability of agricultural crop resources, particularly corn harvests. Resource supply is defined narrowly here as the agricultural crop supply for the area. Because agricultural crop supply is modeled by land area and climatic variables, which may be presumed to affect wild resources as well, agricultural resource supply changes may stand in for resources in general.

Social Organizational Opportunity

Social organizational opportunity is defined as the relationship between the number of social positions, or niches, available, and the number of participants who can be accommodated in a particular niche or position. Where the number of participants is below some limit of niche occupancy, local population may rise to fill the vacancy. Where niche occupancy is met or exceeded, potential participants will be excluded and excess members may be eliminated.

Socioeconomic Opportunity

Socioeconomic opportunity is defined as the relationship between the number of economic positions, or jobs, and the number of workers available to fill the positions. Where the number of jobs exceeds the number of available workers, a demand for labor is created that may serve to increase local population. Where labor exceeds demand, excess workers may be eliminated or encouraged to move elsewhere.

Dependent Variables in the Population Sphere

Five dependent variables in the population subarea are considered: (1) population size; (2) population density; (3) population movement within the region; (4) population health; and (5) population growth rate.

Population Size

Population size is defined as the number of people present at any time during the occupation of the study area. Size is generally inferred from archaeological evidence, primarily architectural remains.

Population Density

The definition of population density follows the ordinary usage, i.e., the number of people per unit area.

Population Movement

Population movement within the region and into the region from outside and vice versa, probably took place fairly frequently during the Anasazi occupation. Population movement is defined as the relocation of populations within the region—into and out of the Dolores area and other areas within the region. When growth rates within the Dolores area exceed those possible through natural reproduction, population movement into the area may be assumed. Movement also may be taking place where growth rates do not exceed theoretical maximums for internally generated growth, of course, but this movement may prove difficult to detect. Detection techniques are described more fully in the following studies of population movement.

Level of Nutrition and Health

The level of nutrition and health is defined as the level of disease, physical trauma, and longevity of the population. The nutritional and health status of the Dolores population is reported elsewhere (Stodder 1985).

Population Growth Rate

Population growth rate is defined as the rate of change between inferred population sizes for the various time periods of interest.

STUDIES UNDERTAKEN AS PART OF THE DOLORES ARCHAEOLOGICAL PROGRAM MODELING EFFORT

Five research projects make up the bulk of the population subarea studies: (1) an analysis of the relative attractiveness of the Dolores area and 2 other areas lying along an elevational cline to the southwest chosen for comparison to the Dolores area; (2) a synthesis of data on the Dolores area resource supply, with an emphasis on the supply of arable land and returns from arable land; (3) an analysis of change in population size and growth rate in the Dolores area; (4) an analysis of change in population size in 2 areas immediately southwest of the Dolores area (the same considered in the evaluation of relative attractiveness) considered to be likely sources of immigrants to the Dolores area; and (5) an analysis of the health status of the Dolores population. Two of these studies – the changes in population size and growth rate in the Dolores area and the evaluation of the health of the Dolores population have been reported fully elsewhere (Schlanger 1985; Stodder 1985).

Relative Attractiveness of the Dolores Area and Other Areas Along an Elevational Gradient in the Sage-Plain

A growing body of research and a synthesis of the results of population trends on the Colorado Plateau and elsewhere in the American Southwest point to a strong correspondence between population growth patterns and

environmental fluctuations at a variety of scales of investigation (Malde 1964; Schoenwetter and Dittert 1968; Irwin-Williams and Haynes 1970; Euler at al. 1979; Berry 1982; Slatter 1979; Jorde and Harpending 1976; Jorde 1977; Cordell 1975). These studies suggest that long-term and short-term changes (or low- and high- frequency variation) in rainfall and growing season length were the most important factors in determining the patterns of population change.

The Dolores area and the land sloping off to the southwest make up an environmental cline defined by an elevational gradient that falls smoothly from relatively high elevations at the Dolores canyon rim and further northwest to relatively low elevations at the San Juan River. The gradual slope between these 2 major drainages is associated with short, cool, and wet growing seasons at Dolores, and long, hot, and dry growing seasons at the San Juan River. The presence of this cline, which occurs over a span of fewer than 30 mi, makes this an excellent place to study the relationship between climatic change and population growth. The underlying bedrock and general physiography, including slope and aspect, is the same across the region and soils are similar (U.S. Department of Agriculture, Soil Conservation Service 1976), so these factors also may be considered constant across the region.

The rolling pinyon, juniper, oak, and sagebrush covered country does not lend itself easily to irrigation and water control schemes, so even today the area is largely a dry-farming region. This suggests rainfall is a critical factor for successful agriculture in the region; the relatively high elevations – just about 5000 ft (1525 m) at the San Juan River, rising to just under 8000 ft (2440 m) in the Dolores area – make growing season length another critical factor.

Comparison Areas Within the Sage-Plain

Two areas within the region were selected for comparison to the Dolores area (fig. 8.1). The first of these, referred to as the Woods Canyon area, lies immediately to the south and southwest of the town of Yellow Jacket, Colorado. This general area has been the focus of a good deal of archaeological research, including work directed by Rohn (1974, 1975), Wheat (1955), the DAP (Ives and Orcutt 1981; Ives and Errickson 1983; Walkenhorst et al. 1983), Fetterman and Honeycutt (1980, 1982), Honeycutt and Fetterman (1982) and the Mesa Verde Regional Research Center, directed by David A. Breternitz (Martin et al. 1971). Recent surveys in connection with Reach-I of the proposed Dove Creek Canal, the Fairview lateral, a Shell Oil carbon dioxide project, and an Empire Electric utility project have amassed a reasonably extensive and complete data base of archaeological resources in the area. This recent work has been conducted so as to be compatible with the chronological scheme in use at the DAP, which makes the area particularly attractive as a study unit for this investigation.

The second area is at the southwestern end of a transect drawn from the Dolores River to the confluence of McElmo Creek and the San Juan River. This area is Mockingbird Mesa, the site of an intensive survey undertaken by the Bureau of Land Management, Durango office, under the direction of Steven Fuller. This survey was also designed to use the DAP analytical systems for recording and collection, making the area also especially suitable for use in this research.

Reconstructing Past Patterns of Crop Failure in the Region

The relative attractiveness of these areas, and any place in the region, may be assessed by reference to the frequency and patterning of potential crop failures during the period A.D. 600 to 1250. Crop failures are assumed to have taken place in any given year when the annual rainfall fell below 12 in (30.5 cm) or the growing season was shorter than 110 days. The crop failure potential for any given year is estimated based on the tree-ring indices from a high-elevation tree-ring record from the Almagre Mountains of central Colorado, which was used to estimate growing season length, and from a low-elevation tree-ring record from the Mesa Verde region, just southeast of the study region, used to estimate annual rainfall. The method for assessing the crop failure potential is relatively complex and is presented here in some detail.

Petersen's work and paleoclimates of southwestern Colorado provides the key to recognizing prehistoric periods of drought and insufficient growing season length in the region (Petersen and Mehringer 1976; Petersen 1981, 1985; Petersen and Clay 1985). As part of his work in identifying climatic conditions during the occupation of the Dolores area and southwestern Colorado in general, Petersen developed tree-ring-width-based proxy measures for summer warmth and precipitation (Petersen 1983, 1985; Petersen and Clay 1985).

Petersen's technique follows the approach of LaMarche (1974) in using a high-elevation tree-ring record (from trees close to the upper limits of tree line) as a proxy for temperature and a low-elevation record as a proxy for precipitation. The high-elevation record comes from the Almagre Mountains of the central Colorado Rockies, as reported by the Laboratory of Tree-Ring Research at the University of Arizona (Drew 1974); the trees that make up this record are bristlecone pine (*Pinus aristata*). Petersen's low-elevation record comes from a local Dolores area chronology of mixed species,

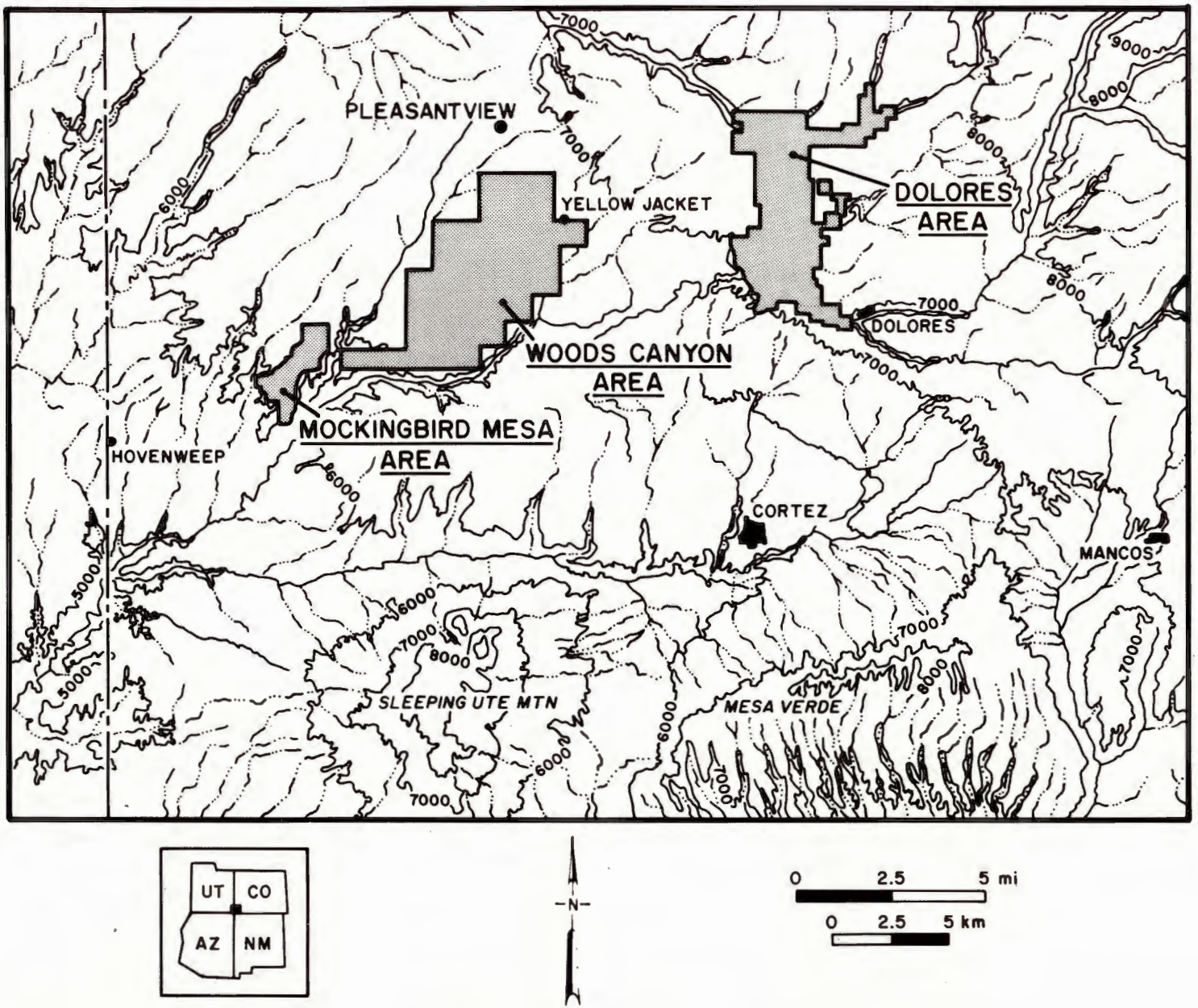

Figure 8.1 – Location of the Dolores, Woods Canyon, and Mockingbird Mesa study areas, southwestern Colorado.

which is extended after A.D. 1136 with a Mesa Verde chronology based on Douglas fir (*Pseudotsuga menzezii*) (Dean and Robinson 1978). Both of these chronologies were prepared by the Laboratory of Tree-Ring Research; however, the Dolores chronology is as yet unpublished. The Almagre Mountains record was obtained from an area considerably distant from the Sage-plain region and may not be the best indicator of climatic conditions in this region. Unfortunately, it is the only long record from a high-elevation stand that covers the time period of interest, and is used here in lieu of a more suitable record.

Petersen's (1983) comparisons of the plots of 10-year averages for the Almagre Mountains normalized tree-ring width indices and 9-year, moving, weighted averages of killing-frost-free periods for the study region, using data on frost-free periods from Bradley (1980) and Petersen (1983:32, fig. 19), indicates that negative tree-ring index departures in excess of one standard deviation equate well with a growing season of fewer than 110 days. His comparison of a plot of 10-year averages of the normalized Mesa Verde tree-ring indices with historic droughts in the A.D. 1900's for the study region (Barry and Bradley 1976) indicates the droughts are roughly correlated with a negative departure of one standard deviation in the tree-ring record (Petersen 1983:36, fig. 21). These correlations were obtained by visual inspection only and have not been subjected to the rigorous testing and confirmation routines developed at the University of Arizona Laboratory of Tree-Ring Research for making climatic retrodictions from tree-ring data (Dean and Robinson 1977; Fritts 1976; Fritts and Shatz 1975; Firtts et al. 1971; Dean and Robinson 1982; Rose et al. 1981).

Identifying drought years in the study region. – Drought is defined here as annual rainfall or less than 12 in (30.5 cm), a figure Hack (1942:8) suggests as the minimum required for crop success with aboriginal corn varieties. Petersen's rough calibration of standard deviation units of departure at Mesa Verde with historic droughts of the A.D. 1890's, 1930's, and 1950's, as reported by Barry and Bradley (1976), can be used to tie the tree-ring width records to drought conditions at various elevations across the study region. The data on the severity of the A.D. 1890's and 1930's droughts are sketchy, but the records for the A.D. 1950's (U.S. Department of Commerce 1948-1981a, 1948-1981b) are sufficiently complete for estimating the drought severity. The A.D. 1950's drought severity may be estimated at a 16.7 percent reduction in annual rainfall across the study region, using records from Northdale, Cortez, Mancos, Mesa Verde, and Dolores from 1948 to 1981 in the climatic summaries. Actual reductions at the stations represented in the weather summaries for the A.D. 1950's were 26.1 percent at Northdale, 18.5 percent at Cortez, 16.0 percent at Mancos, 12.7 percent at Mesa Verde, and 10.2 percent at Dolores (U.S. Department of Commerce 1948-1981a, 1948-1981b). Average annual precipitation for this decade was 9.0 in (22.9 cm) at Northdale, 16.0 in (40.6 cm) at Cortez, 13.5 in (34.3 cm) at Mancos, 15.3 in (38.9 cm) at Mesa Verde, and 16.0 in (40.6 cm) at Dolores.

The actual tree-ring-width index departure in the Mesa Verde record for this decade is −1.28 standard deviations below the long-term mean, so a rough correspondence can be assumed between −1.28 standard deviation units and a reduction in annual rainfall of some 16.7 percent. Standard deviation units of departure equivalent to an annual precipitation total of 12 in (30.5 cm) or less can be calculated for any given elevation by determining the necessary reduction in rainfall for that elevation that brings the local total down to 12 in (30.5 cm) or less. Annual precipitation averages for the various elevations in the study areas are estimated using a regression of annual precipitation on elevation for the 12 weather stations in the vicinity of the study region. The regression line fits precipitation to elevation as

$$Y = 15.993 - 0.0047x + 0.0000066x^2$$

where Y is annual rainfall and x is elevation. The r-square value for this line is 0.95, with an associated probability of less than 0.0001. The estimated corresponding departure values for the various elevations are provided in table 8.1

Identifying short growing seasons in the region. – A similar technique is used to identify short growing seasons in the region. A short growing season year is defined as any year in which the growing season is estimated to have been less than 110 days, the lower limit for successful corn maturation, as reported by Hack (1942:23), Carter (1945:88-89), and Schoenwetter and Eddy (1964:120). Petersen (1985) reports a rough correspondence between a value of -1 standard deviation from the mean in the Almagre Mountain tree-ring index series and a growing season of about 110 days in the study region. The regional average at present is about 130 days (U.S. Department of Commerce 1948-1981a, 1948-1981b) so that the 110 day figure may be assumed to correlate roughly with a 15-percent drop in growing season length. A simple linear model of the relationship between elevation and growing season length is used to estimate growing season length for elevations represented in the study areas. The model is represented by the equation

$$y = -0.02x + 256.468$$

where y is elevation and x is growing season length. The estimated departure equivalents, in standard deviation

Table 8.1 – Estimated tree-ring-index departure equivalents for annual rainfall and growing season length across the study region

Elevation (ft)	Estimated annual rainfall (in)	Departure equivalent to 12 in of rainfall*	Estimated growing season	Departure equivalent to 110 growing season days†
5600	11.6	+0.3	144.5	−1.6
5800	12.3	−0.2	140.5	−1.5
6000	13.0	−0.6	136.5	−1.3
6200	13.8	−1.0	132.5	−1.1
6400	14.6	−1.4	128.5	−1.0
6600	15.5	−1.7	124.5	−0.8
6800	16.4	−2.1	120.5	−0.6
6900	16.9	−2.2	118.0	−0.5
7000	17.4	−2.4	116.5	−0.4
7200	18.4	−2.7	112.5	−0.2
7400	19.5	−2.9	108.5	+0.1
7600	20.7	−3.2	104.5	+0.4
7700	21.3	−3.3	102.5	+0.5
7800	21.9	−3.5	100.5	+0.6

* Standard deviation departure units measured from long-term mean of the Mesa Verde tree-ring record.
† Standard deviation departure units, Almagre Mountain tree-ring record.

units from the long-term mean of the Almagre Mountain record, are given in table 8.1.

Identifying crop failure years in Dolores and the comparison areas. – Table 8.1 contains the information needed to identify individual crop failure years in each of the 3 areas. Two sets of values are generated from this table. The first, or Level 1 values, mark those levels at which rainfall or growing season length would have begun to affect a particular study area. These values correspond to the levels at which rainfall would be insufficient at the lower elevational boundary of the study area and at which growing season length would be inadequate at the upper elevational boundary of the study area. The second level values (Level 2) are set to correspond to the higher elevational boundary for rainfall and the lower elevational boundary for growing season length. If the annual precipitation and growing season length estimates for these values are accurate, then, when these conditions occurred, crops should have failed across the entire elevational range of the area.

Modeling the Relative Attractiveness of the Three Areas

The relative attractiveness of the 3 areas can be determined from the incidence of potential crop failures in each area and by examining the spatial relationship between the areas and the position of the arable portion of the region. The arable portion of the region may be considered to be a sort of movable "farmbelt" that shifts position according to changes in growing season length and precipitation.

Crop failure frequency and relative attractiveness of the three areas. – Determining exactly what drought or short growing season pattern might result in movement from one area to another within the region is difficult, although it appears that a single year of crop failure would probably not be sufficient. Slatter (1979:table 13) provides data supporting a pattern of 2 and 3 crop failure years in succession as one that creates sufficient stress to promote emigration among historic Southwestern Pueblo Indians. His patterns are used here as an approximation of the stress required for population movements within the region.

The simplest way of determining the relative attractivness of the various areas is to compare the frequency of crop failure within each area. When the frequency of failure is lower in one area than in another, the area with the lower incidence is considered to be the most attractive. In general, more attractive areas are expected to receive migrants from less attractive areas. This approach assumes, of course, that other factors affecting attractiveness, such as distance from present location, population density, communal ties, and willingness to relocate, are not operating here.

Going strictly by the criterion of frequency of crop failure, the Dolores area is almost always the least attractive of the study areas and the Woods Canyon and

Mockingbird Mesa areas alternate frequently in their relative attractiveness. The only time the Dolores area has a lower frequency of crop failures than either of the other two is in Period 3, with Level 2 crop failures. Ranks for the areas by period and failure type are listed in table 8.2. The relative attractiveness of each area is illustrated in figure 8.2.

The position of the farmbelt. – Table 8.1 also supplies the data necessary to model the location of the farmbelt during the prehistoric occupation of the region. Figure 8.3 shows the elevation of the farmbelt between A.D. 600 and 1250. This figure was constructed following the methods correlating tree-ring indices, annual rainfall, and growing season outlined previously. These methods do not reflect orographic or physiographic features that may affect local rainfall and growing season length; therefore, the resulting farmbelt reconstructions are approximations, not exact representations.

An example may clarify the procedure for fixing the elevations of the farmbelt at a particular time. For the decade A.D. 700 to 710, the Mesa Verde tree-ring-index average departure is -1.31 standard deviation units and the Almagre Mountain tree-ring-index average departure is -0.02 standard deviation units. These departures are associated with annual rainfall of 12 in (30.5 cm) or more at elevations equal to or greater than 6400 ft (1952 m) and growing seasons of 110 or more days at elevations of 7400 ft (2257 m) or lower, respectively. The lower boundary of the farmbelt for this decade is thus set at 6400 ft (1952 m) and the upper boundary is set at 7400 ft (2257 m).

The farmbelt reconstruction identifies several features of the relative attractiveness for the 3 areas and the climatic characteristics of the region in general. The most interesting feature is that for most of the A.D. 600-1250 period, the farmbelt is narrower than the range of elevations in the study areas. Furthermore, it appears that the farmbelt shifted frequently during the Anasazi occupation of the region. Finally, shifts in the location of the farmbelt may have had a greater effect on the Dolores area than on the Mockingbird Mesa and Woods Canyon areas. The greater part of the Dolores area falls outside the farmbelt during Periods 2, 5, and 7.4, whereas the greater part of the Mockingbird Mesa area falls outside the farmbelt only during Period 7.3, and no period occurs during which the greater part of the Woods Canyon area lies outside the farmbelt. If shifts in the location of the farmbelt at the illustrated frequencies of 10 and 20 years affect occupation patterns in the region at all, they probably had their largest effect in the Dolores area.

Predictions for population movement between the study areas in response to changes in relative attractiveness. – Population is expected to respond to the relative attractiveness of the areas by moving from areas of low attractiveness, measured by high frequencies of crop failure, to areas of high attractiveness, measured by low frequencies of crop failure. This movement is expected to be particularly marked when areas switch positions in their ranking based on crop failure frequency. A good example of this is seen in figure 8.2 where the line connecting the Woods Canyon values and the Mockingbird Mesa values cross. Using these criteria, emigration from Woods Canyon to Mockingbird Mesa is expected to take place during Periods 2, 5, 7.1, and 7.4 and may be reflected in a drop in population in Woods Canyon and a rise in population in the Mockingbird Mesa area at these times. Predictions for population movement based on crop failure frequency are summarized in table 8.3.

Migration into the Dolores area. – The crop failure and farmbelt reconstructions suggest that immigration into the Dolores area from the Woods Canyon area or the Mockingbird Mesa area was probably not due to overall greater climatic attractiveness in the Dolores area. The Dolores area was almost always the least attractive of the 3 areas in terms of crop failure frequency and relationship to the farmbelt. If immigration were to occur because of an enhanced attractiveness of the Dolores area, however, it should occur during those periods when the Dolores area is the least affected by crop failures and when the area falls largely within the limits of the reconstructed farmbelt.

This analysis of crop failure frequency indicates the most probable periods for the Dolores area to receive migrants from the rest of the study region would be Periods 3, 4, 6, 7.1, 7.2, and 7.3. The farmbelt reconstructions suggest that migrants might come to the Dolores area in Period 1, at the boundary between Periods 3 and 4, in Periods 6 and 7.1, at the beginning and end of Period 7.2, and in Period 7.3. Immigration from the Woods Canyon and Mockingbird Mesa areas is not expected to occur in Periods 2 and 5.

Potential harvest shortages and relative attractiveness. – Burns (1983) recent study of potential harvest shortages for the period A.D. 652 to 1968, which is based on a calibration of corn and beans harvests from 5 counties in southwestern Colorado and 5 tree-ring chronologies from the northern Colorado Plateau, provides another source of inferences about population movement in the region. Burns retrodicted series of harvest shortfalls and excesses were created by assuming the long-term mean of the retrodicted potential yield per harvested acre was equal to a normal consumption level for inhabitants of the region. Retrodicted harvests in excess of the long-term mean were assumed to have produced surpluses, and retrodicted

Table 8.2 – Relative attractiveness ranking for the three study areas by period and crop failure level.

Period	Level 1			Level 2		
	Single-year duration 1st 2nd 3rd	Two-year duration 1st 2nd 3rd	Three-year duration 1st 2nd 3rd	Single-year duration 1st 2nd 3rd	Two-year duration 1st 2nd 3rd	Three-year duration 1st 2nd 3rd
1	2 3 1	2 3 1	2 3 1	2 3 1	2 3 1	2 - 3 1
2	3 2 1	3 2 1	3 2 1	2 3 1	2 - 3 1	2 - 3 1
3	2 3 1	2 3 1	2 3 1	2 1 3	2 - 3 1	2 - 3 - 1
4	2 3 1	2 3 1	3 - 2 1	2 3 1	2 - 3 1	2 - 3 - 1
5	3 2 1	3 2 1	3 2 1	3 2 1	3 2 1	3 2 1
6	3 - 2 1	3 2 1	3 2 1	3 2 1	2 - 3 1	3 - 2 1
7.1	3 2 1	3 2 1	3 - 2 1	2 3 1	2 3 - 1	3 - 2 - 1
7.2	2 3 1	3 2 1	3 2 1	3 2 1	2 - 3 1	3 - 2 - 1
7.3	2 3 1	2 3 1	3 2 1	2 3 1	2 3 1	3 - 2 - 1
7.4	3 2 1	3 2 1	3 2 1	3 2 1	3 2 1	2 3 1

Ranks are from best (1st) to worst (3rd). Dashes indicate equivalent ranking.
1 – Dolores area.
2 – Woods Canyon area.
3 – Mockingbird Mesa area.

harvests smaller than the long-term mean were assumed to have resulted in shortfalls. After introducing a storage effect that simulated a variety of storage patterns (equal to maintaining stores of 1-1/2 times to 5 times the long-term mean production per harvested acre), Burns was able to identify series of years characterized by harvest shortfalls. Burns best data has to do with dry bean harvests, which were evidently prone to more severe shortfalls than corn (Burns 1983:196), but the shortfall pattern for the 2 is similar.

Burns retrodictions allowed him to identify a number of shortfall patterns, including "24-year famines" that equaled the length of the "Great Drought" of A.D. 1276-1299, the most severe decades of shortfalls, periods of 6 or more successive years of shortfall, and long periods of successive or nearly successive shortfalls. Between A.D. 652 and 1250 Burns detected severe 24-year famines (using a 3-year storage pattern) that occurred between A.D. 705-726 and A.D. 1170-1193 (Burns 1983:203, table 7.15). Decade shortfall periods (based on a 3-year storage pattern) occurred between A.D. 709 and 718, A.D. 715 and 724, A.D. 751 and 760, A.D. 870 and 879, A.D. 1146 and 1155, and A.D. 1171 and 1180 (Burns 1983:235, table 7.19). Lengthy periods of shortfall (using a 3-year storage pattern) occurred between A.D. 705 and 726, A.D. 751 and 757, A.D. 870 and 876, A.D. 995 and 1003, A.D. 1035 and 1041, A.D. 1170 and 1176, A.D. 1184 and 1193, and A.D. 1240 and 1246 (Burns 1983:240, table 7.21).

Taken altogether, Burns studies indicate potential shortfall difficulties between A.D. 705 and 727, A.D. 751 and 760, A.D. 870 and 879, A.D. 995 and 1003, A.D. 1035 and 1041, A.D. 1146 and 1155; A.D. 1170 and 1193, and A.D. 1240 and 1246. These correspond to a shortfall episode of 24 years duration during Period 1 (or the boundary between Periods 1 and 2), a relatively severe decade during Period 2, a relatively severe decade during Period 4, a shortfall episode of 9 years duration during Period 7.1, an episode of 7 years duration during Period 7.2, a severe decade in Period 7.2, and an episode of 7 years duration in Period 7.4, following the abandonment of the Dolores area. The shortfall episodes are distributed fairly evenly across the occupation span of the region and no particular period appears to have been more severely affected than any other, with the possible exception of late Period 1 or early Period 2.

The relationship between Burns shortfall periods and the relative attractiveness of various areas in the region presented thus far is best illustrated in a comparison of the shortfall periods and the farmbelt reconstruction (fig. 8.3). Burns (1983) crop data comes from land that lies below most of the elevations of the Dolores area, and the harvests are tied more closely to precipitation than they would be in the Dolores area. It is not surprising, therefore, that the shortfall periods documented by Burns correspond closely with upward movments in the reconstructed farmbelt but fail to correspond to reconstructed drops in the farmbelt. The prehistoric reconstructed farmbelts drop below 7000 ft (2135 m) only twice between A.D. 600 and 1250 for short periods. Because Burns shortfall periods result from rather particular patterns of shortfall years, such

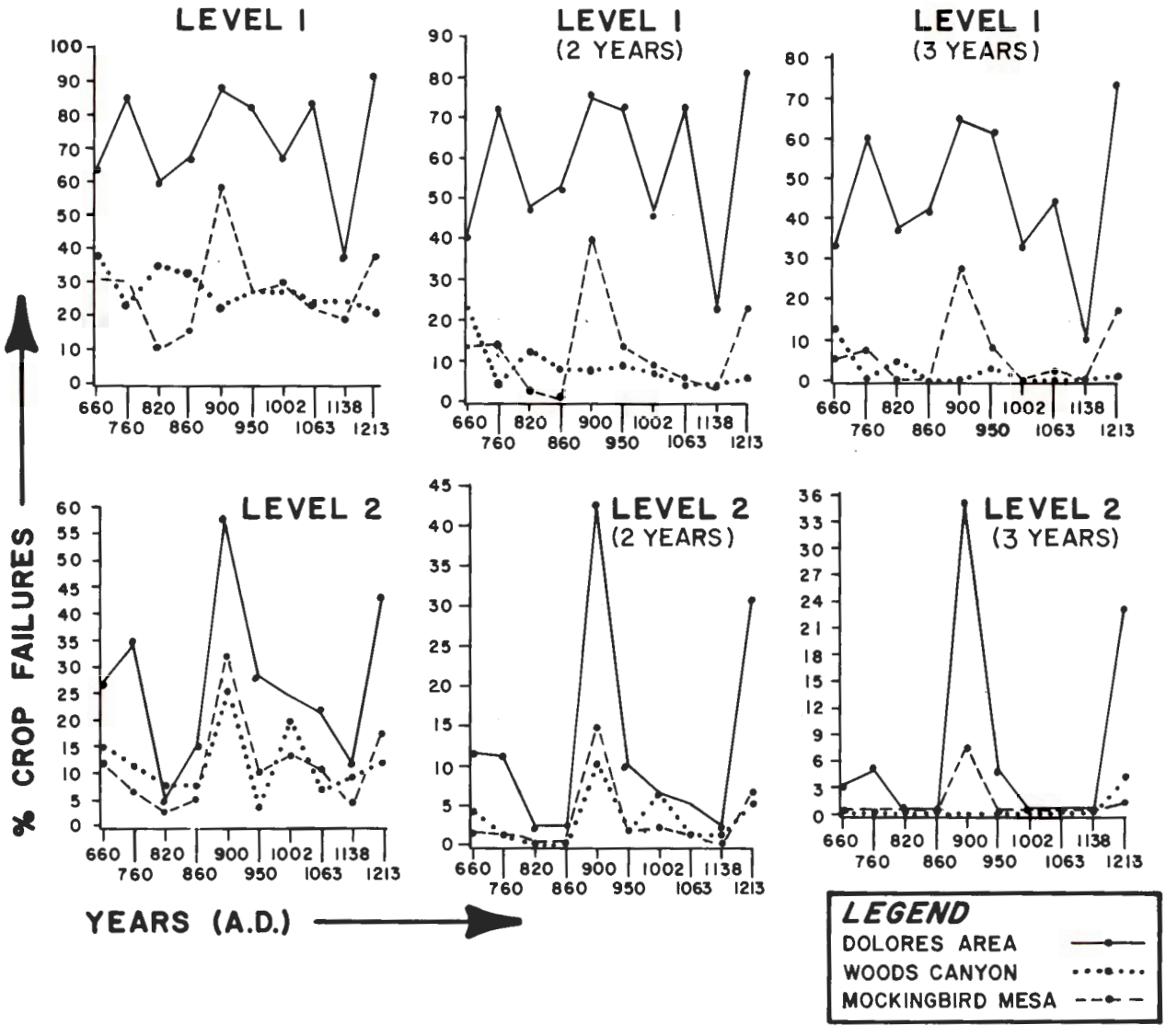

Figure 8.2 – Crop failure percentages for the Dolores, Woods Canyon, and Mockingbird Mesa study areas. Points are plotted at period midpoints.

that not every year in which a shortfall occurred would be part of an extended shortfall period, not all years in which climatic stress occurred would be identified as shortfall episodes in his analysis. This feature of his analysis and the fact that the farmbelt reconstructions are based on decade averages and not individual years explain the differences between the farmbelt reconstructions and Burns shortfall periods.

The shortfalls Burns identifies may have prompted movement from the lower lying areas, below 7000 ft (2135 m) or so, to higher elevations, such as the Dolores area, particularly when the shortfall episodes at the lower elevations corresponded to periods with a relatively high farmbelt, such as occurred in Periods 4, 7.1, and 7.3. These periods may be considered especially favorable for emigration from the Woods Canyon and Mockingbird Mesa areas into the Dolores area.

Resource Supply in the Dolores Area

Changes in resource supply, restricted here to agricultural resources, were examined using 2 proxy measures. The frequency of crop failure in the Dolores area for each time period was used as an indicator of general changes in agricultural resource supply, and the potential corn production for the Dolores area for each period was treated as a more direct indication of agricultural resource supply.

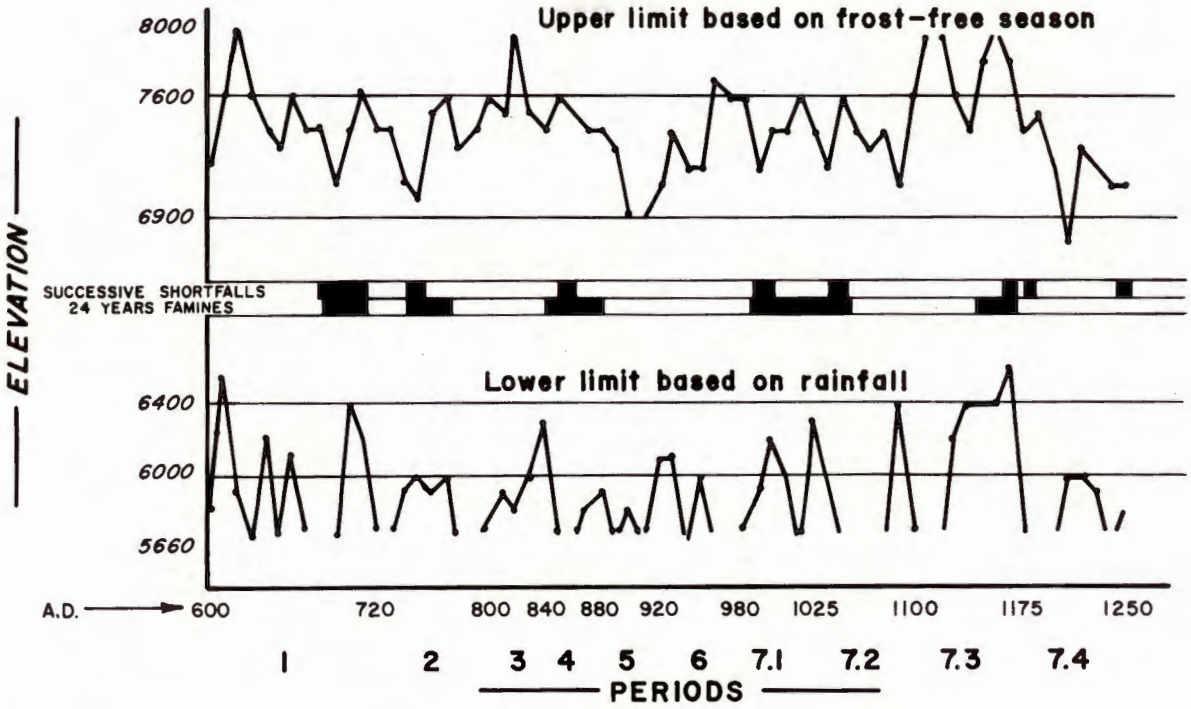

Figure 8.3 – Estimated farmbelt position in relation to shortfall periods. Successive shortfalls and 24-year famines adapted from Burns (1983).

Crop Failure Frequency in the Dolores Area

The frequency of crop failure per period in the Dolores area is reported in table 8.1 and illustrated in figure 8.2.

The frequency of failure is assumed to hold a fairly direct relation to agricultural resource supply, such that as failures increase, agricultural resource supply decreases. The pattern of crop failure frequencies by period is quite similar for the Dolores area regardless of which level of crop failures are considered or which particular pattern – single years, 2 successive years, or 3 successive years – is used. The crop failure frequency is low in Period 1, rises in Period 2, and falls in Period 3. The frequency rises again in Periods 4 and 5, falls throughout Periods 6, 7.1, 7.2, and 7.3, then rises in Period 7.4. The exception to this pattern is single years of Level 1 failures, which rise in Period 7.2, fall to a low in Period 7.4, then rise to a high level in Period 7.4. The highest incidence of crop failures occurs in Periods 5 and 7.4. Ranking the crop failure frequency for each measurement level and type and combining these scores gives the following ranking for crop failure frequency for each period from lowest to highest: Period 7.3, 3, 4, 7.1, 1, 7.2, 2 and 6, and 5 and 7.4.

Arable Land and Agricultural Production Potential

The following discussion of arable land and agricultural production potential is based on research conducted by Orcutt (1985).

The soil quality, susceptibility to frost, and location in zones subject to cold air pooling of the Dolores area lands, and the climatic conditions prevailing during the various periods were used to construct estimates of the potential corn production within the Dolores area. Soil quality and cold air susceptibility data come from Orcutt (1985). The relevant climatic conditions were modeled by the changes in the tree-ring indices from a low-elevation tree-ring chronology (the Mesa Verde record) and a high-elevation tree-ring chronology (the Almagre Moutain record) in much the same manner that crop failure frequency was modeled in the previous section on relative attractiveness in the region. The records were calibrated somewhat differently, however, with a negative departure of 1 standard deviation from the long-term mean, signaling dangerously short growing seasons when such deviations were recorded in the Almagre Mountain chronology and potential drought conditions when such deviations were recorded in the Mesa Verde chronology.

In Orcutt's (1985) development of potential production figures, she employed a study area that included the Dolores area (the DAP takeline) and a 1-km radius around that area, resulting in a total study area size of 137 km^2, roughly twice the size of the Dolores study area in this chapter. This area is similar enough to the Dolores area in its distribution of soil types and topography that the pattern of changes in potential productivity determined for the study area may be

Table 8.3 – Predicted population change in the study areas

Period	Area(s) losing population	Area(s) gaining population
1	Dolores, Mockingbird Mesa	Woods Canyon
2	Dolores, Woods Canyon	Mockingbird Mesa, Woods Canyon
3	Dolores, Mockingbird Mesa	Woods Canyon, Mockingbird Mesa
4	Dolores	Woods Canyon, Mockingbird Mesa
5	Dolores, Woods Canyon	Mockingbird Mesa
6	Dolores, Woods Canyon	Mockingbird Mesa
7.1	Dolores, Mockingbird Mesa	Woods Canyon
7.2	Dolores, Woods Canyon	Mockingbird Mesa
7.3	Dolores, Mockingbird Mesa	Woods Canyon
7.4	Dolores, Woods Canyon	Mockingbird Mesa

Areas are listed in order of greatest to least expected change.

assumed to apply to the Dolores area used here. In the following discussion, Orcutt's figures are adjusted to account for the size difference between the Dolores area and her study area (65.5 km^2 and 137 km^2, respectively).

Orcutt's area was divided into 4-ha units, each of which was assumed to be capable of producing approximately 7 585 000 kcal from corn when conditions were good. The yield from each unit was adjusted for cold air susceptibility, soil quality, drought conditions, and a fallow period that kept half the lands out of production at any one time. Yields from all the units within the Dolores area were totaled to provide the average annual corn yield in kilocalories per period (table 8.4). Potential population figures, calculated by allowing an annual consumption rate of 329 kcal per person, are also provided in table 8.4. This consumption rate is set to equal half the estimated annual caloric requirement for the average human, using a figure of 1800 calories as the daily requirement (Hassan 1981:48).

The potential population for the Dolores area ranges from a low of 4644 people in Period 7.1 to a high of 6540 people in Period 4. A trend toward increasing potential population or increasing supportable population occurs from Periods 1 through 4. The support level declines sharply in Period 5, rises slightly in Period 6, and then declines again in Period 7.1. After Period 5 (ca. A.D. 880 to 920), the support level falls below that projected for any of the preceding periods. In general, then, this analysis suggests a 2-part division of the Dolores sequence, a period of rising support levels or rising potential for population from A.D. 600 to 880 and a period of lowered potential after A.D. 880.

Population Change in the Dolores Area

Changes in population size, density, growth rate, and habitation size were studied as part of the DAP modeling studies. The greatest research effort went into determining population size for the area, an endeavor requiring a series of studies to be made, including an analysis of site types and typological assignments for sites known primarily from survey records (Schlanger and Orcutt 1985); selection of an appropriate population proxy measure (Schlanger 1985); experimentation with methods of estimating site size from surface evidence such as rubble mound area, overall site size, and length of the rubble mound (Wilshusen 1982); and determination of structure longevity and duration of site occupation (Schlanger 1985). The results of these studies are summarized here.

Calculating the Dolores area population for each of the time periods involved the following steps, progressing from the Dolores area archaeological data to estimates of population size: (1) identification of habitations; (2) determining the number of proxy population units present at each site; (3) determining in which period or periods the site was occupied; (4) figuring the duration of site occupation; and (5) assigning a population total to the site.

Identification of Habitations

Habitations were identified by reference to a site type model that specified differences between 3 general types of sites expected in the Dolores area: (1) nonresidential sites, or limited activity loci; (2) short-term summer residences, or seasonal loci; and (3) permanent residences, or habitation loci. Only habitation loci were included in the calculation of human population totals for the Dolores area because these sites represent the year-round occupations. Inclusion of seasonal loci or limited activity loci would risk an overestimate of local population.

Habitations in the Dolores area are "occupied continuously, or for a major portion of the year" and "substantial architectural remains such as rooms, pitstructures, and outside work areas are usually present" (Kane 1983:23). These sites are the locus of most personal maintenance activities (including housing and food preparation, storage and consumption) and tool manufacture and maintenance activities. The architectural features associated with these sites include domestic pitstructures, integrative pitstructures (kivas and great kivas), above-ground living rooms, storage rooms, ramadas, and cists. Above-ground structures shift from small, usually round or oval, noncontiguous rooms early in the occupation of the Dolores area to rectangular, contiguous rooms arranged in single or

Table 8.4 – Potential kilocalories of corn production and levels of population support

Period	Average annual kcals of corn* ($\times 10^3$)	Potential population†	Actual momentary population estimate	Percent of potential	Maximum population§	Percent of potential
1	1 926 105	5854	13	0.2	125	2.1
2	2 029 562	6169	185	3.0	1225	19.9
3	2 014 069	6122	290	4.7	970	15.8
4	2 151 826	6540	1250	19.1	4175	63.8
5	1 734 283	5271	675	12.8	2255	42.8
6	1 915 962	5824	45	0.8	230	3.9
7.1	1 534 338	4664	65	1.4	245	5.3
7.2	1 772 754	5388	95	1.8	585	10.9
7.3	1 833 906	5574	10	0.2	60	1.1

* Corn production figures based on 50 percent fallow.
† Potential population based on 50 percent corn diet, 329 kcal/year.
§ Maximum population represents a total of people per period, not adjusted by length of period.

double rows late in the occupation. Walls in the early rooms are made of jacal or mud turtlebacks and stone. Walls in the later contiguous rooms usually feature a stone slab or cobble base, above which there is either coursed stone masonry topped with jacal (ordinarily in the back rooms of the double row roomblocks), or jacal and dirt (primarily in the front rooms) (Kane 1984a; Lipe and Breternitz 1980).

Unexcavated sites that exhibited substantial architectural remains, including upright sandstone slab alinements, large pieces of unshaped rubble, masonry walls and wall fall, and evidence of subsurface pitstructures were identified as habitations. Analysis of the surface artifact assemblages associated with these sites confirmed these identifications (Schlanger and Orcutt 1985). Such sites are distinguished from those exhibiting no domestic architectural features or small concentrations of small chunks of sandstone rubble (identified as limited activity loci and seasonal loci, respectively) by generally higher numbers of artifacts, but fewer types of artifacts per collection unit than are encountered at the other site types. Habitation collections contain absolutely greater numbers of types of artifacts, however. In comparison to seasonal loci (the other site type with domestic architecture found in the area), the assemblages from habitations contain relatively high proportions of flaked lithic tools and debitage and relatively lower proportions of gray ware sherds and manos (Schlanger and Orcutt 1985). The higher proportion of gray ware sherds and manos at the seasonal loci are expectable consequences of summer residence patterns that necessitate water storage and transportation, a casual camp life, and corn processing activities.

Site type determinations for those sites for which no architectural information was available were made using a discriminant function technique (Klecka 1980). The discriminant function was created from a set of known habitation sites and sites that fit the architectural model (Schlanger and Orcutt 1985). Some sites could not be satisfactorily placed in any of the 3 types, because of either insufficient data in the surface collection or insufficient data about the architectural type.

Proxy Population Measures and Estimation of Site Size

The living, or dwelling, room was chosen as the best population proxy for the Dolores area. These living rooms are used as the architectural expression of a household, a population unit that may be translated more directly into estimates of population size. A structure-based proxy was selected because structures or structural remains are relatively easy to detect in the field, and survey field crews were specifically instructed to search for architectural remains and to record them in detail, and because the excavation of about 400 prehistoric structures in the Dolores Project area (Kane 1984a) has resulted in a considerable body of information on structure function, form, construction, relationships between architectural elements at sites, and relationships between structure form and function (Wilshusen 1984; Glennie and Lipe 1984; Hewitt et al. 1983; Varien 1984; Lightfoot 1984; Gross and Wolf 1984; Kane 1984a).

Two types of living rooms are present in the Dolores area. Domestic activities, marked by roofed, enclosed rooms with hearths, storage, and food preparation facilities, took place in pitstructures early in the local archaeological sequence and in both surface structures and pitstructures later. The greatest portion of the occupation of the Dolores area took place between A.D. 600 and 950, a period of architectural innovation and

variety in structures and structure arrangements. The question was which structures were residences (contained fire hearths, were roofed or fully enclosed, and had a large enough floor area to accommodate at least one sleeping person) and should be included in dwelling rooms counts for the purpose of estimating human population at the site?

The earliest habitations assigned to the A.D. 600-950 occupation pose no problem because only one type of domiciliary structure, the pithouse, is present. At sites occupied between A.D. 700 and 900, however, the situation is confused by the frequent presence of surface structures and pitstructures, both of which exhibit features characteristic of domiciliary structures. No clear concensus on the relative functions of pitstructures and surface dwelling rooms has emerged from the recent, well-documented debate on this subject (Gillepsie 1976; Bagley-Baumgartner 1984; Gilman 1983; Powell 1980; Breternitz 1982; Kane 1984b). The major focus of the debate is the seasonal use of the 2 structure types, with surface rooms in the position of potential summer dwellings and pithouses in the position of potential winter dwellings for the same occupying group. If surface rooms and domiciliary pithouses are seasonally occupied, but functionally equivalent, counting both will result in an overestimate of the number of dwelling rooms present, and will eventually result in estimates of local population that are too high. If both types of rooms are occupied simultaneously, however, failure to count one will result in underestimates of local population.

This problem was resolved for this study by reference to the floor area enclosed in each type of structure at different times (Schlanger 1985). Three questions are relevant to the winter-summer problem. First, are pitstructures larger than surface structures, on the average? Because the ratio of surface dwelling rooms to pitstructures often exceeds 1:1, occupants of the surface rooms would have to share a winter pitstructure. Second, are the pitstructures larger than the combined area of their associated surface dwellings? Third, could the households occupying the surface structures all fit into the pitstructures during the winter, or any other season? Data for this analysis came from a sample of 14 pitstructures and their associated surface structures chosen to span the period between A.D. 600 and 920.

A comparison of pitstructure floor area to surface dwelling room area per household in surface structures revealed that in the majority of cases (10 of 14 cases), pitstructures were larger than the average associated surface dwelling, lending support to the winter-dwelling hypothesis (Schlanger 1985). When pitstructure area was compared to aggregate surface dwelling area, a temporal trend emerged. For those samples occupied before A.D. 780 or 800, pitstructure area was larger than the associated surface dwelling total. After A.D. 800, surface dwelling space was greater than pitstructure space. These results support the winter pitstructure dwelling hypothesis for the pre-A.D. 800 occupation, but fail to support the hypothesis for the post-A.D. 800 occupation (Schlanger 1985). When pitstructure space per surface dwelling room is compared with average surface dwelling room area, addressing the third question, A.D. 800 again appears to mark a boundary in structure use. After A.D. 800, pitstructure space per surface dwelling room falls below the average surface dwelling room area. This indicates living in the pitstructure during the winter would have entailed a considerable reduction in space per person. Given an average of 4 to 6 people per surface dwelling room and 1.5 m^2 per person, surface room occupants attempting to fit into pitstructures in the winter would have taken up all the available floor space making this an impossible situation (Schlanger 1985). These analyses indicate the pitstructures associated with surface dwelling rooms after A.D. 800 were probably not used as domiciles by the entire occupying group.

The solution to the problem of what to count as a proxy population measure was to use the number of surface dwelling rooms per site for those sites occupied after A.D. 800 and to use the median number of pitstructure dwelling rooms per site, derived from excavated sites, as the population proxy measure for those sites occupied between A.D. 600 and 800 unless surface architectural remains were substantial.

The number of dwelling structures present at sites occupied after A.D. 800 was estimated from the quantity and dimensions of rubble mounds composed primarily of sandstone rubble and decomposing building stone. A conversion factor of 50 m^2 per dwelling room was used to estimate dwelling room and household totals. This figure was chosen after reviewing work on the relationship between various measures of site size and number of households, or dwelling units, in the Dolores area (Wilshusen 1982), a consideration of the size of structures, and a consideration of the amount of rubble present per household at sites that had been completely or nearly completely excavated (Schlanger 1985).

Assigning Sites to Periods

All temporal site assignments used to estimate population for the Dolores area are based on ceramic assemblages from the modern ground surface for sites at which no excavation was conducted and ceramic assemblages from both surface and excavated proveniences for those sites at which excavation took place. The assignment method followed Blinman (1983, 1984).

Temporal assignments for both surface assemblages and households inferred from excavation data are available for a set of 21 sites in the area, enabling a comparison of the 2 assignment methods. All 21 sites were completely or almost completely excavated and the surface assemblages contain either all artifacts visible on the site surface prior to excavation or a 50-percent sample of the site surface artifacts, with collection units arranged in a checkerboard pattern across the site surface. The surface collection assignment and the excavation assignment are the same or very nearly the same (i.e., Period 4 for the surface collection and Periods 4.2 through 5.1 for the excavation material) for 14 (67 percent) of the 21 sites. In 5 cases (23.8 percent), the surface collection assignment did not include an earlier occupation or indicated a later occupation than the excavation assignment. In 2 cases (9.5 percent), the surface collection assignment did not include a later component indicated by excavation. In 3 cases (14.3 percent), the surface collection assignment contained a later component not picked up by the excavations. Presumably these later components did not include habitations (Schlanger 1985).

Estimating Site Occupation Duration

Site occupation duration was estimated from data on structure lifespans, data on the number of remodeling episodes per structure, and the length of occupation spans based on period assignments.

Archaeological evidence from 25 structures with tree-ring dates, archaeomagnetic determinations, ceramic assemblage date assignments, and stratigraphic data indicate that a structure lasted no more than 30 years (Schlanger 1985); ethnographic evidence and remodeling studies based on the data collected by the University of Arizona Laboratory of Tree-Ring Research (Ahlstrom 1984) suggest an average life expectancy of about 10 to 12 years.

Remodeling evidence, primarily in the form of multiple floor-building episodes, indicates relatively few of the structures in the Dolores area were remodeled. Only about 11 percent of a sample of 601 surface rooms and 65 pitstructures with excavation-based evidence for the number of floors had more than 1 floor. Rooms built early in the Dolores occupation (between A.D. 600 and 800) have higher frequencies of multiple floors than do rooms built between A.D. 800 and 920. Rooms built between A.D. 920 and 1150 have the highest incidence of multiple floors (47.4 percent for surface structures and 22.2 percent for pitstructures [Schlanger 1985]); however, 9 of the 10 structures with 3 or 4 floors belong to the middle portion of the occupation (between A.D. 800 and 920). The largest number of floors per structure in the sample is 4.

Data from excavated sites indicates that the smaller sites, with 2 or fewer households, have occupations of fewer than 30 years; sites with 3 or more households tend to be occupied considerably longer (Schlanger 1985). Larger sites first occupied in Period 2 (between A.D. 720 and 800) tend to increase in size through Period 5 (A.D. 880-920). Sites originally occupied during Period 4 (A.D. 840-880) tend to have occupation spans of 80 to 100 years, with a maximum population size in late Period 4 or 5 (Schlanger 1985). These data fit fairly well with the remodeling frequencies. Although sites in the early and late portions of the occupation had higher frequencies of multiple floors, most of the structures with multiple floors in these periods had only 2 floors, supporting the notion that total site occupation length for these periods was 30 years or less. Sites occupied in the middle portion of the occupation (A.D. 800-920) had the highest incidence of 3-floor and 4-floor structures, which supports the other excavation evidence for longer occupation spans during this period.

Household Totals and Population Size Estimates for the Dolores Area

The number of households estimated for the Dolores area for each period is presented in table 8.5. Momentary household population figures, or the average household population present at any time during a period, are calculated by multiplying the total number of dwellings by an adjustment factor, dwelling uselife/length of period, that corrects the estimate for uselives of structures and the length of the period. Twelve years was used as the uselife value for dwellings with 1 floor, and 24 years was used as the uselife value for structures with more than 1 floor. The proportions of dwellings with 1 floor and more than 1 floor were taken from analyses described earlier and in Schlanger (1985). The household figures were transformed to human population estimates by allowing 5 people per household, following a review of ethnographic and archaeological evidence for household size among native peoples of the American Southwest (Schlanger 1985).

The reconstructed population curve for the Dolores area (fig. 8.4) shows a very low momentary population for Period 1 (A.D. 600-720) followed by increasing momentary population levels from Period 1 through Period 4 (A.D. 600-880). The population rise between A.D. 800 and 880 (i.e., from the beginning of Period 3 to the end of Period 4) is quite large and represents more than a 4-fold increase in momentary population. After Period 4, momentary population drops quickly to about 1/2 of the previous level by Period 5 (A.D. 880-920) and then drops drastically again to the level estimated for Period 6 (A.D. 920-980). Momentary population rises during Periods 7.1 and 7.2 (A.D. 980-1100), but falls again in Period 7.3, the last occupation

Table 8.5 – Estimated momentary household and human population

Period	Momentary household population	Momentary human population
1	3	13
2	37	185
3	58	290
4	250	1250
5	135	675
6	9	45
7.1	13	65
7.2	19	95
7.3	2	10

period in the Dolores area, to a level approximately equal to that in Period 1. The whole pattern is a remarkably balanced rise and fall in Dolores area population.

Population Density and Relationship to Arable Land

The estimated population maximum of 1250 people in Period 4 gives a maximum population density for the 65.5-km² Dolores area of about 19 people per km². This figure is somewhat misleading, however, because not all of this land is arable. The amount of arable land in the area may be estimated by using Orcutt's (1985) data on the potential returns, in kilo-calories of corn per year, for the land in the Dolores area. Orcutt's calculations give a figure of about 3392 ha (35 km²) of land capable of producing some corn during each year of the Dolores occupation. The amount of land capable of producing enough corn to supply half of an individual's caloric requirements for a year, calculated as a minimum of 329 kcal (based on 50 percent of the annual 657-kcal figure used by Hassan [1981:48]), is estimated at 2276 ha for the duration of the Dolores occupation. When density estimates are adjusted for arable land, maximum achieved population density falls at about 37 people per km² of land for which some return may be expected and 54 people per square kilometer of land capable of supplying the annual corn requirement per capita. Density per period for each estimate of arable land is presented in table 8.6.

The Dolores situation may be profitably compared with that at Oraibi, a Hopi village at the southwestern edge of Black Mesa in northeastern Arizona (Bradfield 1971). Bradfield's study is used for comparison because it is the best documented work of this kind known to the author. The Hopi are not perfectly analogous to the Dolores area Anasazi, however, as they currently cultivate foods not used prehistorically (e.g., wheat, alfalfa, chili, peaches, apples, plums, and cherries) but introduced by the Spanish in the 17th century (Dozier

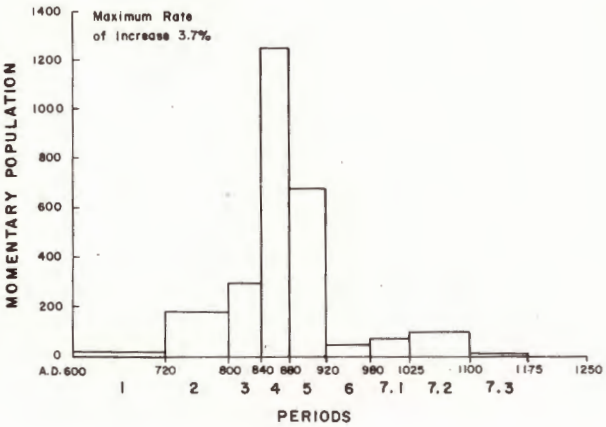

Figure 8.4 – Estimated Dolores study area momentary population, A.D. 600 to 1250.

1970:127), and because they engage in trade for sheep with their Navajo neighbors. Corn remains their primary crop, grown almost entirely for local consumption and the level of corn production is probably close to that of the prehistoric Anasazi.

Arable land figures for the village of Oraibi were estimated from Bradfield's (1971:pocket map) map of cultivated lands in the Oraibi Valley. These estimates include all land in the main river flood plain and tributary valleys up to the boundary of the foot of the side valley slopes. These areas contain almost all of the currently cultivated fields and abandoned fields mapped by Bradfield. The remaining fields, fed by springs and seeps near Old Oraibi, were also included in the estimate of arable land. Orchards and lands in the general location of existing orchards were not included in the total.

Population maximum densities, and available acreage per person for the Dolores area and for Oraibi are given in table 8.7. These figures show Dolores area population density may have been as much as twice as high as that identified by Bradfield at Oraibi. If the Dolores area were populated at the Oraibi density, maximum population would have been around 710 people using the arable lands capable of producing some corn, and 481 people using the figure for arable lands capable of supporting 1 individual for 1 year. Estimated momentary populations for Periods 4 and 5 both exceed these maximums (table 8.6).

It is also informative to compare the Dolores area figures with the Oraibi figures from the standpoint of available acreage per person. Bradfield (1971) estimates the Hopi plant 2 acres to corn per individual per year, and plant an additional half acre to other crops, including the cotton, tobacco, beans, and squash, cultivated prehistorically, bringing the total cultivated

Table 8.6 – Population density and acreage per person

Period	Estimated momentary population	Acres per person producing		Persons per km² producing	
		some	enough	some	enough
1	13	106.0	71.0	0.4	0.6
2	185	7.4	5.0	5.4	8.0
3	290	4.7	3.2	8.5	12.6
4	1250	1.1	0.7	36.8	54.3
5	675	2.0	1.4	19.9	29.3
6	45	30.5	20.5	1.3	2.0
7.1	65	21.1	14.2	1.9	2.8
7.2	95	14.4	9.7	2.8	4.1
7.3	10	137.3	92.1	0.3	0.4

Table 8.7 – Comparison of Dolores area and Oraibi population densities

Sample	Maximum population	Area (km²)	People per km²	Acres per person
Dolores area land with "some" production capability	1250	34	36.8	1.1
Dolores area land capable of supplying "enough" corn for an individual	1250	23	54.3	0.7
Village lands at Oraibi ca. A.D. 1900	800	42	20.9	11.8

acreage up to 2-1/2 acres per person (Bradfield 1971:21). This estimate is also supported by Woodbury (1961:38), who used Stephen's report from the Hopi Mesas (Parsons 1936:954-955) and Hack's (1942:10) research on Hopi land use in the A.D. 1930's, in Woodbury [1961:38]), to estimate that "the Hopi and their ancestors have probably always needed to plant 3 or 4 acres per person each year. . . As a guess we can use 2 acres per person as the minimum" (Woodbury 1961:38).

With total arable land based on acres capable of supporting an individual, the Dolores inhabitants would have had fewer than 2 acres available per person from Period 4 through Period 5 (A.D. 840-920) (see table 8.6). When they plant 2-1/2 acres per person, the Hopi at Oraibi are actually cultivating only 20 percent of the land potentially available for cultivation. At this rate, the Dolores occupants would have been planting over 20 percent of the available acreage during Periods 2, 3, 4, 5, 7.1, and 7.2. Planting at a rate of 2-1/2 acres per person allows a maximum population density of 100 people per km², a density that was never attained by the Dolores occupants (table 8.6).

Co-residential Group Size

Co-residential group size, where the group is comprised of those households living in physical proximity, with the potential for face-to-face encounters during ordinary daily activity, represents another aspect of population density. Two measures of co-residential group size are presented here: (1) the number of households per excavated site; and (2) the number of households per contiguous roomblock (table 8.8). A full discussion of the methods used to arrive at these figures is presented by Schlanger (1985).

Households per site. – The median, rather than the mean, number of households per site is discussed here because the mean is highly influenced by the value for 1 site, Grass Mesa Village (Site 5MT23).

The median number of households per site reaches a peak during Period 4; the range in household numbers per site also peaks at this time. The greatest number of households per site occurs at Grass Mesa Village, which lies on an isolated finger of land above the confluence of two watercourses. Both its placement and its size are apparently unique in the Dolores Project area. The next largest site in this period is still larger than any other site in any other period; in fact, the next 4 largest sites assigned to Period 4 are still larger than anything found in the other periods.

The high median number of households per site in Period 4 is maintained through Periods 5 and 6, and the

distribution of the values for median household number per period suggests 2 groups: (1) those periods characterized by sites of 1 or 2 households (i.e., Periods 1, 2, and 7.3), and (2) periods with 5 to 7 households per site (i.e., Periods 4, 5, and 6). Sharp breaks in median number of households per site occur between Periods 3 and 4 and Periods 6 and 7.

The distribution of households per site through time (fig. 8.5) shows a predominance of sites with 1 and 2 households for Period 1, 2, 3, and 7. During Periods 4 and 5, there is a wide range of households per site.

Households per rubble mound. – Data on rubble mound size are available for the 94 sites that could be assigned to a single period. The inferred number of households per rubble mound, using a conversion factor of 50 m^2 of rubble to 1 household, is at a peak during Periods 5 and 7 (table 8.8). These data are interpreted to mean that the size of some cooperating social unit, the members of which lived in contiguous rooms and so had some daily contact, was at a peak in the Dolores area during these periods. Period 4, which has the highest overall momentary population and the highest median number of households per site, has roomblock units similar in size to those in Periods 1, 2, 3, and 6. Period 1 is a time of very low momentary population in the Dolores area, Periods 2 and 3 are times of rising population, and Period 6 is a time of declining population. That Period 4 should share roomblock size characteristics with Periods 1, 2, and 3 suggests the high population achieved in Period 4 was the result of a coalescence of groups of a size common to these periods. The rise in roomblock size in Period 5 suggests a change in the internal organization of these clusters of rooms. This change apparently did not survive into Period 6, a time of sharply reduced population.

Population Growth Rates

Population growth rates were calculated using the following formula:

$$r = \ln (N_2/N_1) / t$$

where N_1 is the population of the earlier modeling period, N_2 is the population of the later modeling period, and t is the time between modeling periods.

Two ways of calculating the time between periods are presented in table 8.9; elapsed time is reckoned from period midpoint to midpoint, and maximum elapsed time is calculated from the beginning of the first period to the end of the later period.

Potential Rates of Increase for the Dolores Area

The potential rate of increase possible for any given population may be estimated from several population parameters: (1) average lifespan for women after they reach childbearing age; (2) birth spacing; (3) total births per female, or the gross reproduction rate; (4) mean age at childbearing, or the generation length; and (5) net reproduction rate, or the gross reproduction rate reduced by the proportion of women surviving to the mean age at childbirth. Values for these parameters were estimated for the Dolores area as: (1) average lifespan of 30 years for those who reach reproductive age (Stodder 1983; Schlanger 1985); (2) 28 months birth spacing (Hassan 1981:127); (3) 5 births per female (Schlanger 1985); (4) mean childbearing age of 24 years (Hassan 1981:139, Schlanger 1985); and (5) a net reproduction rate of 1.44 (Schlanger 1985).

The potential natural growth rate for a stable population in the Dolores area is calculated as the Lotka rate (P), which is derived from the net reproduction rate as follows:

$$P = (y\ NRR) - 1$$

(Source: Hassan 1981:139) where y is the mean age at childbearing, or 24, and NRR is the net reproductive rate (1.44), which is the gross reproductive rate of 5.14 (reproductive period of 12 years, child spacing of 28 months) adjusted by the proportion of female births (48.8 percent) and then adjusted by the proportion of women who survive to the mean age of childbearing (57.4 percent in the Mesa Verde sample).

For the Dolores area, P is estimated as 0.0153, which represents an annual increase of 1.53 percent, or 15 people per thousand.

Alternatively, growth potential may also be calculated as

$$r = \ln (NRR) / GL$$

(Hassan 1981:139) where GL is the generation length, or the mean age at childbirth.

This equation yields a value of 0.0152 for r, almost identical with the Lotka rate figure. If a generation length of 20 years is used instead of 24 years, these calculations give growth values of 0.0244 for P and 0.0241 for r.

The potential growth rate of population in the Dolores area can be estimated to fall between 0.015, or 1.5 percent per year, and 0.024, or 2.4 percent per year. The true maximum growth rate probably lies toward the upper end of this range; the lower end of the range is a conservative estimate of the potential growth rate for the area.

When the empirically derived rates exceed the theoretical maximum range of 0.015 to 0.024, growth in the

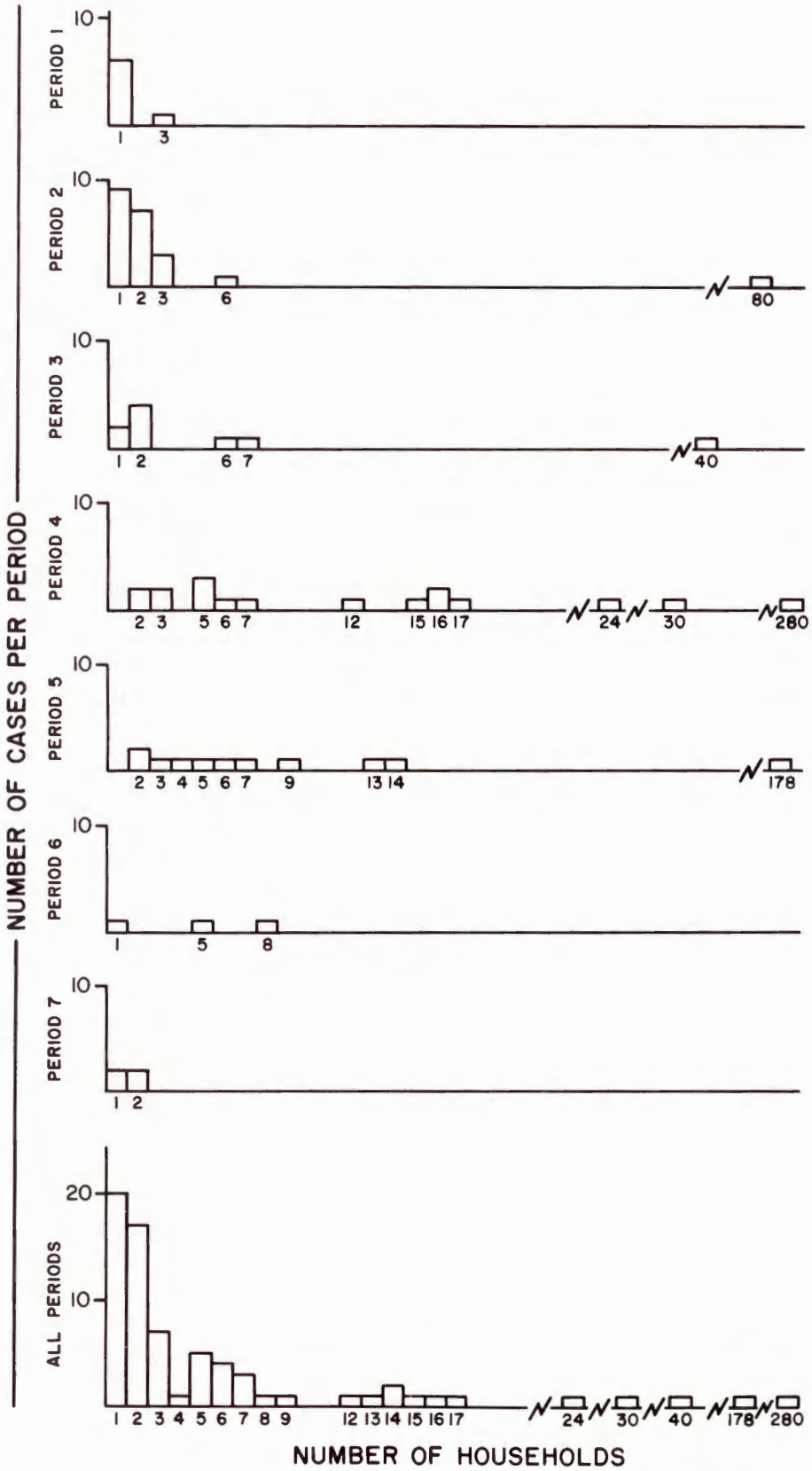

Figure 8.5 – Distribution of households per site by period in the Dolores study area.

Table 8.8 – Households per site and households per rubble mound

Period	Mean No. of households per site	Median No. of households per site*	No. of cases	Range in household No. per site	Mean rubble area	No. of cases	Households per rubble mound
1	1.3	1.0	7	1-3	117.6	7	2
2	5.6	2.0	21	†1-80, 1-6	126.1	25	2
3	7.0	2.0	9	†1-40, 1-7	92.3	6	1
4	26.4	7.0	17	†2-280, 2-30	132.8	19	2
5	21.4	6.5	12	†2-178, 2-14	200.2	31	4
6	4.7	5.0	3	1-8	64.0	1	1
7	1.5	1.5	4	1-2	288.8	5	5

* Excavated sites only.
† Grass Mesa figures. Second range is with Grass Mesa removed from the sample.

Table 8.9 – Growth rates in the Dolores area

Periods	Measured from period midpoint to midpoint	Measured from beginning of first period to end of next period
1 to 2	0.0266	0.0133
2 to 3	0.0075	0.0037
3 to 4	0.0365	0.0183
2 to 4	0.0190	0.0119
1 to 4	0.0230	0.0160
4 to 5	-0.0156	n.o.
5 to 6	-0.0544	n.o.
6 to 7.1	-0.0066	n.o.
7.1 to 7.2	0.0061	n.o.
7.2 to 7.3	-0.0313	n.o.

n.o. – No observation possible.

Dolores area may be considered to be in excess of what might be expected from local population growth alone. Such instances point to times of probable population movement into the area. A period by period analysis (table 8.9) indicates 2 episodes of high growth rate; growth between Periods 1 and 2 and growth between Periods 3 and 5 exceeds the theoretical maximum when rate of growth is calculated using the period midpoints. Growth rates do not exceed the upper theoretical maximum when the maximum elapsed time period method is used, although the growth rate between Periods 3 and 4 does exceed the lower limit of the theoretically achievable range. This analysis indicates that movement into the area is at least partially responsible for the high population in Period 4. The jump in population during Period 2 may also be partially due to population movement into the Dolores area.

Regional Population Change

Regional population was studied directly, by comparing the population trends in the Dolores area with those in the Woods Canyon and Mockingbird Mesa areas, and indirectly, by analyzing the proportion of ceramics in the Dolores area assemblages that originated outside the region, particularly in the vicinity of the 2 comparison areas.

Regional Population Trends

Population changes within the region defined by the Dolores area on the north and Mockingbird Mesa on the south were studied through an analysis of 3 population samples: (1) the habitations recorded in the Dolores area; (2) the habitations recorded in the Woods Canyon area; and (3) the habitations recorded on Mockingbird Mesa. Determinations of which sites represented habitations followed the methods outlined previously. Only those sites that could be placed into a single period or into 1 of 2 consecutive periods on the basis of the ceramic assemblage from the surface collection or on the basis of excavation data, were included in the analyses. As site size data for the Woods

Canyon and Mockingbird Mesa areas was not as complete as the data for the Dolores sample, the Dolores area sample parameters for median site size per period and site occupation duration were used to estimate sizes in these areas. Estimates of median site size per period for the periods after A.D. 980, when the Dolores data are poor, were made from the site size information reported by Rohn (1971) and Hayes (1964) for Chapin and Wetherill Mesas, Mesa Verde National Park. The Mesa Verde figures are the best data currently available from anywhere relatively close to the study region.

The procedure used to generate population estimates for the 3 samples follows. First, site total per period was adjusted by median number of households per site and estimated frequency of structure reoccupation. These parameters were taken from the Dolores area analyses reported earlier. Second, momentary population, in households, was determined by adjusting the household population total for site occupation duration (set at a conservative figure of 20 years). Third, momentary household population was multiplied by 5 to get the final momentary human population figures. For purposes of consistency, the Dolores sample was treated in the same way as those from Woods Canyon and Mockingbird Mesa. The Dolores population curve estimated in this manner differs from the Dolores population curve presented earlier (fig. 8.4), primarily in the relative sizes of the Period 7.1 and 7.2 occupations. In the earlier curve, based on actual site by site estimates of size for the Dolores area, momentary population rose from Period 6 to Period 7.2. In the curve based on Dolores area parameters for median site size and site occupation duration, population decreases slightly from Period 6 through Period 7.3. Period 3 population is also slightly higher in the curve derived directly from the Dolores data.

The percentage of sites per period per area and the percentage of momentary population per period per area are presented in figures 8.6 and 8.7; the actual population values are listed in table 8.10. The shape of the curve based on numbers of sites, which can be taken as an index of site construction or foundation activity, differs from that made by the estimated momentary population, which may be considered as a sort of occupation intensity index. The difference is particularly pronounced for the Dolores area, where the greatest population occurs during Periods 4 and 5, both of which have relatively high numbers of households per site compared to the earlier period. The 2 measures result in similar graphs for the Woods Canyon and Mockingbird Mesa areas, which exhibit very low levels, or no habitations at all, during Period 4.

These figures are drawn to show the relative distribution of sites or population per period within each area;

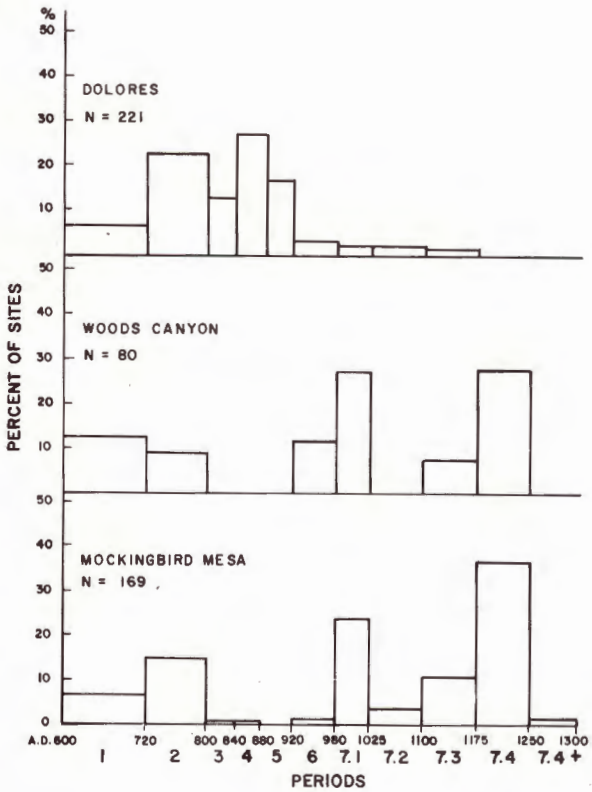

Figure 8.6 – Distribution of sites by period in the Dolores, Woods Canyon, and Mockingbird Mesa study areas.

the actual numbers of sites or people are different from area to area. For example, a drop of 10 percent in the Dolores area represents a loss of about 240 people, whereas a drop of 10 percent in the Woods Canyon area represents a loss of about 60 people. These 3 areas are only samples from a much larger region, and as relative population levels fall and rise in one area, there may be no corresponding absolute increase or decrease in another area.

Site construction or establishment activity is high in the Dolores area during Periods 2, 3, 4, and 5, with Periods 2 and 4 registering the greatest site foundation rates. Site construction activity is highest in Periods 7.1 and 7.4 in the Woods Canyon and Mockingbird Mesa areas. Interestingly, construction activity in all 3 areas is relatively high for Periods 1 and 2. Site construction activity in the Dolores area forms a fairly smooth curve, rising to a peak in Period 4, with a secondary peak in Period 2, and then falling steadily through Period 7.3. The pattern of site establishment activity in the other 2 areas is similar, with gaps of low points between Periods 2 and 6, and again between Periods 7.1 and 7.3. The Woods Canyon curve shows longer and more pronounced gaps than does the Mockingbird Mesa curve.

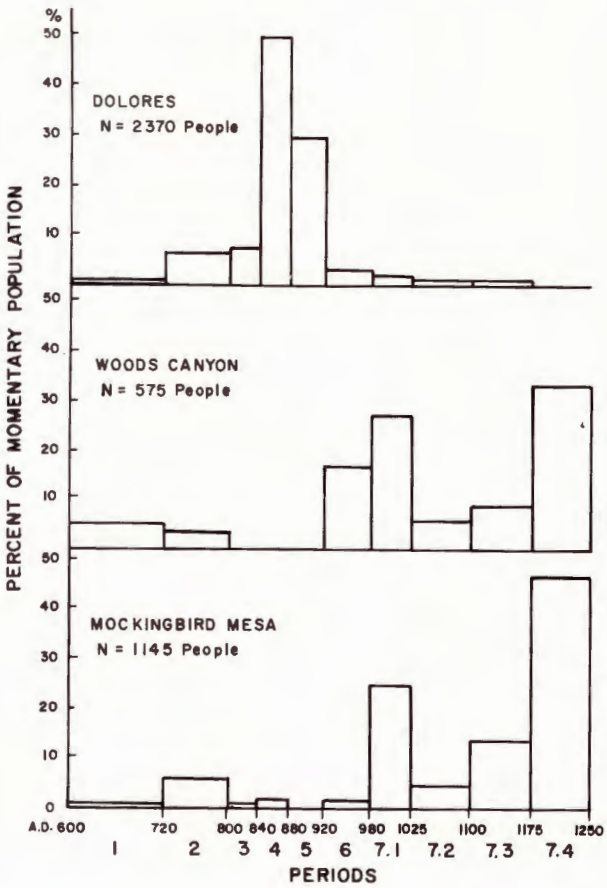

Figure 8.7 – Estimated momentary population by period in the Dolores, Woods Canyon, and Mockingbird Mesa study areas.

The estimated momentary population curves are similar to the site curves. For the Dolores area, the rise and fall pattern is even smoother for these data than for the site distribution data. The same gaps and low spots that occurred in the Woods Canyon and Mockingbird Mesa patterns for sites are present in the estimated momentary population histograms.

The most striking feature of these graphs is the correspondence between peaks on the Dolores graph and troughs on the graphs of site and population distribution for the other 2 areas. The relatively high population early in the occupation of the Woods Canyon and Mockingbird Mesa areas correspond to low levels in the Dolores area, particularly in Period 1. While population remains stable or climbs slightly in the Dolores area during Period 3, population and sites drop drastically in the other two areas. The remarkable peak in the Dolores pattern in Period 4 is matched by absences or extremely low site and population levels in the other 2 periods. The re-establishment of population in the Woods Canyon and Mockingbird Mesa areas during Period 6 occurs during continued decline in the Dolores area. Surprisingly, however, when population begins to decline abruptly in Period 5 in the Dolores area, no corresponding increase in population or sites occurs in the other 2 areas. The relative population boom in the Woods Canyon and Mockingbird Mesa areas during Period 7.3 and especially during Period 7.4, is matched by very low population levels and an absence of population altogether in the Dolores area. Period 7.2, when the Dolores area experiences a slight rise in population (fig. 8.7), corresponds to a drop in population in the Woods Canyon and Mockingbird Mesa areas. These correspondences are a good indication that the Dolores area, the Woods Canyon area, and the Mockingbird Mesa area were all occupied by the same regional population.

The Regional Contribution of Dolores Area Ceramic Assemblages

The composition of Dolores area ceramic assemblages was examined for evidence of population change and movement within the region. When people were present in the 3 areas, Dolores assemblages are expected to contain ceramic pieces that were manufactured in all 3 areas, as the regional populations exchanged goods and services throughout the region. When populations were absent from Woods Canyon and Mockingbird Mesa, the contribution of ceramics from these areas is expected to decline in proportion to those items manufactured in the Dolores area.

Areas of ceramic manufacture, or "manufacturing tracts" (Lucius 1981), are identified for the Mesa Verde region on the basis of tempering material, clay characteristics, paint type, and design style (Blinman and Wilson 1985). Four manufacturing tracts occupying three geographic areas are important to this analysis.

Dolores Manufacturing Tract

This tract is characterized by a "particular variety of crushed igneous rock temper" (Blinman and Wilson 1985:11). The geographical extent of the Dolores Tract covers much of the region except for a section near the center (Blinman and Wilson 1985:fig. 1). The excluded section stretches from the southern and western borders of the Dolores area southward and westward in a fan-shaped area that includes the Woods Canyon and Mockingbird Mesa sample areas.

San Juan Manufacturing Tract

The San Juan Tract is characterized by a second variety of crushed igneous rock temper. This tract is located to the south of the Dolores area and to the east of the Utah-Colorado border, with the highest frequencies of

Table 8.10 – Site and population estimates for the Dolores, Woods Canyon, and Mockingbird Mesa areas

Period	Dolores					Woods Canyon				Mockingbird Mesa				Woods Canyon and Mockingbird Mesa
	Sites		Population		Population	Sites		Population		Sites		Population		Population
	N	%	N	%	per km²	N	%	N	%	N	%	N	%	per km²
1	13	7.8	15	–	0.4	3	7.9	30	5.2	5	4.5	10	0.9	1.0
2	44	26.3	145	6.1	4.3	1	2.6	20	3.5	7	6.3	70	6.1	7.0
3	27	16.2	170	7.2	5.0	0	0.0	0	0.0	0	0.0	5	0.4	0.5
4	40	24.0	1170	49.4	34.4	0	0.0	0	0.0	0	0.0	20	1.7	2.0
5	28	16.8	705	29.7	20.7	0	0.0	0	0.0	0	0.0	0	0.0	0.0
6	6	3.6	75	3.2	2.2	3	7.9	95	16.5	2	1.8	20	1.7	2.0
7.1	3	1.8	40	1.7	1.2	13	34.2	155	27.0	30	26.8	285	24.9	28.5
7.2	3	1.8	25	1.0	0.7	4	10.5	35	6.1	5	4.5	50	4.4	5.0
7.3	3	1.8	25	1.0	0.7	3	7.9	50	8.7	14	12.5	155	13.5	15.5
7.4	0	0.0	0	0.0	0.0	11	28.9	190	33.0	49	43.8	530	46.3	53.0
7.4*	0	0.0	0	0.0	0.0	0	0.0	0	0.0	2	–	†	–	–
Total	167	100.0	2370	100.0	n.a.	38	100.0	575	100.0	§112	100.0	1145	100.0	n.a.

* Sites placed in one period or another (i.e., Period 1 or Period 2) were assigned to a single period in proportion to the distribution of sites placed in single periods.

† No estimate possible because period endpoint is unknown.

§ Not including Period 7.4*.

All percents are figured for columns.

n.a. – Not applicable.

this temper type found thus far in assemblages from Mesa Verde National Park (Blinman and Wilson 1985:11). This tract may include the Woods Canyon and Mockingbird Mesa areas.

Cahone and Sandstone Manufacturing Tracts

These 2 tracts are characterized by the presence of varieties of crushed sedimentary rock tempers. Both are believed to occupy the same geographic area in the center of the Mesa Verde region and include the Woods Canyon and Mockingbird Mesa areas (Blinman and Wilson 1985:13, fig. 2).

Although all assemblages from the 3 sample areas are dominated by Dolores Tract sherds (Blinman 1983), the relative proportions of the San Juan and Cahone/Sandstone Tract components are highest in the areas covered by these tracts. When these tracts were not occupied, the San Juan and Cahone/Sandstone components of the Dolores area assemblages are expected to register decreases.

Data used in the following analyses are from those Dolores samples with the best temporal control and the highest spatial provenience integrity. Sample size ranges from 273 sherds in the Period 7.1 sample to over 45 000 sherds in the Period 5 sample. Six of the seven temporally ordered samples contain over 10 000 sherds, so sample size was not a constraint on the analyses. The relative proportions of Dolores Tract, San Juan Tract, and Cahone/Sandstone Tract sherds in each period are listed in table 8.11 and illustrated in figures 8.8 and 8.9. The changes in proportions between Dolores Tract and the combined values of the San Juan and Cahone/Sandstone Tract sherds are significant at the 0.05 level in all cases except for the change in gray ware proportions between Periods 1 and 2 and the change in white ware proportions between Periods 2 and 3.

The momentary population estimates for each area reported in the previous section were used to generate expectations for change in manufacturing tract proportions. The following changes are expected: (1) no change in relative proportions between Periods 1 and 2; (2) a rise in Dolores Tract proportions in Period 3; (3) no change or a rise in Dolores Tract proportions in Period 4; (4) a rise in Dolores Tract proportions in Period 5; (5) a drop in proportion of Dolores Tract sherds in Period 6; and (6) a drop in proportion of Dolores Tract sherds in Period 7.1.

The changes in the relative proportions of the gray ware sherds from each of the 3 manufacturing areas match the expectations in all cases: no significant change occurs in the proportions from Period 1 to Period 2; the expected rise in Dolores Tract gray wares happens in Periods 3, 4, and 5; and the expected drop in proportion of Dolores Tract gray wares occurs in Periods 6 and 7.1.

The white ware picture is more complicated. No real change was expected between Periods 1 and 2, but Dolores Tract white ware proportions register a drop. A rise in the proportion of Dolores Tract sherds was expected in Period 3, but there was no significant change in the proportion of Dolores Tract white wares in Periods 2 and 3. A rise in Dolores tract proportions occurs if only Cahone/Sandstone sherds are considered, however. The expected rise in proportion of Dolores Tract sherds in Period 4 is met. The Dolores Tract component was expected to rise again in Period 5, but the data show it actually falls. Again, however, if only the Cahone/Sandstone and Dolores Tract sherds are considered, the expected rise occurs. The drop in production of Dolores Tract sherds expected for Period 6 is matched by the data. In Period 7.1, the Dolores Tract proportion is expected to drop, but it actually rises.

In general, the Cahone/Sandstone and Dolores Tract white ware proportions behave as expected from the population model, while the San Juan component does not conform. The Period 5 rise in San Juan Tract sherds, which could come from Mesa Verde as well as the Woods Canyon or Mockingbird Mesa areas, suggests that exchange patterns between the Dolores area and the surrounding regions were realined when population levels dropped south and west of the Dolores area (in the vicinity of the Woods Canyon and Mockingbird Mesa areas). The drop in both Cahone/Sandstone and San Juan white wares in Period 7.1, when the southern areas were reoccupied, suggests that the Dolores area did not switch back to the old, pre-Period 4 and 5 exchange pattern after these areas were reoccupied.

RESULTS AND CONCLUSIONS

Resource Supply and Population Change Within the Dolores Area

Resource supply figures based on the potential corn production in the Dolores area indicate high, but relatively stable population potentials for the Dolores area from Periods 1 through 3. Potential rises sharply in Period 4, then declines in Period 5. The model of resource supply and population underlying this work predicts stable and plentiful conditions will bring on a rise in local population, particularly through intrinsic growth. Actual population values rise from Period 1 through Period 4, as predicted. These results suggest the growth period in the Dolores area (ca. A.D. 600 to 880) was sustained or supported by the relatively high agricultural potential during this time. Certainly the high

Table 8.11 – Relative proportions of Dolores, San Juan, and Cahone/ Sandstone Tract gray ware and white ware sherds by period

Period	Gray ware				White ware			
	Sherd count	% Dolores Tract	% San Juan Tract	% Cahone/ Sandstone Tract	Sherd count	% Dolores Tract	% San Juan Tract	% Cahone/ Sandstone Tract
1	10 094	96.50	0.32	3.18	656	90.49	4.03	5.49
2	22 925	96.41	0.22	3.64	1076	80.48	9.25	10.27
3	26 824	97.22	1.01	1.77	1065	79.68	19.77	0.55
4	25 610	98.10	1.03	0.87	1243	90.36	7.02	2.62
5	46 533	98.68	0.89	0.42	3499	81.91	17.66	0.42
6	21 040	94.30	5.36	0.34	3560	46.50	53.23	0.27
7.1	273	53.94	45.41	0.64	28	98.50	1.50	0.00

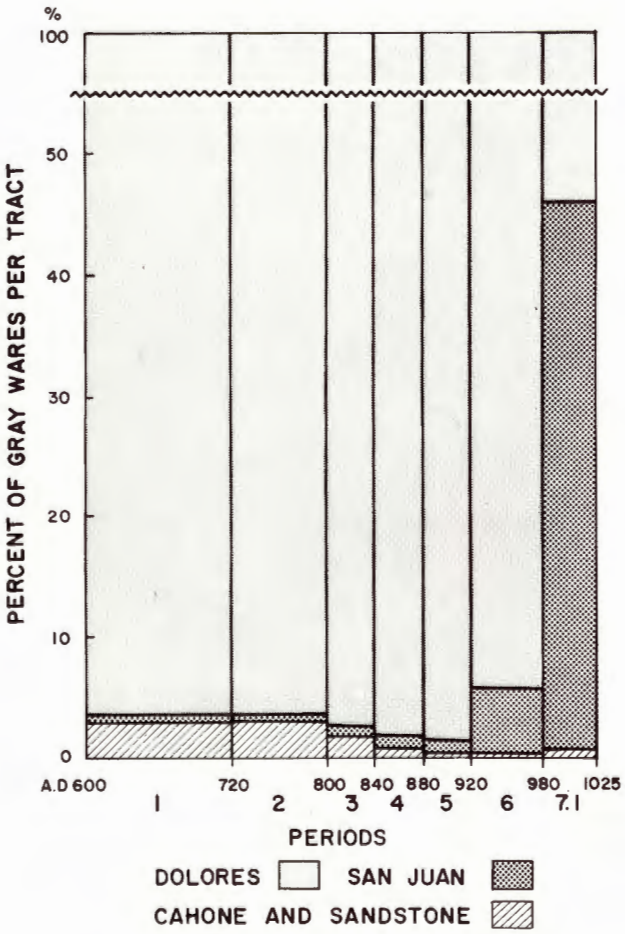

Figure 8.8 – Proportions of Dolores, San Juan, and Cahone/Sandstone Tract gray ware sherds, by period.

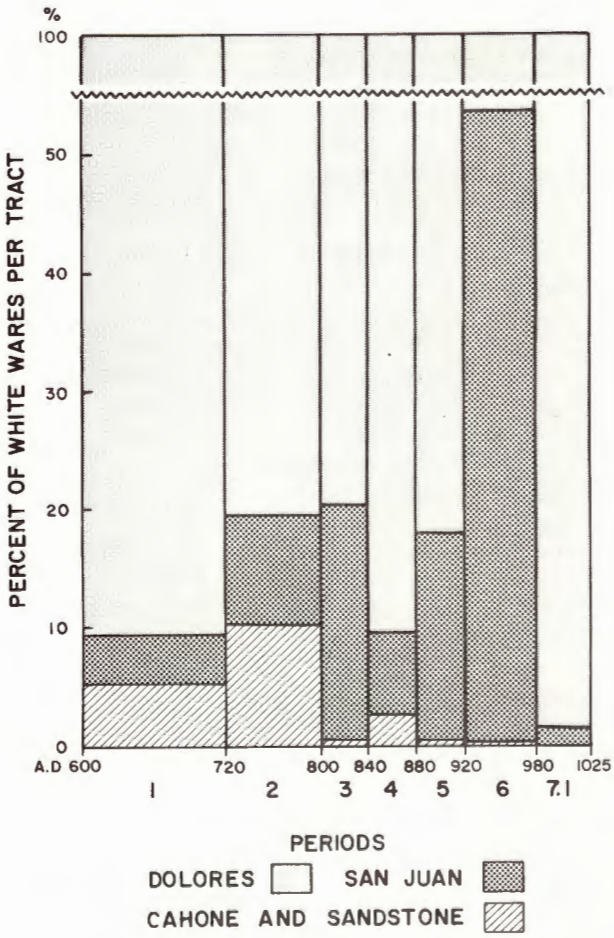

Figure 8.9 – Proportions of Dolores, San Juan, and Cahone/Sandstone Tract white ware sherds, by period.

production potential would have been an incentive for the initial occupation of the area. The high rate of growth between Periods 1 and 2 and Periods 3 and 4, when growth exceeded the theoretically expectable intrinsic growth maximum, matches expectations for population behavior under these conditions.

Period 5 potential population values drop by about 20 percent from the high registered in Period 4. This drop in population potential is echoed in a drop in actual population during this period, as expected from the modeled relationship between resource supply and population size.

In Period 6 population potential rises again almost to the pre-Period 5 level. This rise is not reflected in a similar rise in actual population, however. Potential population falls precipitously again in Period 7.1, which registers a 20 percent drop from the Period 6 level. There is a slight rise in actual population during Period 7.1, which is not expected. Population potential rises once more through Periods 7.2 and 7.3, but actual momentary population rises only during Period 7.2, dropping to the lowest level in the occupation sequence of the Dolores area in Period 7.3.

The population-resource supply predictions are borne out between A.D. 600 and 880, during the growth phase of the Dolores area occupation. The predictions are not well matched with the study results after A.D. 880, when population in the Dolores area was in decline.

Relative Attractiveness and Population Movement

The studies of relative attractiveness suggest that the Dolores area may have been attractive to regional populations only under fairly special circumstances. Estimated crop failure frequencies for the 3 sample areas, which were based on low elevation and high elevation tree-ring-index values, indicate that, at least on a period-by-period basis, the Dolores area would have been the least attractive of the 3 areas studied; the 2 areas to the southwest (Woods Canyon and Mockingbird Mesa) alternated in relative attractiveness. The fact that the Dolores area did support a substantial population for some time suggests that either this overall, period-long measure of attractiveness is not a particularly good measure of actual attractiveness, or that population was not responding to such gross measures of attractiveness as this long-term one. The latter alternative appears the more likely in view of the other attractiveness studies. The crop failure frequency analysis suggests the most likely periods for the Dolores area to receive immigrants from the rest of the region would have been during Periods 3, 4, 6, 7.1, 7.2, and 7.3.

The farmbelt reconstructions, based again on a complex link between tree-ring indices, growing season length, and precipitation across the elevational span of the research region, offer what appears to be a more reasonable picture of relative attractiveness. These reconstructions suggest that the most likely times for migrants to come to the Dolores area would have been during Period 1, the boundary between Periods 3 and 4, in Periods 6 and 7.1, at the beginning and end of Period 7.2, and in Period 7.3.

Petersen's farmbelt reconstructions (chap. 4, sect. 6) suggest migration to the Dolores area may occur in Period 1 and should occur in Periods 2, 3, 4, and early Period 5, and Periods 7.1, 7.2, and 7.3. The Dolores area is most attractive in Periods 3 and 4. The initial horticultural occupation of the Dolores area, beginning in Period 1 and continuing in Period 2, confirms the first of these predictions. Although the Period 3 population in the Dolores area is not very much greater than that estimated for Period 2, and the growth rates are not in excess of what might indicate immigration, the presence of population in the Dolores area at this time, coupled with the absence of population in the 2 areas to the southwest, confirms the expectation of growth through a relative attractiveness differential during this period. Periods 3 and 4 were predicted to be growth periods for the Dolores area, and these expectations are borne out. The actual population growth between Periods 3 and 4 represents the highest growth rate during the Dolores occupation, in excess of what could be expected for intrinsic growth. This growth rate, along with the very low population levels in the Mockingbird Mesa area and the absence of population in the Woods Canyon area, is strong support for the effects of differential relative attractiveness at this time. Period 5 was not predicted to be a growth period for the Dolores area, in terms of its relative attractiveness, and the actual population drop in this period is some confirmation of this prediction. The absence of population to the southwest is not predicted by the relative attractiveness model, however, and it cannot be explained in terms of this model.

The density of population across the region may also be considered as a measure of relative attractiveness. Under an economic model, such as that employed here, areas with higher population densities would be less attractive than areas with lower population, especially when the agricultural potential in the areas is fairly similar. Agricultural potential across the region is only close during Period 1, however, which complicates evaluation of this measure of relative attractiveness. During Period 1, population density is lower in the Dolores area than it is in the Mockingbird Mesa area, although it is not substantially lower. The economic model would predict that the Dolores area should receive immigrants

from the Mockingbird Mesa area in this case. The other relative attractiveness measures already predict that the Dolores area will receive immigrants from the southwestern sections of the region in Period 3, and the actual population changes support these predictions. For the other periods, differences in agricultural potential, as measured by the frequency of crop failure and the position of the farmbelt, make it difficult to predict what effect population density differences should have on population movement.

The socioeconomic demand and social organization demand elements in the model would have the opposite effect in regards to population density, however. Areas with high density may be expected to attract more population, as long as the roles are not more fully occupied. It is difficult to see how the population rise and fall in the 3 areas can be explained in terms of these variables. The Period 5 population carryover in the Dolores area, which the environmental relative attractiveness measures suggest is not the optimum place in the region at this time, may be explained in part by these relationships.

Population Trends in the Dolores Area and Change in Other Subsystems

The population changes in the Dolores area may serve to promote change in other aspects of the Dolores system, particularly the type of social organization needed, the demand for resources, and the subsequent use of resources. Changes in overall size, density, and rate of change may all be important catalysts for change in these parts of the system. The greatest changes in population size, density, and growth rates are reviewed here.

Overall population size, density, and growth rates all reach a peak in the Dolores area sometime during Period 4. If changes in social organization and economic organization occur in the Dolores area during the prehistoric occupation, they should be evident in this period or during Period 3 (this is not to say that such changes cannot occur during other times as well). The Dolores area was undergoing rapid population growth, due to both high intrinsic growth rates and migration throughout the period A.D. 600-880, and adjustments in social organization and economic organization can be expected at any time during this period. Adjustments in social organization should take the form of attempts to integrate greater numbers of nonkin or more distantly related kin as the population grows larger and the immigrant component increases toward the end of this period. The form of changes in economic organization are harder to predict. Although the maximum population figures for Period 4 and the corn production potential of that period combine to indicate a population living at about 60 percent of local corn-carrying capacity, there is no evidence for extreme stress of the agricultural potential of the area at any time during the occupation except possibly during Period 4.

As population begins to decline, sometime in Period 5, the shrinking population of the area may also have posed adaptational problems for the Dolores occupants. Period 5 represents a severe reversal of the previous population trends; Period 6 shows an even more drastic reversal. These changes may engender social and socioeconomic responses designed to cope with a declining workforce and social network. The change in exchange networks, indicated in a gross fashion by the analyses of manufacturing tract proportions in the ceramic assemblage, suggest some realinement in this sphere that may be such a response. Social and economic changes made in response to the rapid growth phase of the Dolores area occupation may not be easy to reverse; population may tend to abandon the area in fairly large groups of several households. The site size data on households per site and households per rubble mound discussed earlier suggest that the groups of people who came together in the large sites of Period 4 gave rise to groups who remained together for the most part in Period 5, despite the declining production potential of the area and the drop in relative attractiveness.

Conclusions

The population patterns discussed in this chapter follow the relative attractiveness and resource supply indices fairly closely and lend support to an economic explanation for the population trends in the Dolores area. At some points the population pattern and the expectations diverge, however, particularly during Periods 6 and 7.1 (ca. A.D. 920-1025) and Period 7.3 (ca. A.D. 1100-1175). The estimated population potential of the area rises in Period 6 but is not matched by a rise in actual population. Actual population rises slightly in Period 7.1, when population potential is dropping. Finally, in Period 7.3, although the relative attractiveness indices and the production potential, or resource supply, figures suggest that the Dolores area should experience rising population levels, actual population drops to its lowest point, and by A.D. 1175 (the end of Period 7.3) the area is abandoned. These results raise the possibility that the growth phase of the Dolores area may have been governed by rather different forces than the decline phase. As population built in the Dolores area during the A.D. 800's, the areas to the southwest were largely abandoned. As these areas built up population (in the A.D. 1000's and 1100's), population dwindled in the Dolores area and eventually the

area was deserted. These patterns suggest the population in the region was limited and operated as something of a unit, so that population moved from area to area in response to environmental changes and social pressures, perhaps in response to the location of existing population concentrations.

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Chapter 9

ANASAZI SPREADSHEETS: THE COST OF DOING AGRICULTURAL BUSINESS IN PREHISTORIC DOLORES

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This chapter builds on Petersen's climatic reconstruction (chap. 4) and on the accumulated excavation and survey data to examine one aspect of the general question that provides a central focus for the DAP economic model: Can any portion of the culture change observed in the Dolores area be explained as the result of attempts to minimize labor input in the context of maximizing, or even "satisficing" (Jochim 1976) output? Or, on the other hand, are costs largely irrelevant (within reasonable limits), with other facts of greater importance in engendering culture change? The role of costs in culture change are discussed further in chapter 6.

In their discussion of the relationship between changing climates and population movements in the Dolores area and in areas to the south and west of the Dolores River valley, Petersen (chap. 4, sect. 6) and Schlanger (chap. 8) conclude that movements into and out of the project area for the period of the main Anasazi occupation correspond reasonably well with the relative agricultural opportunities in these areas. These relative agricultural opportunities are taken to be a rough approximation of agricultural costs, as might be more powerfully measured by the ratio of caloric input to caloric return for agricultural endeavors.

However, a measure of such costs, in calories, is impossible to achieve outside the Dolores area, where we often lack detailed paleoenvironmental and demographic information. Even for the Dolores area, it verges on intellectual arrogance to think that such a measure could be reconstructed for all aspects of agriculture. The goal of this chapter is to work towards providing a measure for the costs incurred by travel to and from residences and agriculture fields and the cartage involved on these trips. These costs are presented as an index, rather than as a firm measure of caloric expense, and the main thrust of interpretation is on relative differences across the project area at any one time and on change in the index through time.

Rather than treating the relationship between population movements and resource supply as affected by climate on a regional basis, as has been done by Petersen (chap. 4, sect. 6) and Schlanger (chap. 8), the focus is on how changing climates and differing agricultural opportunities across the project area affect the distribution of population **within** the Dolores area. Specifically, the extent of population change from one period to the next is examined to determine if it is in a direction consistent with attempts to minimize the costs of agriculture.

The approach developed is to simulate one aspect of agricultural costs across the project area for all sites in each period. A linear relationship is then found between these costs at each location and the estimated number of households at each location. This done, the residuals from this least squares line indicate locations where agriculture was relatively more expensive or less expensive than the project-wide household average. The relative agricultural cost indices represented by these residuals are compared to the population growth or decline for each location from one period to the next. If cost minimization for agriculture was an important factor in decisions to occupy or to leave a specific location, then population should decline in relatively "expensive" locations and increase in relatively "cheap" locations. Surprisingly, the opposite was almost always the case.

A JUSTIFICATION FOR STUDYING AGRICULTURAL COSTS

Two factors provide the rationale for the study of agricultural costs as possible determinants of site location and growth to the exclusion of wild food resources or other plausible environmental variables, such as the presence of potable water and fuel resources. First, Petersen's (chap. 4, sect. 6) reconstruction of changes in

the regional farming belt, viewed as a relative approximation of agricultural costs, has proven useful in explaining population movement into and out of the Dolores area. Here, whether the same effect can be observed on a local scale, or whether different determinants were operating at different spatial scales is of interest. Second, agricultural products were certainly important, and perhaps dominant, in the Dolores Anasazi diet. Plog (1979:112) has surmised that by A.D. 800 to 1000 "most of the western Anasazi diet was derived from food production." Aasen (1984) analyzed coprolites from Turkey Pen Ruin in southeast Utah and found that by Basketmaker III times Anasazi coprolites already contained more corn macrofossils than any other macrofossil. In his review of Southwestern ethnohistory and ethnography, Jorgensen (1983:693) reports all Puebloan groups obtained "more than 50 percent of their total sustenance from agricultural products" with wild plants probably contributing no more than about 20 percent of the diet.

In many areas of the Anasazi Southwest these subsistence considerations appear to have had important implications for the location of residences and field stations. Kintigh (1984), for example, attributes major shifts in residential location among the late prehistoric period Zuni to advances in water-control technology, which changed the location of the most rewarding areas for agriculture. Dean et al. (1978) show a strong and consistent association between arable soils and residential sites in Long House Valley, northeastern Arizona, beginning in Pueblo II times. A final indication of the centrality of agriculture to the Puebloan lifeway is the focus of their ritual on the life cycle of maize (Lamphere 1983:754).

For relatively rare events, such as hunting big game or acquiring construction materials for a pithouse or pueblo with a long life expectancy, the costs incurred are probably not subject to very much selection. The habitual activities of cultivation in predominantly agricultural societies, however, should be more sensitive to costs. Moreover, some areas of the DAP are relatively more rewarding for agriculture than others. Figure 9.1 is a pseudo-three-dimensional view of the Dolores area from a vantage point above it and to the south. The relatively broad, open southern portions of this area have generally high-quality soils and are less subject to cold air pooling; these locations are in contrast to the narrower valleys, steeper canyon walls, and higher mesa tops of the northern portions of the study area. The Dolores River valley can be seen as the depression running approximately north-south in the southern 2/3 of the project area; towards the north it takes a bend to the west at about the point where Beaver Creek flows into it from the east. The northeast-to-southwest trending change in elevation crossing the southern 1/3 of the project area is the House Creek Fault.

METHODS

In this study, the initial calculation of agricultural costs is related to how far people have to go to get to their fields, rather than other kinds of agricultural costs, such as those due to processing or storage, since these are believed to be approximately equivalent across the project area. First, the DAP study area plus a 1-km-wide border was divided into 200- by 200-m cells, each with an area of 4 ha (Orcutt 1985a). There are 3425 of these cells in the 137-km^2 study area. All calculations are based on environmental and demographic data using these cells as the units of observation. In some cases, 2 or more sites fall within a cell, and hence the number of occupied locations is often less than the number of occupied sites for each period. Environmental data are described by the modal attribute in each cell; the dominant soil category, for example, is represented as the only soil category (Orcutt 1985a).

In addition to the spatial location of each cell, the data important to estimating agricultural costs are as follows:

1. The estimated growing season for each location, using 3 possible values: less than 90 days; 90 to 120 days; and greater than 120 days (Petersen and Clay 1985).

2. A soil quality designation based on SCS (Soil Conservation Service) codes of 4 values: 3 and 4, representing the best agricultural soils in the valley; 6, representing soil generally unsuitable for agriculture but contains small pockets of usable soils; and 7, representing soil considered to be completely unsuitable for agricultural use (Petersen 1985a).

3. The number of households in each location in each period, derived from excavation or more often from survey data, as described by Schlanger (chap. 8). The maximum number of possible households for each period is used without corrections for length of period (except for Grass Mesa Village [Site 5MT23]); all households estimated for a site were assumed simultaneously occupied and all locations in use during a period were also assumed simultaneously occupied. (Alternatively, population levels in each location could have been divided by a factor reflecting the use-life of structures and the length of each period. This procedure, which assumes population levels are constant for the duration of each period, is no more justifiable than the one we chose, especially for the early, long periods where fractional households would be associated with many locations. In any case, the lengths of periods 3-6 are approximately equal, so this correction would have

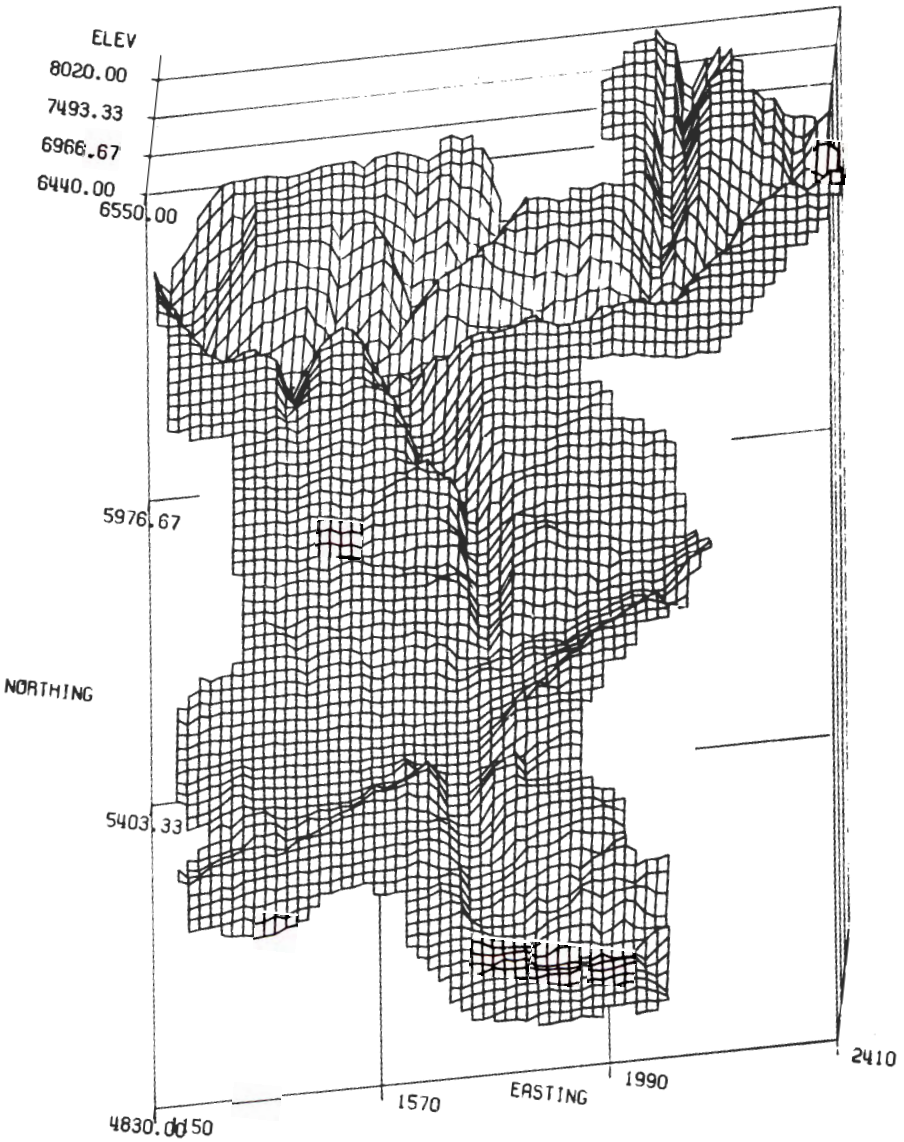

Figure 9.1. – Topographic map of Dolores Project area (from an aerial vantage point to the south), with elevation measured in feet (DAP 161504). Easting and Northings on truncated Universal Tranverse Mercator grid ticks for Zone 12 in tens of meters. Easting 1990 equals 719,000 mE; Northing 6550 equals 4,165,500 mN. On this figure, north-south distances are exaggerated by approximately 3 percent relative to east-west distances.

no effect on the results for the time period of maximum interest.)

In addition to these variables measured for each cell, 2 other factors vary through time. The first is the frequency of shorter-than-average growing seasons, as estimated from the high-altitude Almagre Mountain tree-ring record (Petersen, chap. 4, sect. 6). Within each period, the proportion of years greater than or equal to 1 standard deviation below the long-term mean for this record was used to model reduction in yields due to short growing seasons. Only cells with a growing season of 90 to 120 days were considered to be sensitive to the variations documented in the tree-ring record. This factor is relatively important to the results of this study since these sensitive locations are distributed unequally across the project area. Also, the proportion of years greater than or equal to 1 standard deviation below the mean for the Dolores tree-ring record was used to model reductions in yield due to drought (Petersen 1985b).

Although these reductions vary from period to period, they are the same across the project area within any given period and hence do not affect synchronic relative costs.

For each cell, then, unchanging soil quality and growing-season characteristics are combined with changing multipliers reflecting the likelihood of freeze or drought in each period to calculate *kcalyld* – the probable long-term yield of each cell in terms of kilocalories of corn as follows:

$$kcalyld = 7585 \times d \times sq \times gs \times ff$$

where 7585 = potential yield per 4-ha cell in kilocalories (Calories × 103, or Calories × 106) of corn adapted from Wetterstrom (1976) by Orcutt (1985b, 1985c)

d = drought = proportion of years greater than or equal to 1 standard deviation below the mean in the Dolores tree-ring record for that period

sq = soil quality = 1 for SCS categories 3 and 4; 0.2 for SCS 5; and 0 for SCS 7

gs = growing season = 1 for cells in the greater than 120-day belt; 0 for cells in the less than 90-day belt; and for each period, the proportion of years greater than or equal to 1 standard deviation below the mean in the Almagre Mountain tree-ring record for cells in the 90-to-120-day belt

ff = fallow factor = 0.5 for all periods and locations.

The multipliers associated with drought and short growing season are shown in table 9.1 for each period. Potential corn yields are reconstructed across the project area for each period using this algorithm; potential yields during Period 1 are shown, by way of example, in figure 9.2.

The agricultural cost index was constructed through simulation for Periods 1 through 7.2. Given the known location of population and the reconstructed potential corn yields of each 4-ha unit of land within the project area, simple decision rules were applied to simulate the size and shape of the catchment needed to supply sufficient corn for the inhabitants of each site. We assumed 5-person households, caloric requirements of 2400 Cal/person/day (after Wing and Brown [1979:2]; also Orcutt [1985c, 1985d]), and a 60-percent contribution of agricultural products to the total caloric intake. The analysis that follows is sensitive to changes in these assumptions where calculations of absolute travel distances and sizes of catchments are concerned. However, **relative** differences through time and across space are unaffected by changes in these assumptions. The modeled 60-percent contribution of agriculture to the diet is almost certainly too high for Period 1 and probably too low for Period 4. Nevertheless, this figure was not allowed to change through time to preserve the maximum amount of comparability for the calculated indices.

Table 9.1 – Proportion of each period without dry years and without short growing seasons

Period	Dates (A.D.)	Proportion of period without dry years	Proportion of period without short seasons
1	600-720	0.83	0.92
2	720-800	0.87	0.94
3	800-840	0.85	1.00
4	840-880	0.92	0.95
5	880-920	0.80	0.67
6	920-980	0.83	0.90
7.1	980-1025	0.67	0.87
7.2	1025-1100	0.77	0.89

Catchments are built around each occupied cell in the following manner. A first pass through the data assigns all cells within an arbitrarily large radius around each occupied cell to that cell; many cells are thus initially assigned to more than 1 site. Caloric need for each occupied cell is next determined by multiplying its number of households times the caloric requirements/household. Each occupied cell then "claims" the cell it occupies and calculates the yield, if any, from that cell. (In this case, that yield is reduced by a factor proportional to the number of households occupying the cell to reflect lost opportunities for agriculture due to space required for the settlement.) If this yield is not sufficient, then each occupied cell ranks all the unclaimed cells in its first radius (eight 4-ha cells) and claims them, one at a time, until needs are met. In this part of the simulation, no cell may be claimed by more than one occupied cell. If needs are still unmet, this process is repeated for each tier (second, third, and so forth) of cells around each occupied cell until needs are met for each occupied cell. Cells with no potential agricultural potential productivity are not claimed. Because each occupied cell selects from only one tier of cells before selection opportunity passes to the next occupied cell, no occupied cell is artificially forced to have an extremely large radius for its agricultural catchment. However, in areas where sites are closely packed, all catchments tend to be large and somewhat distorted. The results of this process for Period 1, a time of low site density, are shown in figure 9.3. In this figure cells

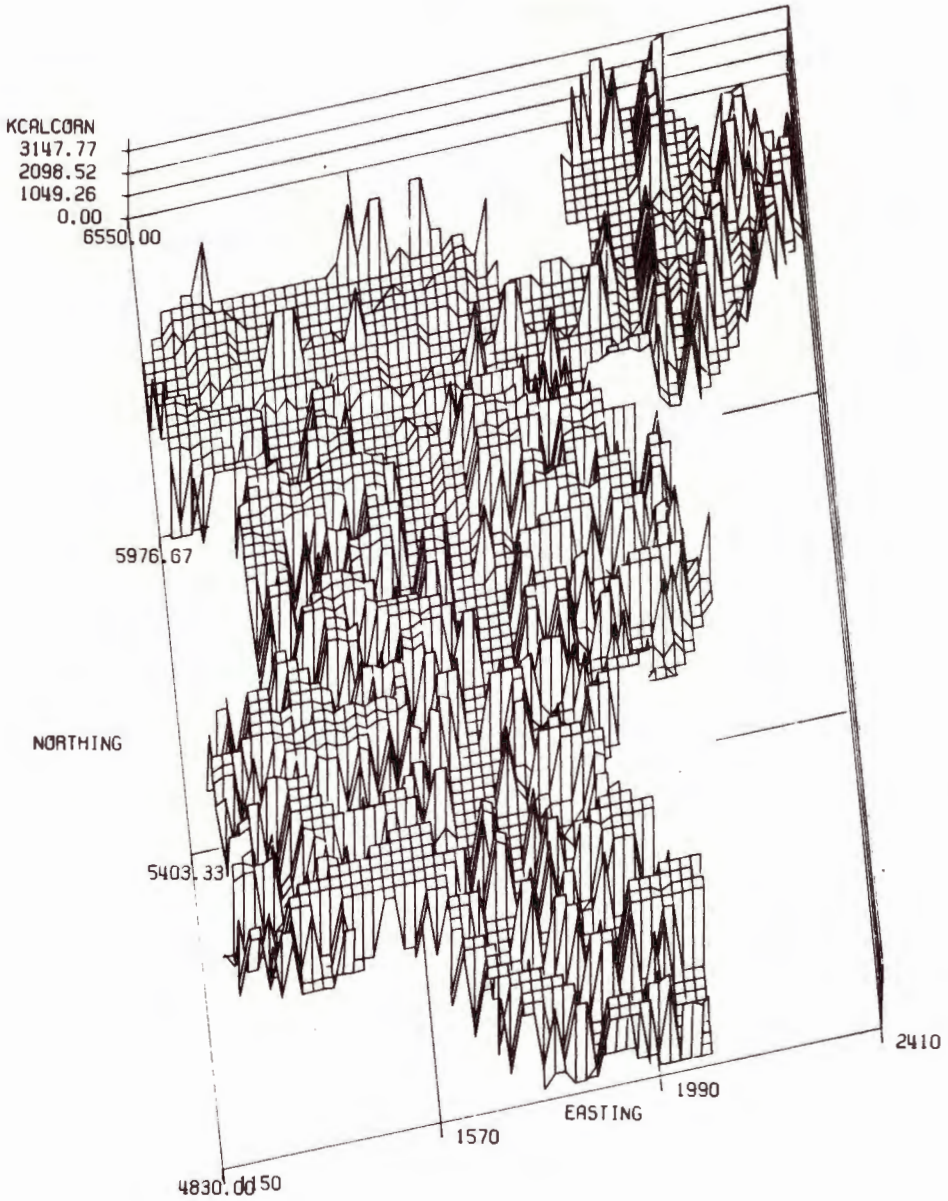

Figure 9.2 – Potential corn yield in kilocalories, Period 1 (DAP 161510).

that depart from zero on the Z-axis have been "claimed" by an occupied cell, and the height of each cell on the Z-axis reflects its reconstructed yield. Unfortunately, directly checking the validity of this selection process is impossible. No agricultural field dating to the Anasazi period of occupation has been identified with any certainty. Even if it had been, the association of a specific field with a specific site could be made only on the basis of propinquity, the same criterion used in this model.

After a catchment is built, the agricultural cost index is computed for each occupied cell by multiplying the Euclidean distance of that occupied cell to each cell in its reconstructed agricultural catchment by the potential corn productivity of that cell. (A simple distance measure is calculated at the same time.) For each site these products are summed across all the cells in the agricultural catchment. Therefore, a cell far from a residence and contributing a high corn yield is more costly – and contributes more to the index – than does either a cell close to home contributing the same yield or an equally distant cell contributing a smaller yield. This index reflects only the costs involved in walking back and forth to fields and cartage. It is assumed that no field houses are in use.

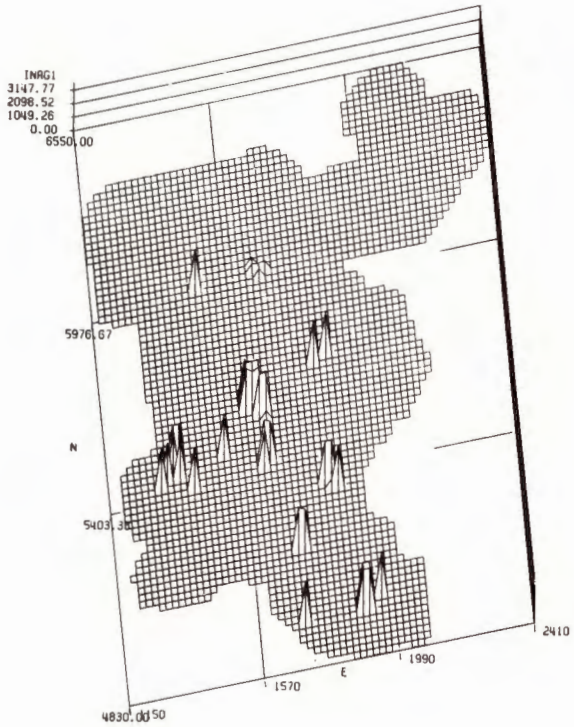

Figure 9.3 – Simulated agricultural catchments in Period 1 (DAP 161516).

The decision to include yield in the cost estimates requires some explanation. Cells may have no yield whatsoever for 1 of 2 reasons: they may lie within a short growing season elevational belt, or they may have an SCS code of 7. Such cells do not enter into the cost calculation at all, except in the indirect sense that their presence close to an occupied cell may force selection of fields at a greater distance, thus increasing travel times and costs. For cells that do produce, within any given period the main factor introducing variability in yields is their SCS designation. We assume that cells with a low yield due to an SCS designation of 6 are planted in small areas only. Hence, the number of trips to and from such cells, as well as any cartage, will be proportionately less than for a cell that is fully planted. Since our cost index is meant to be proportional to the number of trips times the distance and cartage involved, these cells are allowed to contribute less to costs than do equally distant cells that are completely planted, require more visits, and involve more cartage. As a check on the effect of including yields in the cost figure, all calculations were also done with a simple distance measure for costs with results similar to those that follow.

RESULTS

Relatively few sites are in the project area during Period 1. All are small, with the largest containing 7 households. Most of these sites are in the Sagehen Flats area (chap. 1). The simulated agricultural catchments around these sites were displayed in figure 9.3. The inhabitants of each site can satisfy their agricultural requirements within very short distances of their residences. The relationship of the agricultural cost index in Period 1, as calculated from these catchment data, to the number of households in each location during that period is shown in figure 9.4. The way the index is calculated virtually guarantees a strong linear relationship between the cost index (on the X-axis) and the number of households at each location (on the Y-axis). The regression line tracks the average relationship, across the project area, between the number of households and the agricultural cost index. However, variability around the regression line is due to the agricultural characteristics of the area immediately surrounding each site. Locations where agriculture is cheaper (for each household) than the project-wide average for any period will fall above this line and will have positive residuals. Locations below this line have fewer households than the project-wide average for the estimated costliness and thus partition those costs among fewer households, each having relatively high costs/household.

Under the assumption that people should respond to agricultural cost differential by moving from locations with relatively high cost experience (negative residuals on this regression), we compare the change in population in Period 2 **for all cells occupied in Period 1**. In Period 2, many more sites are in a much wider portion of the project area, but sites remain small. The scatterplot (fig. 9.5) for the change in population from Period 1 to Period 2 (on the Y-axis) versus the residuals from the previous regression (on the X-axis) shows a weak and nonsignificant negative relationship (table 9.2) between the 2 variables, the opposite of the direction predicted. Practically speaking, the relative cost experience of a location for agriculture in Period 1 has no effect on the growth or decline of population at that location by the next period. This does not indicate no selection from the environment for agriculturally favorable places; it does indicate no selection of **previously occupied** places where costs were favorable. A previous analysis comparing the composition of catchments for 1-km-radius habitations to catchments for random points identified selection for good-quality agricultural locations and avoidance of poor-quality agricultural locations among habitation sites for all periods prior to Period 6 (Orcutt 1985a). No conflicts were noted among occupied cells in the process of claiming the 46 cells required for agriculture during Period 1 (table 9.3)

For Period 2 the relationship between agricultural costs and number of households in occupied locations is

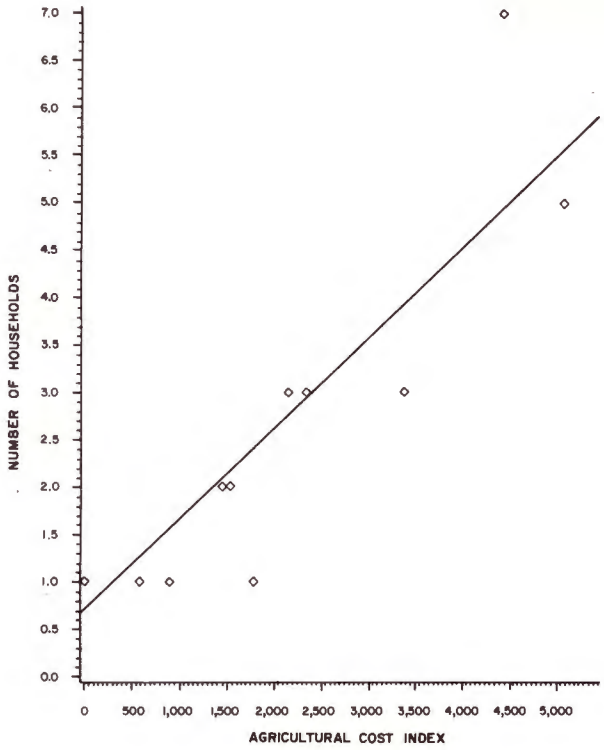

Figure 9.4 – Agricultural costs versus number of households, Period 1.

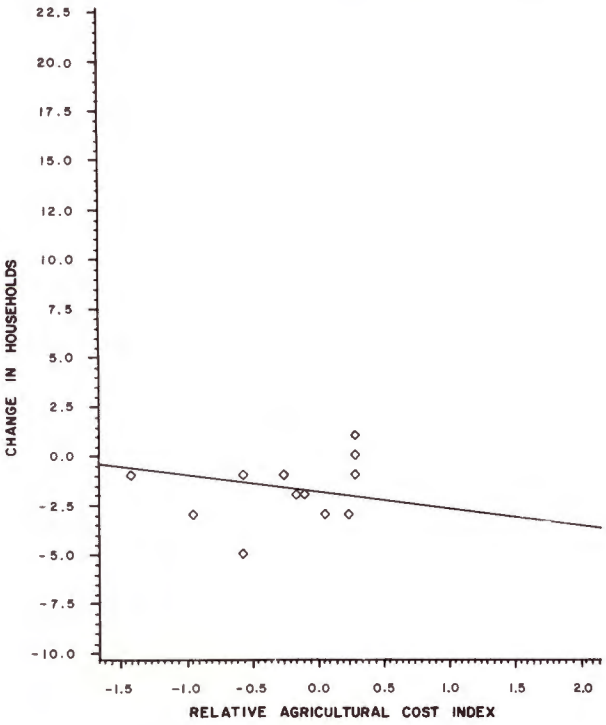

Figure 9.5 – Agricultural costs versus change in number of households, Period 1 to Period 2.

shown in figure 9.6. In this and the following periods, this relationship begins to take on a slightly curvilinear appearance as locations with large numbers of households increase costs at a faster rate than locations with fewer households (the cost of aggregation). When plotted against a linear function, this results in positive residuals for many small- and moderate-sized settlements and negative residuals for most larger settlements. The change in population in Period 3 for locations occupied in Period 2 (on the Y-axis of figure 9.7) and the relative agricultural cost experience of those locations in Period 2 (the residuals from fig. 9.6) exhibit a weak but significant negative relationship. Most population increase taking place in previously occupied locations is in zones of average agricultural costs; both relatively "expensive" locations and relatively "cheap" locations lose population across the Period 2-3 boundary. The negative trend, however, shows that cheap locations lose more population, on the average, than expensive locations.

Simulated agricultural catchments for all Period 3 sites are shown in figure 9.8. Comparing this figure with figure 9.2, a fair amount of unused agricultural land still appears to be available in the project area. The relationship between agricultural costs and number of households in locations occupied in Period 3 assumes an even more markedly curvilinear quality (fig. 9.9).

Figure 9.10 shows the change in Period 4 population for Period 3 locations, plotted against the residuals from figure 9.9. Three cells with population growth in excess of 38 households (in the upper left-hand quadrant of figure 9.10) are largely responsible for this negative trend. Of these, the most influential is Grass Mesa, the uppermost data point in the figure, with an increase of 89 households from Period 3 to Period 4. (This study uses an older set of population figures for Grass Mesa than those presented by Kohler [1985], but the figures are generally similar.) Without those 3 cells having the largest population increase, population redistribution in the project area across the Period 3/4 boundary has a weak, nonsignificant positive relationship with relative agricultural costs – apparently population growth or decline at small sites is generally more responsive to agricultural costs than it is at large sites. The number of cells claimed and the number of cells in conflict rise dramatically in Period 4 (table 9.3).

The agricultural costs in Period 4 are compared against the number of households in occupied cells in figure 9.11. The residuals from this regression are compared in figure 9.12 with the change in population in Period 5 for locations occupied in Period 4. Once again, most population growth in Period 5 takes place in areas that were average cost for agriculture in Period 4; both high-cost (negative residual) and low-cost (positive residual)

Table 9.2 – Summary of regression analyses, by period

Model	n	r	r^2	a	b	F	p
HH1 = AVAGCINI	15	0.90	0.82	0.7159	0.00095	62.5	0.0001
DELPOP21 = Residuals		–.32	.10	–1.8750	–.86436	1.6	.2214
HH2 = AVAGCIN2	66	.93	.86	1.6470	.00032	389.5	.0001
DELPOP32 = Residuals		–.33	.11	–2.1343	–.96422	8.1	.0060
HH3 = AVAGCIN3	44	.88	.77	2.2451	.00031	147.1	.0001
DELPOP43 = Residuals		–.36	.13	–3.3333	–2.71124	6.4	.0155
HH4 = AVAGCIN4	65	.93	.87	3.8373	.00020	441.0	.0001
DELPOP54 = Residuals		–.37	.14	–4.7727	–.40463	10.6	.0018
HH5 = AVAGCIN5	36	.94	.88	5.4865	.00019	257.5	.0001
DELPOP65 = Residuals		–.33	.11	–12.5405	–.95326	4.3	.0461
HH6 = AVAGCIN6	5	.96	.96	1.9780	.00058	47.6	.0023
DELPOP76 = Residuals		–.04	.00	–2.5000	–.29166	0.0	.9433
HH7 = AVAGCIN7	6	.95	.92	1.8850	.00036	53.9	.0007
DELPOP87 = Residuals		.27	.07	–4.5714	.88419	0.4	.5649
HH8 = AVAGCIN8	6	.97	.95	4.9634	.00029	86.3	.0002
DELPOP98 = Residuals		–.23	.05	–15.4286	–1.00000	0.3	.6135

HHn is the population (in household units) of each location in Periods 1 through 7.2 respectively.
DELPOPm is the change in population from one period to another. For example, DELPOP21 (Period 1 through Period 2) is positive if the number of households at a location is larger in Period 2; otherwise, it is negative or zero.
AVAGCINn is the agricultural cost index for each period.
Residuals are the difference between the predicted number of households at a location (given the average relationship between agricultural costs and number of people at each location in each period) and the actual number of households (based on survey or excavation data) as calculated in the previous model. Where there are more households than predicted, the residuals are positive and the agricultural costs for transport and travel are lower than the average over the valley for that settlement size. Where there are fewer households than predicted, the residuals are negative and the agricultural costs/household are above that of the local average.

locations lose population, although the significant negative linear trend (table 9.2) indicates that cheap locations lose more than expensive locations.

The simulated agricultural catchments for all sites in Period 5 (fig. 9.13) suggest a considerable portion of the available arable lands are in agricultural use by this time. Table 9.3 shows the number of cells in agriculture and the number of cells in conflict decline slightly at this time in response to population decline. Figure 9.14 shows the relationships between costs and number of households for locations occupied in Period 5; figure 9.15 uses the residuals from this regression to compare the relative agricultural cost experience for locations occupied in Period 5 with their change in population across the Period 5/6 boundary. In this time of almost complete depopulation, the negative relationship is hardly surprising or meaningful. No locations occupied in Period 5 gained population in Period 6 and residential site locations shifted towards the extreme southern end of the project area where they remained until final depopulation. The last 3 periods of occupation are not discussed due to our small sample size, although summaries of the analyses for the first 2 periods can be found in the tables.

DISCUSSION

Table 9.4 summarizes much of what was learned from these simulations about travel distance and relative agricultural costs in the project area. The average agricultural cost index/household was estimated by using the mean number of households for each occupied cell in each period as Y and solving for costs (x) using the slope and intercept estimates from table 9.2; the result

Table 9.3 – Number of cells claimed for agriculture and number of cells in conflict for each period

Period	No. of cells in conflict*	No. of cells claimed	Ratio conflict/ claimed
1	0	46	0.0
2	103	309	0.33
3	157	322	0.49
4	1421	810	1.75
5	992	681	1.46
6	0	37	0.0
7.1	61	72	0.85
7.2	52	117	0.44

*Number of blocked attempts to choose any cell already selected by another occupied cell.

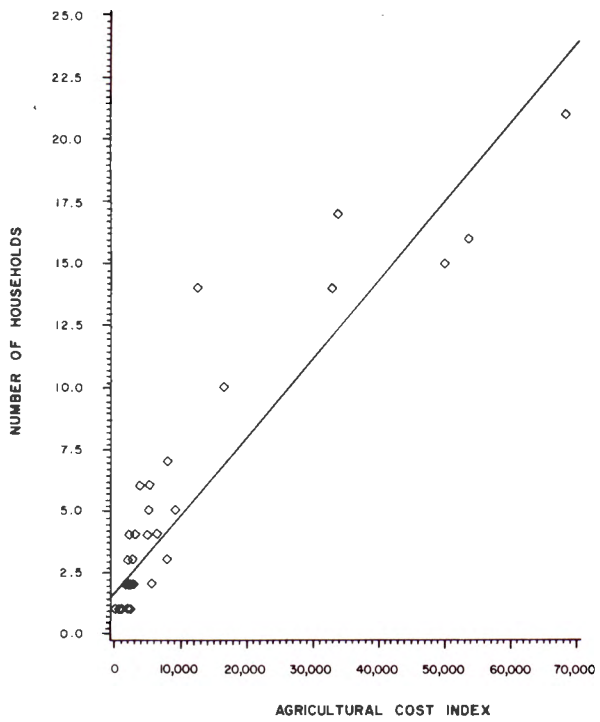

Figure 9.6 – Agricultural costs versus number of households, Period 2.

was divided by the average number of households for each occupied cell. The same approach was used to calculate the average distance traveled (regression estimates were calculated but not reported for the relationship between number of households and travel distance for each period).

The agricultural cost index increases dramatically from Period 1 to Period 2, coinciding with the appearance of a 2-tiered settlement hierarchy (chap. 10) implying the existence of a simple decision-making hierarchy

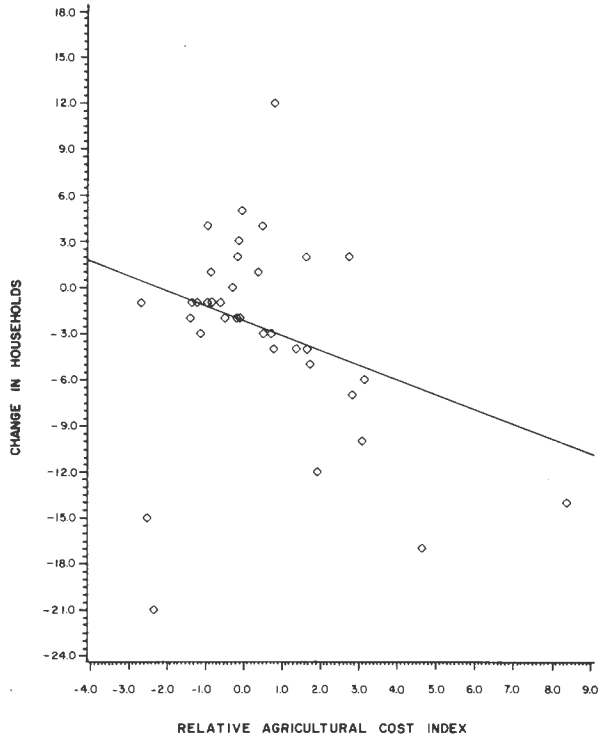

Figure 9.7 – Agricultural costs versus change in number of households, Period 2 to Period 3.

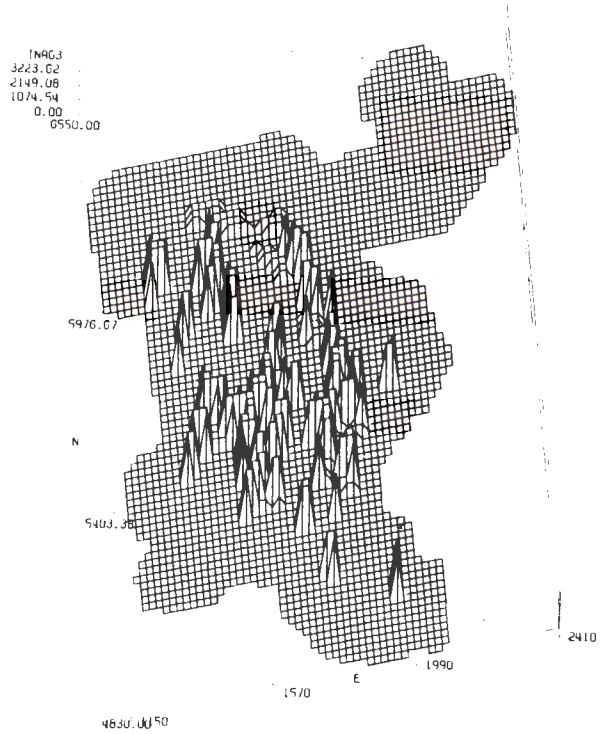

Figure 9.8 – Simulated agricultural catchments in Period 3 (DAP 162203). Height of cell on Z-axis reflects the *Kcalyld* for each "claimed" cell in this period.

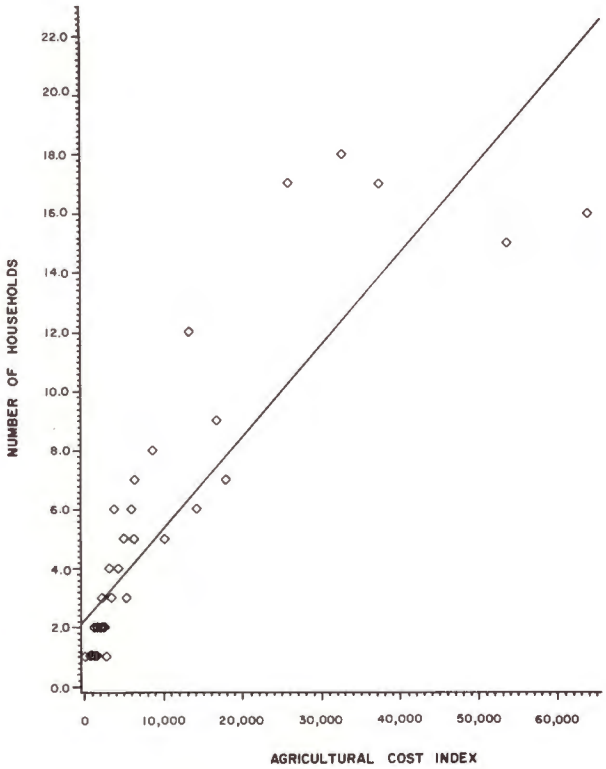

Figure 9.9 – Agricultural costs versus number of households, Period 3.

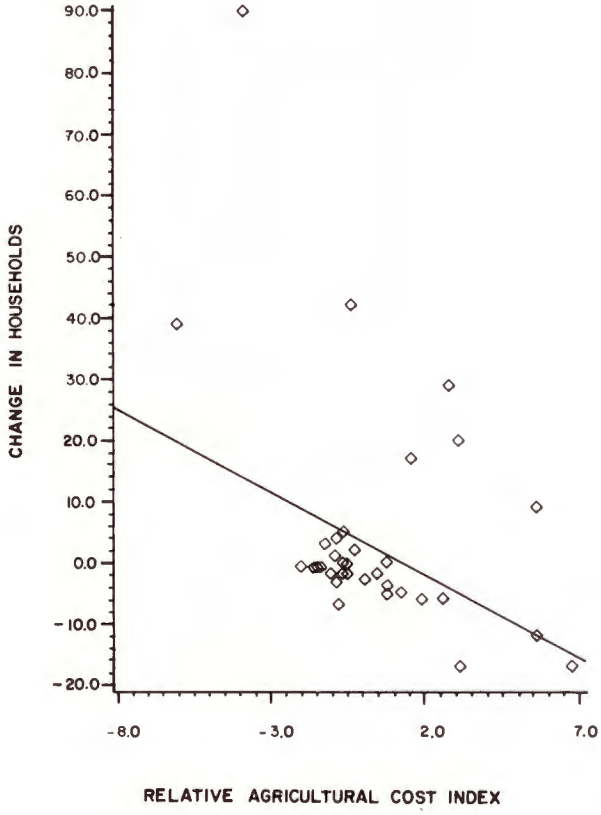

Figure 9.10 – Agricultural costs versus change in number of households, Period 3 to Period 4.

(Lightfoot 1984). Costs remain at similar levels in Periods 2 and 3, as does the decision-making hierarchy. Costs again increase rapidly from Period 3 to Period 4 and remain at the same level in Period 5. Both Periods 4 and 5 display a 3-tiered settlement hierarchy indicative of a 2-tiered decision-making hierarchy. Costs remain high in Period 5 despite the decrease in population due to continued population aggregation (table 9.4) and deteriorating climate (table 9.1). The fact that average travel distance goes up in Period 5 as costs remain similar (or decline slightly) indicates the fields farthest from the habitation sites were poor yielders.

The crash in costs and travel distance in Period 6 accompanies a decline in settlement complexity to a 2-tiered settlement hierarchy. Costs increase again in Periods 7.1 and 7.2, which are characterized by 2-tiered and 3-tiered settlement hierarchies, respectively. As Orcutt (chap. 10) discusses, the changes in settlement complexity correlate with changes in population density, aggregation, and proxied agricultural intensification. Changes in agricultural costs, as measured here, are sensitive to aggregation and population density, thus the close correspondence between changes in cost and changes in settlement complexity.

Even at the period of maximum costs, the average travel distance from residence to fields is less than 2 km, well under the 6.5 km cited by Bradfield (1971) as the usual limit of distance between field and residence for the Hopi, given foot transport, and comfortably within the ranges of average distance to fields for peasant agricultural communities in a long series compiled by Chisholm (1968). Certainly, no support is found for the contention that the project area was abandoned because of unacceptably great distances from residence to field. However, these estimates show that by Period 5, travel distances and the costs they incurred were substantially higher than earlier in the colonization cycle. The economic model assumes if total costs were less in another area, population would flow to that area. On the assumption agricultural costs are an important part of total costs, and following discussions by Petersen (chap. 4, sect. 6) and Schlanger (chap. 8), the nearly total abandonment of the project area during Period 5 could be in response to regional cost differentials.

The economic model, however, does not predict the behavior of settlement placement and growth observed in these data at the local scale. People were not systematically selecting areas with relatively low-cost potential in the Dolores area. Instead, most population growth and rearrangement was towards places with average costs/household or even towards places where costs/household were slightly higher than the project average.

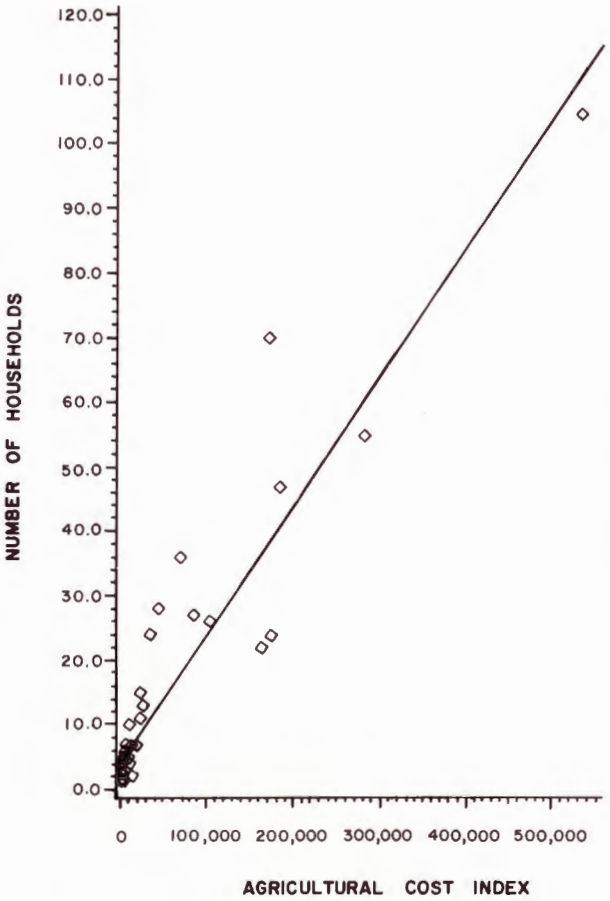

Figure 9.11 – Agricultural costs versus number of households, Period 4.

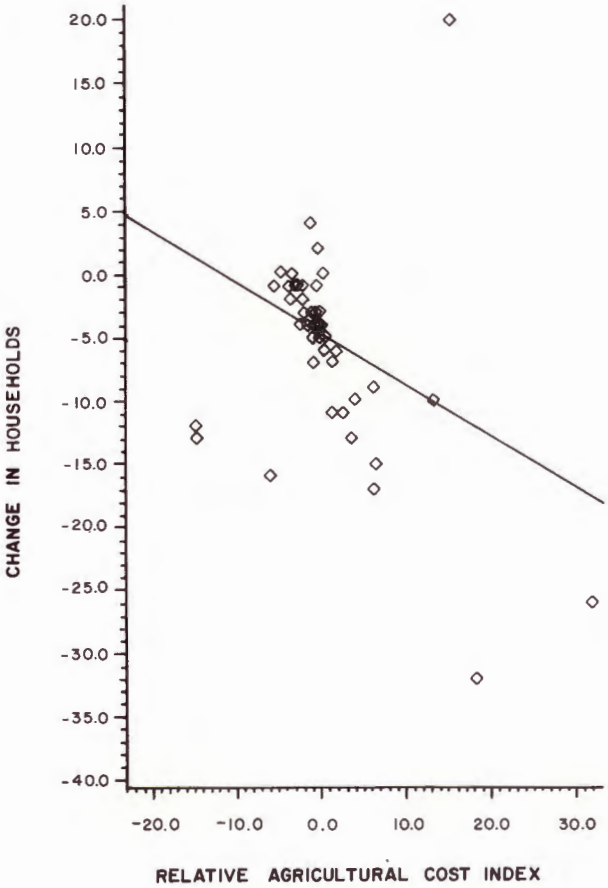

Figure 9.12 – Agricultural costs versus change in number of households, Period 4 to Period 5.

These results – which appear to run in a direction opposite that predicted by an economic model – can be accommodated in several ways without abandoning the idea that Anasazi populations in the Dolores area were sensitive to, and behaved according to, least cost principles. First, this study does not consider all costs. Important activities (for example, fuel collection and hunting) with variable costs across the project area may explain the surprising results. Second, costs probably respond to social organizational factors that cannot be taken into account in a simple model such as this. Perhaps a more efficient organization of task groups and the more extensive division of labor that might be associated with aggregation more than overcome any cost penalties associated with aggregation.

However, additional work along these same lines might indicate the same thing suggested by the present results, if taken at face value: the growth of population in stable locations into large aggregations in the Dolores Project area does not follow least cost principles. Of formative period sites in the Valley of Mexico and southern Veracruz, admittedly on a different scale of sociopolitical organization than the Dolores Anasazi, Earle (1976) noted the founding and spacing of large villages or regional centers followed another. The social factors operating in this distinction probably operate, in miniature, in smaller scale societies as well (refer to our results for population growth across the Period 3/4 boundary). The small Dolores habitations, often founded and abandoned within 1 period, probably do respond to least cost environmental factors much better than do the somewhat larger sites that heavily influence the results of the analyses reported here. The approach used here does not directly evaluate whether the choice of new locations in any period is in response to least cost principles.

Areas that were quite expensive, on our index, do not normally experience much growth, but areas that were quite cheap do not either. One mechanism probably at work in this process is aggregation itself. Large sites come to increasingly dominate the best agricultural areas, even though they may not be located directly in them. This begs the question of what causes aggregation, but at least it is clear, based on our results, that

Figure 9.13 – Simulated agricultural catchments in Period 5 (DAP 162209).

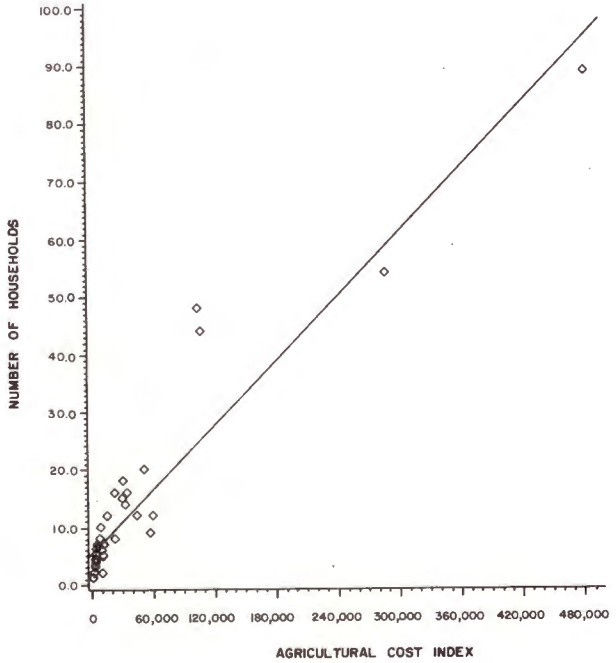

Figure 9.14 – Agricultural costs versus number of households, Period 5.

it has little to do with cost minimization, although costs are not ignored. Based on these results, we would suggest a tentative compromise between the 2 models being compared in the DAP general model. Perhaps important forces were at work governing the distribution of population within the Dolores area that could operate most effectively within this "average cost" zone. Increasing costs – up to a point – may actually stimulate sociopolitical organization and hence population

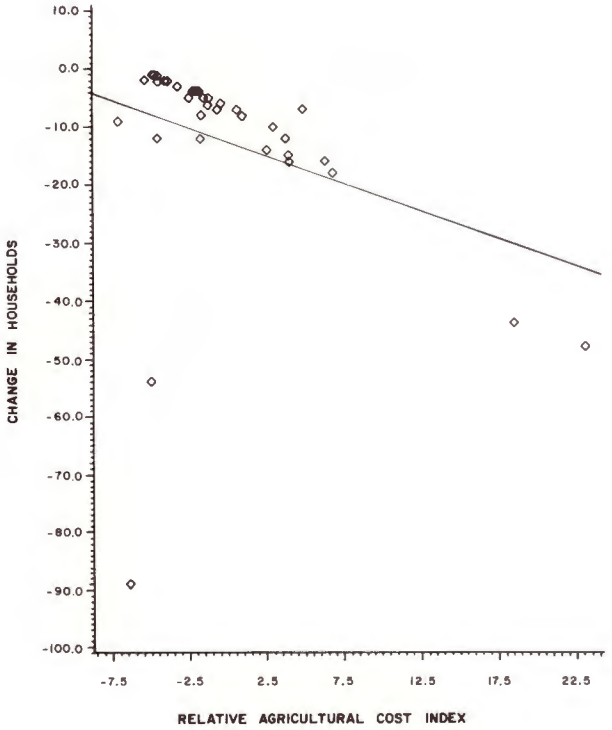

Figure 9.15 – Agricultural costs versus change in number of households, Period 5 to Period 6.

Table 9.4 – Average agricultural costs and travel distances to fields/household, evaluated at mean *n* of households/occupied cell

Period	Mean *n* of households/ occupied cell	Average travel distance/ household* (km)	Average agricultural cost index/ household
1	2.1	0.24	698
2	3.4	0.66	1611
3	4.8	0.74	1723
4	10.4	1.27	3155
5	13.2	1.66	3076
6	5.3	0.38	1085
7.1	7.6	0.88	2087
7.2	15.4	0.89	2343

*Simulated one-way distance from residence to fields.

growth. The existence of a socially driven "power" or "growth" model for change embedded within a satisficing model, rather than at odds with a least cost model, would be consistent with these results.

A methodological point should be made in closing.The approach used here is different than most "catchment"-oriented studies, where an area of constant size and shape around each site is used to calculate agricultural productivity or the availability of some other resource. The catchments calculated by the simulation are certainly not identical to those that would actually have been in use around our sites, but we believe that they are a better approximation to the real situation than a simple radius drawn blindly around each site.

It is interesting to speculate as to what our results might have been had we used the constant-radius approach. Certainly, unless the radius was quite large, some of the larger sites would have actually been exploiting an area larger than that ascribed to them. If we had then calculated the relationship between agricultural productivity (on the x-axis) and population size (on the y-axis), we would have found that larger sites had more people than would be expected based on the productivity of the agricultural catchments.

This is exactly the approach used by Steponaitis (1981), among others, although he used site size (in hectares) as a proxy for population size. Steponaitis was able to distinguish among several groups of formative sites in the Valley of Mexico that ranged in size from less than 10 to well over 100 ha, based on the slopes and intercepts of the regression lines between site size and the agricultural productivity of their 1.5-km catchments. Because the secondary regional centers supported considerably more people than the local centers, and the local centers more than the nuclear villages, without having significantly greater agricultural productivity within 1.5 km, Steponaitis argued that there must have been a flow of tribute from nucleated villages to local centers, and from local centers to secondary regional centers.

We suggest that Steponaitis' results could have easily been an artifact of the constant and rather small radius size he used to compute agricultural productivity. We found that catchment shape and size varied widely among sites within periods. Had we artificially restricted catchment size to a single, small radius, we too would have achieved results in which 2 or 3 groups of sites were apparent in any given period on scatterplots between number of households and catchment productivity, but it is doubtful whether these groups should be used to imply a flow of tribute in our situation. Steponaitis may well be correct in his inferences about flow of tribute, but his argument is not significantly strengthened by his spatial analysis.

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Chapter 10

SETTLEMENT BEHAVIOR MODELING SYNTHESIS

Janet D. Orcutt

The DAP's efforts to develop and test a model of culture change (Lipe 1983) involved dividing the larger model into several components destined for in-depth investigation. The settlement behavior component discussed here consists of the interactions among independent and dependent variables. The structure of the settlement behavior model emphasizes multiple paths of influence and feedback among variables. While more difficult to operationalize, feedback, or "circular causality" (Ellen 1982:180), models provide more accurate depictions of reality than unidirectional (i.e., *a* causes *b*) models (Ellen 1982).

Two years after the development of the DAP general model, it was decided that a second model also should be examined. After some discussion over what the second model should be, Lightfoot's (1984) model of sociopolitical change was deemed acceptable. While the sociopolitical model (also called the social model [Lipe, chap. 6]) is addressed in this chapter very little time was available for developing expectations from the social model and for testing the model. Because the social model has a strong economic undertone, the distinctions between the 2 models are fuzzy and it was preferred to view them as parts of the same model of culture change; however, personal biases did not affect the analysis of settlement organization (see discussion of the social model), which faithfully follows Lightfoot's approach.

The emphasis in this chapter is on the settlement behavior model and the studies that test portions of the model. Following a presentation of the components in the model and summaries of the studies, the performance of the settlement behavior model is assessed. Next, an attempt is made to test expectations for settlement organization derived from the social model. The social variables are then integrated into the settlement behavior model, expectations are derived, and the fit between the expectations and the settlement hierarchy data are examined.

THE SETTLEMENT BEHAVIOR MODEL

The original formulation of the settlement behavior model (Orcutt 1983) focused on the question "Why are there changes in settlement behavior?" The original model presented the interrelationships among the settlement behavior variables (site location, settlement permanence, population, aggregation, intercommunity spacing, and land-use intensification) and the independent variables (resource mix, population, social organization, exchange, and facilities). Figure 10.1 depicts settlement behavior as a dependent variable influenced by several independent variables. No feedback occurs between settlement behavior and the independent variables in this figure because it represents an oversimplification of the relationships among these variables; it does, however, identify the independent variables believed to influence settlement behavior and sets the stage for the more complex relationships presented in figure 10.2.

Figure 10.2 is the refined version of Orcutt's (1983) settlement behavior model. The variables in the model are the same as those originally presented; changes to the original model arise from an increased understanding of the theoretical foundations of the model, and the end product is a better (and more complex) depiction of the relationships among the variables.

The following discussion explains the processes in the flow diagram (fig. 10.2). The presentation is as logical and simple as possible, given the number of variables and arrows connecting the variables. The discussion begins with the variables at the top of figure 10.2 and proceeds downward through the diagram.

Catchment Composition and Diversity

Site locations can be perceived as points from which resource exploitation occurs. The area exploited is the catchment area. Catchment areas can be described in

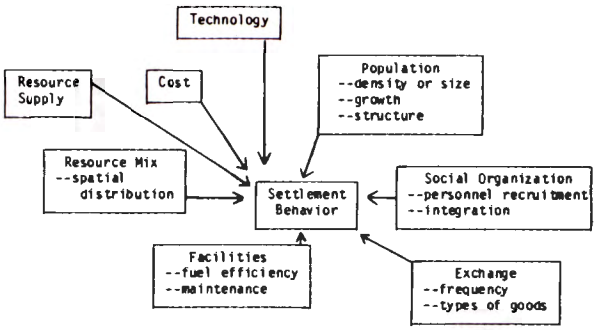

Figure 10.1 – Independent variables affecting settlement behavior.

terms of composition (resource structure) and the diversity of the resource present.

In the model, catchment composition and diversity are affected by resource use (mix), exchange, and settlement permanence. Theoretically, a diverse resource mix would require a diverse catchment with many different resources, and a more focal, or intensified, economy would require a less diverse catchment with fewer kinds of resources. Frequent participation in an exchange network (intersite) would require catchments capable of supplying the exchanged products; conversely, the absence of particular resources in a catchment might encourage participation in an exchange system. Settlement permanence affects catchment composition because the longer a catchment is utilized, the greater the effects on the resource structure. In a situation where a catchment is used more frequently, a different resource structure may evolve of more intensive exploitation. A catchment that is exploited sporadically and for a short time will retain its natural resource structure longer than one that is used frequently.

Resource mix diversity and catchment composition/diversity might influence the number of types of catchments, in that a diverse economy should encourage selection for diverse catchments, leading to a wide variety of catchment types, and an intensified economy (lacking in resource mix diversity) should result in the opposite. The resources exploited within a catchment should affect the tool assemblages (composition and diversity) associated with those catchments. A catchment's resource structure (composition) should be a factor in resource exploitation costs, depending on the maximum potential yield of each resource and the spatial distribution of each resource.

Types of Catchments

Catchments can be grouped into types, either for individual site types or for all sites regardless of type, depending on the kinds and quantities of resources present. The variables affecting the types of catchments in a settlement system are catchment composition/diversity and site type diversity. In a diverse economy, individual catchments are expected to be diverse and the potential exists for greater variety between catchments. A higher diversity of site types, reflecting the diversity in the economy, also leads to greater variety between catchments. Less internal catchment diversity or less site type diversity in a more focal economy leads to less variety in the types of catchments in the settlement system. The type of catchment exploited affects tool assemblage composition/diversity – similar catchments should have similar assemblages, and these assemblages should differ from those associated with other types of catchments.

Site Type Diversity

Settlement systems are composed of sites with different functions. The diversity of these functional types in the settlement system is affected by resource mix. Thus, a diverse resource mix will encourage a higher diversity of functional site types because more resources are exploited than in a less diverse economy. In the latter, site type diversity should be lower because the economy concentrates on fewer resources.

Resource Use (Mix)

Resource mix refers to the kinds and proportions of (subsistence) resources used by a population. In this model, resource mix is affected by resource exploitation costs. The latter is a complex variable affected by several other variables (fig. 10.2). A detailed discussion of the complexities involved in understanding resource costs and the effects of changing costs on resource mix is presented under resource costs.

Resource mix affects catchment composition and diversity in the manner described above; i.e., more diverse resource use leads to more diverse catchments containing a variety of resources. Resource mix also affects the personnel needs necessary to assure successful subsistence strategies. More intensive subsistence strategies (which focus on fewer kinds of resources) can require a larger labor force for activities such as land clearance and constructing water control/diversion and soil control features than less intensive (more diverse) strategies; additionally, the risk attending intensive strategies can be mitigated through larger groups that can support systems of intravillage sharing and distribution of food. More intensive subsistence strategies that produce more per unit area should encourage settlement permanence and aggregation because more people can be supported in the same location for a longer time.

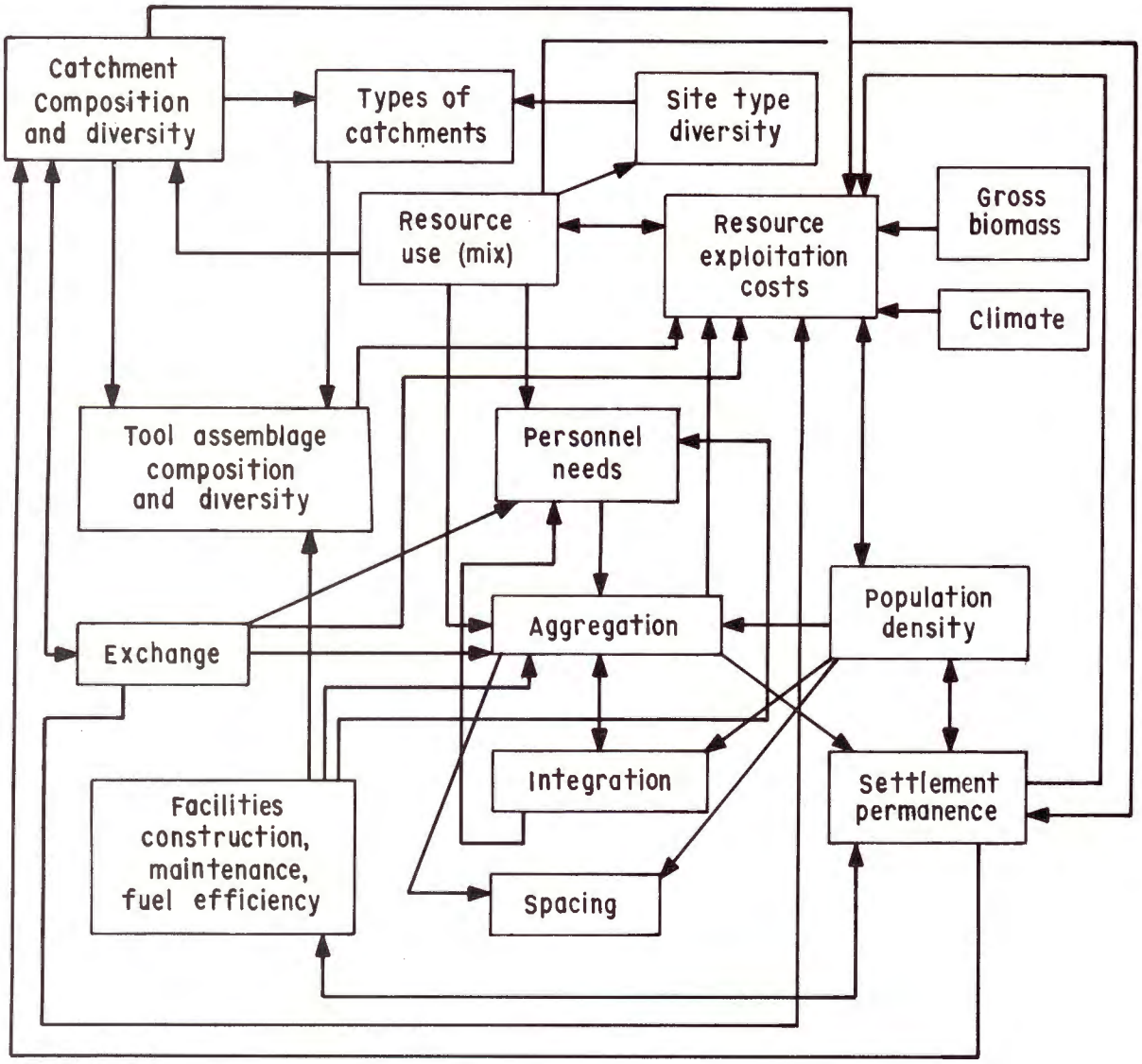

Figure 10.2 – The settlement behavior model.

Resource Exploitation Costs

The concept of resource costs encompasses the relationships among several variables, some of which are shown in figure 10.2. Resource costs, as part of a least cost or least effort decision structure, have been modeled by Earle (1980). In general, the costs of procuring resources are affected by technology, transportation, collection, processing, and storage (Earle 1980). The individual costs of procurement activities are summed to produce an estimate of the total cost of exploiting a particular resource. The cost of a subsistence strategy and the maximum potential yield of the resource determine whether that resource will be exploited relative to other resources (resource mix).

In the settlement behavior model, resource costs are affected by gross biomass, climate, catchment composition and diversity, tool assemblage composition and diversity, exchange, aggregation, population density, and settlement permanence. The overall resource structure of an area (gross biomass) and climate (precipitation, temperature) are 2 variables that affect the productivity of all resources and ultimately the productivity of potential subsistence resources. While not the only variables affecting resource productivity, they do play a major role in the maximum potential yields of critical resources. The types, density, diversity, and spatial distributions of resources (catchment composition and diversity) also determine the maximum potential of resources; for example, few types of resources

sparsely distributed in an area in low densities will have lower maximum potential yields than few types of resources abundantly distributed and in high densities. Technology (tool assemblage composition and diversity) affects the costs of procuring resources and, in the case of such technological innovations as water/soil control devices, can effect the maximum potential yields of resources. Exchange affects the shapes of resource cost curves by making resources available that otherwise might be too expensive to procure directly.

Population distribution (aggregation, population density) also affects resource costs on the regional and catchment levels. Population density affects the population's total caloric requirement; an increase in population density raises the population's caloric (output) requirement and, if all resources are exploited at the same marginal cost (Earle 1980), the increased output requirement leads to exploiting resources at a higher, still uniform, marginal cost. Under these circumstances, intensification of existing strategies and diversification into new strategies are predicted (Christenson 1980; Earle 1980). Any changes in resource mix will then affect the costs of exploiting those resources (positive feedback), eventually producing a different resource mix.

Aggregation as a measure of population density **within** a catchment area, has the same affects on resource costs and resource mix as population density. In addition, larger aggregates create a greater potential for human disturbance of the environment, particularly through agriculture, and there is more opportunity to alter the resource structure in favor of anthropogenic communities (i.e., biotic communities common to disturbed soils). The resource costs in anthropogenic communities usually are lower than those in natural communities because the resources are more evenly distributed, their locations are predictable, and the yields are higher (Ford 1984). Settlement permanence also is part of this density-aggregation-disturbance pattern as the longer an area is exploited, the greater the potential for altering the natural resource structure. The relationship between settlement permanence and the spatial distribution of resources will reflect transportation costs, thus affecting the shape of a resource's cost curve.

All of these aspects of resource costs affect the subsistence choices that a population makes (resource mix). In general, resource mix changes for 2 reasons: (1) changes in output requirements (due to changes in population density, aggregation in a catchment) produce a movement along the cost function to arrive at an appropriate mix (Earle 1980); and (2) changes in any of several variables (gross biomass, climate, tool technology, exchange, settlement permanence) will affect the shape of the cost function, thus leading to adjustments in resource mix (Earle 1980). Differential resource costs between catchments, localities, or regions can affect population density in that lower cost areas should attract population.

Tool Assemblage Composition and Diversity

The kinds of tools and diversity of foods in an assemblage are affected by the resource composition and diversity in a catchment area and by the variety of types of catchments in a region. Catchments with a diversity of resources, reflecting a diverse economy, will have diverse assemblages, and catchments with low resource diversity, reflecting a less diverse economy, should not have diverse assemblages. In a region, if there is a variety of different types of catchments, assemblages should comprise a variety of tools and these assemblages should be diverse. If few types of catchments are in a region, assemblage diversity should be low and there should be few tool types.

The requirements for constructing and maintaining facilities should affect the kinds of tools found in assemblages; thus, sites with more facilities should have different tools and a higher diversity of tools compared to sites with fewer facilities. Technology affects resource cost curves. A technology that increases procurement efficiency, thus lowering the cost of exploitation, allows a resource to become more important in an economy (Earle 1980; Hill and Hawkes 1983; Yost and Kelly 1983). A technology that increases the maximum potential yield of a resource allows intensification of that strategy (Earle 1980).

Exchange

The products obtained through indirect procurement, the repetitiveness with which these activities occur, and the amounts of materials involved in these transactions are affected by catchment composition and diversity. If resources are lacking in a catchment area, exchange partnerships with persons having the resource(s) but lacking in something else can balance resource inequities or insecurities. Also, the use of exchange partnerships for risk minimization (i.e., maintaining ties for use in times of stress) may affect the choice of a site location to include exchangeable products in the catchment. Exchange affects resource costs by lowering the costs of direct procurement. How often one must engage in procurement or manufacture of exchange products affects personnel needs and the size of the aggregate participating in the system. An aggregated population can support an exchange system demanding frequent participation better than a dispersed population because the former has quicker, better organized access to personnel and resources than the latter.

Facilities

Facilities construction, maintenance, and fuel efficiency is affected by settlement permanence. As people become more sedentary, investments in facilities that would bind them to a particular location become feasible (and probably necessary). Sedentary populations can defend their storage facilities, for example, better than a mobile population that is not always there to protect the investment. Time for constructing facilities is available when a population resides in one place longer, and it is easier to maintain facilities when the population or a portion of the population is resident. The investment in (storage) facilities also encourages settlement permanence because storage makes it possible for a population to reside in one place and exist on stored foods rather than moving residences in pursuit of food.

Facilities require the technology for construction and maintenance, thus tool assemblages will reflect these activities. A labor force larger than the family may be required to construct and maintain some facilities (e.g., water control devices, irrigation canals, centralized storage areas), thus personnel needs will rise. The presence of storage facilities and devices that raise resource productivity encourage population aggregation in those sites because larger groups of people can be supported.

Personnel Needs

Activities that require the participation of extrahousehold groups will encourage the formation of larger aggregates. The permanence of these aggregates will depend on the frequency with which they must function, and the amount of security or risk buffering they offer.

Personnel needs are affected by resource mix, exchange, facilities, and integration. Intensified subsistence strategies often need cooperative labor groups and security buffers in the form of food collection and distribution. Sizeable exchange systems need a large population base to function. Facilities require labor groups for construction and maintenance. Integration requires personnel to fill social positions and to provide food collection/distribution when crops fail or when the supply of stored goods is low (Ford 1972).

Personnel needs affect aggregation because the greater and more frequent these needs are, the more incentive there is to form population aggregates. These aggregates may be temporary or permanent depending on their function and the frequency with which they must operate. The costs of forming and disbanding aggregates must be weighed against the costs of maintaining permanent aggregates.

Aggregation

Aggregation refers to a nucleated population whose members interact regularly (Glassow 1977; Henderson 1979). The greater the need for labor groups or cooperation in food collection/distribution, the more aggregation will occur. Exchange systems also encourage aggregation for their perpetuation and success (Graves et al. 1982). Larger aggregates are "encouraged" by the presence of storage facilities and other facilities that raise resource productivity. Population density and aggregation also are related; as density increases, the problems of dispersed populations infringing on other's territories become more obvious and aggregation is one way to alleviate such problems. As integrative needs increase, aggregation will be favored over dispersion. Changes in resource mix can affect aggregation as strategies producing more per unit area may encourage people to aggregate.

Aggregation affects the spacing between population aggregates; as aggregates grow in size, the space between them should increase. In a region where population density is low and aggregation is low, the space between aggregates will be high; if population grows and aggregates remain small, the space between aggregates will decrease and problems of unwanted interaction and "trespass" will develop. Population aggregation is one solution to the problems. The formation of widely spaced aggregates provides sufficient territory for subsistence pursuits and allows the formation of buffer territory between aggregates. Aggregation will affect resource costs because of the effects of larger aggregates on the natural resource structure and the output requirement of the aggregated group. Aggregated groups are more likely to be in permanent settlements because of logistic problems with large group mobility.

Integration

As the number of component groups in a society grows, and as the activities that these groups perform become more differentiated, positions develop to coordinate and tie the groups together (Plog 1974, 1978). An aggregated population is better able to fill these positions than a dispersed population, thus the need for integration encourages aggregation. The opposite also is true: aggregated populations need integrative mechanisms to pull disparate groups together and to assure that the society can operate as a whole.

The effects of population density on integration are similar to those on aggregation: the higher the density, the greater the need to coordinate activities and movements to avoid conflicts.

Spacing

The amount of space between population aggregates is affected by the degree of aggregation and population density. As aggregation increases, so will the space between aggregates. As population increases, the space between aggregates will decrease. If population density increases, the space between aggregates will decrease until population aggregation occurs; at that time, the space between aggregates will begin to widen.

Population Density

As the population in a given area grows, the density of that population increases. Population density is important in this model because of the implications of growth for so many aspects of the socioeconomic system. Most of these relationships have been described previously and are summarized here.

Population density affects resource exploitation costs, aggregation, integration, spacing, and settlement permanence. A population's caloric requirement is determined by the size and age-sex structure of the population; changes in population density affect this caloric requirement which, in turn, affects the level at which resources must be exploited to meet the requirement. An increase in population density raises the output requirement, resulting in the exploitation of resources at a higher marginal cost than before. Changes in population density will affect aggregation and integration. As population density grows, integration and aggregation will increase in response to population packing and the need to coordinate the movements and activities of a larger population. Population density affects the spacing between population aggregates. As density increases, the space between aggregates will decrease; however, this is mediated by population aggregation.

Population density affects settlement permanence for reasons similar to those for its affects on aggregation. The higher the density in an area, the greater the potential for conflicts with a mobile subsistence strategy. Settlement permanence reduces mobility, thus helping to alleviate some of the problems faced by a denser population.

Population density is affected by settlement permanence because as mobility becomes restricted there are more opportunities for new populations to move into an area and establish new settlements. Population density also is affected by costs, with lower cost areas being more attractive than higher cost areas.

Settlement Permanence

The length of time that a habitation is occupied during the year is affected by aggregation, population density, facilities, and subsistence strategies (resource mix). The costs of maintaining mobility under aggregated conditions are likely to be high, thus, as aggregation increases, so should settlement permanence. This does not imply that people do not move; it implies that not everyone moves at the same time (i.e., a portion of the population always is in residence at the habitation). Population density and settlement permanence are related – an increase in density will eventually require curtailed mobility. The presence of facilities requiring protection and maintenance will encourage settlement permanence, or at least a "skeleton crew" in residence at the habitation for most of the year. Settlement permanence affects facilities construction as the longer people are in one place, or if they return regularly, the more feasible the investment in permanent facilities for storage or subsistence intensification. Finally, subsistence strategies requiring increased production per unit area will encourage settlement permanence.

Conclusion

The settlement behavior model is complex, and attempts to test such a model cannot deal with all of the relationships at once. Several studies using DAP data were designed to explicate some of the relationships. In the following 2 sections, the DAP data used in the settlement behavior modeling studies are described and the modeling studies are summarized.

DATA BASES

The most commonly used data in the settlement behavior studies were the set of intensively surveyed sites in the DAP takeline and the environmental data from which site catchment contents were computed. These data are briefly described here.

The survey sites provide data on over 900 prehistoric sites within the DAP takeline, and for 90 to 95 percent of the sites, the survey data represents the only data recorded. This is the only data base suitable for settlement studies as it covers both the river valley and the uplands, and represents 100-percent coverage of the takeline except on canyon walls. The excavation data favor the river valley and large habitation sites, a situation unsuitable for settlement system analyses. The sites have been placed into functional site types based on surface architecture; the site type classification yielded 480 limited activity loci, 319 habitation loci, 67 seasonal loci, and 75 sites of unknown type.

Most of the sites in the Dolores area are limited activity loci; unfortunately, these sites are the most difficult to date making them the least useful data for diachronic studies. However, some analyses were conducted using

limited activity site data, and these are discussed in the modeling study summaries. The seasonal loci also are difficult to date, which limits the kinds of studies that can be done with these sites. Habitation sites are the easiest to identify and the easiest to date, thus, they form the basis for most of the settlement behavior modeling studies.

An environmental data set was compiled for use in the catchment studies, which were an important part of the settlement behavior modeling effort. A grid of 200- by 200-m cells, based on UTM (Universal Transverse Mercator) coordinates, was placed over the Dolores takeline, plus 1 km outside the takeline (for a total of 13,728 ha). For each cell, all types of water sources were coded and the dominant soil quality, cold air drainage risk, and vegetation were coded (Orcutt 1985a). Based on site UTM coordinates, the appropriate cells within a specified distance up to 1 km from the site were included in the site's catchment area by Microsoft and SuperSoft Fortran programs run on an IBM PC.

The variables in the environmental data set have been described by Orcutt (1985a) and are summarized here. The water types present in the Dolores area, according to the USGS (U.S. Geological Survey) 7.5′ topographic maps, are permanent drainages, intermittent drainages, marshes, springs, and no water. Soil quality is based on the Soil Conservation Service's land-capability classes (Nielsen 1979). In the Dolores area, 4 of these classes are present: III, IV, VI, and VII. In the catchment studies these were named "good," "adequate," "marginal," and "nonagricultural." Cold air drainage risk refers to spatial variability in the growing season related to physiography and elevation. The 3 types of cold air drainage risk and associated growing season length are: low (greater than 120 days), moderate (90 to 120 days), and high (60 to 90 days). A risky growing season (Orcutt 1985b, 1985c) shifts moderate risk land to high risk and shifts low risk land to a growing season of greater than 90 days (Petersen and Clay 1985).

Vegetation cover types in the Dolores area consist of the following: big sagebrush, riparian, aspen, pinyon-juniper, oak, mountain brush, ponderosa-oak, oak and Douglas-fir, and mountain brush and Douglas-fir. Two vegetation maps were constructed for the Dolores area to show the vegetation distribution for different climatic conditions in the past. One map, based on the vegetation ca. 1920, shows the vegetation distribution for periods that are characterized by relatively moist conditions: A.D. 600 to 800 and between approximately A.D. 1000 and 1100 (Petersen 1985a:fig. 1). The second map reconstructs the vegetation distribution for periods with relatively drier conditions: A.D. 800-1000 and 1100-1175 (Petersen 1985a:fig. 9).

MODELING STUDY SUMMARIES

Studies developed to test aspects of the settlement behavior model are summarized in this section. One study deals with site types, several of the modeling studies focus on aspects of the catchment composition relationships, and one study examines aggregation and spacing in the context of the settlement behavior model.

Site Type Studies

The definition of functional site types is critical to settlement system analyses. Schlanger and Orcutt (1985) examined the relationships among architectural site types, based on architecture, modeled functional site types, and artifact assemblage characteristics. If the expected site types were proxies for functional site types, then the assemblage variables should confirm the architectural characteristics. The goal was not to refine existing typologies, such as that employed by the Southwestern Anthropological Research Group (Plog and Hill 1971), because archaeologists still are coping with the task of distinguishing the site types commonly in use. For example, sites with 1 or 2 rooms ("small sites" [Pilles and Wilcox 1978; Ward 1978]) are classified as habitations by some (Euler and Chandler 1978:78; Plog 1978:58) and as limited activity sites by others (Dean and Lindsay 1978:111; Dean et al. 1978:29).

Three general site types were expected in the Dolores are: (1) non-residential sites (limited activity loci); (2) short-term residences (seasonal loci); and (3) permanent residences (habitation loci). Three kinds of sites could be distinguished from the survey data on the basis of architecture: (1) sites with no architecture visible on the surface and no indication of subsurface architecture; (2) sites with concentrations of small chunks of sandstone rubble; and (3) sites with substantial architectural remains, including upright sandstone slab alinements, larger pieces of unshaped rubble, masonry walls and wall fall, and subsurface pitstructures. Whether these architectural types fit the expected general site types was assessed using a model of artifact assemblage characteristics.

The model of expected differences between site types was based on 2 concepts. First, the more time spent in a place during a given episode of use, the more domestic activities will take place and be reflected in the archaeological record. Thus, length of stay or anticipated length of stay will influence the investment made in facilities for housing, cooking, food storage, and equipment storage. The 2 extremes of the length-of-stay continuum are the permanent residence (habitation locus) and the short-term procurement or collecting site (limited activity locus). Second, the site types are part of an integrated system of tool use and discard (Binford

1979; Ellis 1978; Russell 1978). These 2 principles structure the following definitions and assemblage expectations for the 3 site types: limited activity loci, seasonal loci, and habitation loci.

In the Dolores area, limited activity loci sites were used for a short time (days) and for a single economic season by a few individuals (Kane 1983:20). The activities performed at these sites probably varied from place to place and the characteristics distinguishing these sites as a group result from their use by workers coming from a residential base and include the absence of permanent shelters or houses, and an artifact assemblage composed primarily of discarded, unusable tools and the manufacturing debris from tool repairs and quickly made tools. Relatively few tool types should be present at any one of these sites.

Seasonal loci were used for several days, weeks, or even 2 or 3 months by small social groups (Kane 1983:21-22). Seasonal sites have architecturally bounded spaces similar to those at habitations (i.e., aboveground rooms consisting of 1 living room and several storage rooms) but lack pitstructures (Kane 1983:22). Because these sites are in use for relatively long periods, discarded materials should reflect domestic activities – cooking and food preparation, eating, and tool manufacture and maintenance. As secondary habitations the assemblages should resemble those from habitations more than those from limited activity loci.

Habitation loci were continuously occupied or were occupied for a major portion of the year. Architectural remains are substantial, including rooms and pitstructures (Kane 1983:23). Because these sites represent the primary residential component in the settlement system, they should be the locus of most personal maintenance – housing, food preparation, storage, and consumption – and the locus of the greatest amount of tool manufacture and maintenance. The number of tasks performed, and the tools and equipment needed to perform them, should be greatest at these sites.

Three stages of analysis were designed to test the fit between the architectural types and the expectations for those types. All artifact assemblage variables used in the analyses are from the DAP additive technologies (Blinman et al. 1984) and reductive technologies (Phagan and Hruby 1984) analytic systems. The artifacts come from systematic, intensive surface collections (Bohnenkamp et al. 1984; Schlanger and Harden 1983); the majority of the materials are from complete ("100 percent") collections of all stone and ceramic artifacts found on the site surfaces.

In the first stage of analysis, 48 sites from the probability survey (Schlanger and Harden 1983) were used in analysis of variance and discriminant analysis. Of the 48 sites, 31 could be typed and 17 are "unknown" because of incomplete architectural data. A large number of variables was used, including the number of flaked lithic tool types, the number of nonflaked lithic tool types, the number of ceramic types, and the total number of artifact types (refer to Schlanger and Orcutt [1985] for a complete list of the variables). The analysis of variance indicated the groups are significantly different with respect to all the variables except the number of ceramic types; the F value greater than 1 for the number of ceramic types, however, indicates that the groups are different but not statistically different (Schlanger and Orcutt 1985).

The model of functional types expects the number of tool types to increase from limited activity loci to seasonal loci to habitation loci, and intragroup variation in the number of tool types should decrease from limited activity loci to seasonal loci to habitation loci, reflecting reduced intragroup variation in site functions. These expectations were tested using predicted and actual means and CV's (coefficients of variation) for the variables. The results indicate complete agreement between the predicted and actual rank orders for the number of nonflaked lithic tool types and for the number of ceramic types; the mean and CV rank orders do not agree with the predicted order for the number of flaked lithic tool types, and the CV rank order does not match the predicted order for the number of all artifact types. Overall, however, good agreement was achieved between the actual and predicted rank orders, lending support to the architectural types as functional types (Schlanger and Orcutt 1985).

Discriminant analysis was used in the first stage to confirm the group assignments based on architecture using the artifact variables. The variables consisted of the assemblage proportions of 20 artifact types, flaked lithic tool energy input, nonflaked lithic tool energy input, and ceramic energy input (Schlanger and Orcutt 1985). The discriminant analysis results are described in detail by Schlanger and Orcutt (1985); they indicate good group separation based on Wilk's lambda, and the correlations between the variables and the discriminant functions, and the group centroids on the functions conform well with the expected differences between the site types. Generally, the discriminant functions separate the groups on the basis of the relative contributions of: (1) expedient tools (utilized flakes and debitage without cortex); (2) domestic maintenance items (sherds); and (3) nonflaked lithic tools, especially manos, associated with food preparation. Limited activity loci have high proportions of expedient tools and low proportions of sherds and manos. Seasonal loci have low proportions of expedient tools and high proportions of sherds and manos. Habitation loci are similar to seasonal loci and

have higher proportions of expedient tools and lower proportions of sherds and manos than seasonal loci.

The discriminant analysis classified 90.3 percent of the sites correctly. One (7.1 percent) of the 14 limited activity loci was classified as a habitation locus and 2 (20 percent) of the seasonal loci were classified as habitation loci. All habitation loci were classified correctly.

In the second stage of analysis, a different set of sites was used and the number of variables was reduced to 7 (Schlanger and Orcutt 1985). The discriminant functions and group centroids indicated that the site types were distinguishable along the lines expected and generally supported the differences obtained in the first stage discriminant analysis. Classification accuracy was high, 90.6 percent correct, with only 3 sites being misclassified by the discriminant analysis.

Because the 2 discriminant analyses had confirmed the site groups with high accuracy, it was decided the second stage discriminant functions would be used to classify 198 sites for which we knew the site type but which were entered as "unknown." This is different from the confirmatory uses of discriminant analysis discussed above; in this part of the study, the discriminant analysis was expected to assign ungrouped ("unknown") sites to groups, allowing us to assess the accuracy of the procedure.

Only 43.4 percent of the "unknown" cases were assigned to the correct type (Schlanger and Orcutt 1985). Although the classification accuracy is low, it is not as low as making random site type assignments. A tau value of 0.16 indicates 16 percent fewer classification errors than would be expected if sites were randomly assigned to types (Klecka 1980:51), indicating that when architectural features cannot be used to make type assignments, the discriminant classification technique would be preferable to assigning sites at random.

In the third stage of analysis, a potentially complicating cultural factor that may have contributed to the poor discriminant classification performance was examined. While many factors can contribute to assemblage variability that would cause the discriminant analysis to have difficulty in making correct assignments, Schlanger and Orcutt (1985) decided to examine functional shifts in use that did not correspond to architectural changes. If agriculture became more important in the Dolores subsistence economy as local population grew and natural resources became more scarce (Kane et al. 1982; Orcutt 1983; Schlanger 1982), site type assemblages might change in response to this economic change. Specifically, an increase in agricultural dependence would increase the use of field houses, of other seasonal loci, and of limited activity loci because the population would be tied to agricultural stores and land; this should produce increases in food storage facilities and food processing facilities and equipment at either the habitation loci or the seasonal loci, and probably at both. Expectations for changes in assemblages were derived to test the economic change hypothesis and the surface collections from 28 habitation sites in 4 temporal groups were used for testing. A discriminant analysis classified 46.4 percent of the sites correctly (28.6 percent better than random assignments), indicating that site type functions may have varied significantly through time. Difference-of-means tests also indicated that assemblage changes through time fit well with the predictions for change based on the economic change model.

These temporal (economic) differences may have affected the second stage discriminant classification. To test this, 35 habitation sites used in the second stage discriminant analysis were assigned to 1 of 2 temporal groups (A.D. 600-800 and 800-920) and the discriminant classifications for each site were examined. Of the 11 A.D. 600-800 sites, 8 were classified as habitations and 3 as seasonal loci by the discriminant analysis; of the 24 A.D. 800-920 habitations, 9 were classified as habitations and 15 as seasonal loci by the discriminant analysis. A Fisher's exact probability test indicates these differences are significant and that the A.D. 800-920 sites are more likely to be classified as seasonal loci than as habitation loci. Because the architectural features at these sites are consistent with the model for permanent habitation sites, Schlanger and Orcutt (1985) concluded that the activities at these sites were more similar to those at seasonal sites during this period (A.D. 800-920), thus introducing variability that the discriminant functions could not handle well.

Despite the confounding effects of assemblage variability on discriminant classification success, the discriminant analysis can be used to classify sites for which architectural data are incomplete. Overall, the architectural types appear to be good proxies for functional site types; however, the possibilities of complicating factors, such as economic change, should be considered.

Catchment/Locational Studies

Orcutt (1985a) examined the relationships among resource costs, resource mix, and habitation site catchment composition/diversity. No direct estimates for resource costs and resource mix were available at the time of the study so proxy measures were developed based on arguments derived from Christenson (1980) and Earle (1980). While these proxies were carefully and logically derived from the marginal cost model, they may not accurately reflect the changes in resource mix.

Several variables – population density, social organization complexity, human disturbance to the natural environment, and climate – have important effects on the marginal cost at which resources will be exploited and on the cost curves themselves (Earle 1980). These form the basis for 2 proxy variables used to predict changing resource use. The variables used to create the proxies are described below.

Population density was computed 2 ways (Orcutt 1985d). First, population density for the Dolores area was calculated, in which case the trajectory is the same as that for population size. Second, population density was calculated relative to the size of the area occupied during each period (data assignments for DAP periods are outlined in chapter 1). The latter provides an estimate of the pressure on local resources, assuming that populations utilize areas closer to them more heavily than distant areas.

Climatic stress refers to below average precipitation and risky growing season length (Orcutt 1985b, 1985c). In the absence of specific knowledge of the differential effects of precipitation and growing season length on a variety of resources, the 2 are considered to represent a similar stress on subsistence resources. The problem in considering the 2 together is that not all resources may respond the same way to moisture stress, to temperature stress, or to both; however, there is support for taking this approach in a gross level analysis (Garza 1978; Shuster 1983; Wetterstrom 1976). Droughts are represented by a tree-ring width greater than or equal to 1/2 standard deviation below the mean (Slatter 1979) in the Dolores (pre-A.D. 1136) or Mesa Verde (post-A.D. 1136) tree-ring chronologies. A risky growing season of 113 days or less is defined by a tree-ring width greater than or equal to 1/2 standard deviation below the mean (Orcutt 1985b, 1985c) in the Almagre Mountain tree-ring index (Petersen 1985b).

The degree of aggregation is used to represent social organization (i.e., the ability to mobilize work groups) and the impact of human disturbance on the environment. Household aggregation, the average number of households per rubble area (Orcutt 1985d), provides an estimate of social organization complexity. Spatial aggregation, the average number of households within 500 m of a rubble area (Orcutt 1985d), represents both social complexity and the potential for environmental disturbance.

The variables were combined to produce 2 potential resource costs/resource mix proxies: (1) project area population density, frequency of climatic stress, duration of climatic stress, household aggregation, and spatial aggregation; and (2) occupation area population density, frequency of climatic stress, duration of climatic stress, household aggregation, and spatial aggregation. Each period was ranked on each of the variables to produce a total rank; the total ranks for the periods represent an "intensification index," where the lowest rank reflects the least intensification and the highest rank reflects the most intensification (tables 10.1 and 10.2). The intensification trajectories are similar for the 2 proxies (figs. 10.3 and 10.4). For the first proxy variables, the periods rank (from lowest to highest) in the following order: 7.3, 1, 6, 3, 2, 4, 7.1, 7.2, 5. For the second proxy variables the periods rank in the following order: 1, 7.3, 3, 6, 2, 4, 7.1, 7.2, 5.

The proxy variables (intensification index) are integrated with additional expectations regarding risk or uncertainty minimization and the long-term implications of human disturbance to make predictions regarding resource use in the Dolores area. Uncertainty was assessed qualitatively and refers only to the uncertainty accompanying climatic stress; responses to uncertainty were expected to be seen in locational selection for soil quality/cold air drainage risk situations. In general, high uncertainty would select for high diversity of soil quality/cold air drainage risk and low uncertainty would select for low diversity; moderating the level of diversity is the predictability of the type of stress and the stress itself. Droughts should select for low and moderate cold air drainage risk land, risky growing seasons should select for low cold air drainage risk land, and the presence of both stresses should select for low and moderate risk land. Human disturbance is assumed to be additive; many years of agricultural manipulation by a growing population creates a positive feedback situation, encouraging the continued use of agriculture and adding to the intensification expected on the basis of the intensification index. A declining population will disturb less land, and if nondisturbance continues, these areas will proceed through normal successional stages. Cost curves for subsistence resources will shift several times throughout the successional cycle with agriculture becoming more costly than in a disturbed habitat.

Based on the predictions using the intensification index and considerations of uncertainty and human disturbance, expectations for changes in habitation catchments were developed for each period (Orcutt 1985a). Environmental data from 1-km radius habitation catchments for pairs of periods were compared and evaluated in light of the expectations; overall agreement between the data and the expectations was not good. In particular, expectations for differences in vegetative and soil quality/cold air drainage risk diversity were not supported by the data. Locations chosen may have offered sufficient diversity and access to appropriate cold air drainage risk situations to allow populations to adjust their land-use strategies when necessary.

Table 10.1 – Rankings on variables, by period

Period	Project area pop density (low-high)	Occup area pop density (low-high)	Climatic stress		Aggregation	
			Freq (low-high)	Length (low-high)	Household (low-high)	Spatial (low-high)
1	3	1	6	3	1	1
2	6	4	7	4	3	4
3	7	5	4	2	4	5
4	9	7	3	1	5	9
5	8	8	9	9	8	7
6	2	3	1	8	6	3
7.1	4	6	8	7	7	6
7.2	5	9	5	5	9	8
7.3	1	2	2	6	2	2

Occup – Occupation.
freq – Frequency.
pop – Population.

Table 10.2 – Total ranks for proxy variables for each period

Proxy variables*	Period 1	2	3	4	5	6	7.1	7.2	7.3
1	14	24	22	27	41	20	32	32	13
2	12	22	20	25	41	21	34	36	14

*1 = Project area population density, frequency and duration of climatic stress,household aggregation, and spatial aggregation (total ranks are plotted in fig. 10.3). 2 = Occupation area population density, frequency and duration of climatic stress, household aggregation, and spatial aggregation (total ranks are plotted in fig. 10.4).

Habitation locations (catchments) were compared to catchments for a set of random points in the Dolores area. The random points represent a nonselection situation that approximates the distribution of environmental characteristics in the Dolores area. The results of this analysis were more interpretable in terms of the expectations for subsistence/locational change than the results of the habitation comparisons.

The most striking pattern to emerge from the habitation-random points comparisons is that the A.D. 600-920 habitation site catchments apparently were placed to maximize good-quality agricultural locations and to minimize poor-quality agricultural locations. Even in periods of high population density, when good agricultural land might have become scarce, this selection still is evident. The post-A.D. 920 catchments do not exhibit selection for good agricultural locations; however, most show a preference against poor agricultural locations. Interpreting the post-A.D. 920 patterns is difficult, although it is tempting to propose that they represent subsistence diversification (which is contrary to what was expected for 2 of the 4 periods). Part of the problem in interpreting the data is that the Dolores area is sparsely occupied after A.D. 920 and it may be necessary to understand the relationship of the Dolores occupation to surrounding areas before a reasonable understanding of the patterns can be achieved.

The major period of occupation in the Dolores area (A.D. 800-920) was characterized by the formation of large villages and communities. Thiessen polygons for 7 villages/communities (McPhee, House Creek, May Canyon, Rio Vista, Grass Mesa, Windy Ruin, and Cline Crest) were constructed to evaluate resource availability, population density and agricultural quality, and the potential for intensification. Problems with the Thiessen polygons that may have affected some of the results are noted but cannot be evaluated: some polygon boundaries are arbitrary due to the absence of bounding communities or the presence of steep canyon walls; none of the polygons have been completely surveyed, and survey coverage varies among the polygons; thus, the analysis of the relationship between population density (for surveyed areas only) and agricultural quality (for the entire polygon) may be suspect.

The polygons differed with respect to vegetative composition, vegetative diversity, soil quality/cold air drainage composition, and soil quality/cold air drainage diversity. Aspects of vegetative composition and soil quality/cold air drainage risk composition were used to assess agricultural quality and to rank the polygons with respect to agricultural quality in the A.D. 800-840, A.D. 840-880, and A.D. 880-920 periods. The type of climatic stress in each period was used to create a list of the best agricultural variables for that climate.

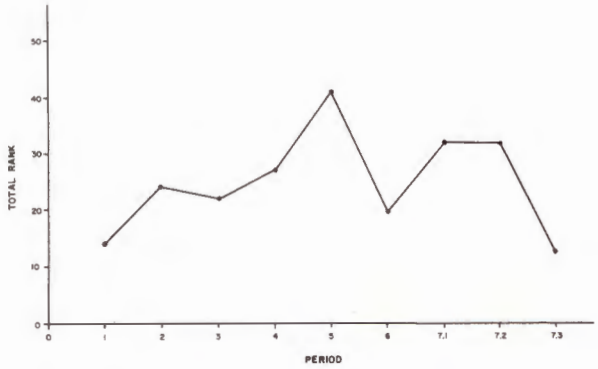

Figure 10.3 – Intensification trajectory, proxy variable one (adapted from Orcutt 1985a:fig. 1).

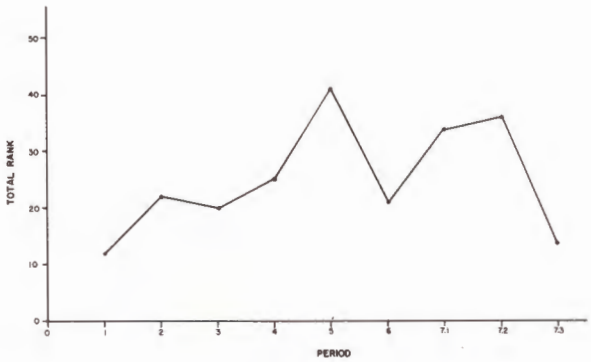

Figure 10.4 – Intensification trajectory, proxy variable two (adapted from Orcutt 1985a:fig. 2).

In addition, variables such as high-risk land, marginal land, and nonagricultural land were assumed to detract from a polygon's agricultural quality.

Because the A.D. 800-840 and A.D. 840-880 periods are characterized by droughts, variables enhancing agricultural quality include: good- and adequate-quality low- and moderate-risk land, and big sagebrush vegetation (the easiest vegetation to clear); the variables subtracting from agricultural quality are good- and adequate-quality high-risk land, all marginal quality land, and all nonagricultural land. For the A.D. 880-920 period, characterized by risky growing seasons, the following variables add to agricultural quality: good- and adequate-quality low-risk land, and big sagebrush vegetation. Subtracting from agricultural quality are good- and adequate-quality moderate- and high-risk land, all marginal quality land, and all nonagricultural land. The percentage of land in each category was added or subtracted to produce a value representing the overall agricultural quality of the polygon in each period; the better quality polygons had the higher ranks, and the poorer quality polygons had the lower ranks.

The polygons were ranked according to population density in the surveyed portions of the polygons and were compared to the agricultural quality ranks to test the proposition that better quality agricultural areas had higher population densities. The correlations in all 3 time periods were low and none were significant. It is not known how much the absence of complete survey in the polygons affected these results, if at all.

Arable land demand in each polygon was simulated to obtain estimates of the potential for increasing agricultural production and to better understand how labor and land intensification might occur. Three modeled demand levels per household were used in the analysis: 3.5 ha/household, 5.0 ha/household, and 8.0 ha/household (Bradfield 1971; Culley et al. 1982; Ford 1968; Lange 1968). Each of these figures includes a 50-percent fallow (modified from Ford 1968); thus, cultivated land is 1.75 ha/household, 2.5 ha/household, and 4.0 ha/household. Cultivating 1.75 ha/household provides 67 percent of a population's annual caloric requirement and produces a surplus of calories equivalent to approximately 0.7 to 1.9 months/household (Orcutt 1985b, 1985c); cultivating 2.5 ha/household provides 96 percent of a population's annual caloric requirement and provides a surplus of calories equivalent to 6.6 to 7.5 months/ household (Orcutt 1985b, 1985c); cultivating 4.0 ha/household provides 100 percent of the annual caloric requirement and a surplus of approximately 18 months/household (Orcutt 1985a). These figures strongly suggest high production is necessary if storage capacity is to be more than a fraction of a year.

Arable land demand in the polygons was simulated using momentary population estimates. The simulations indicated that in the A.D. 800-840 period all of the polygons had sufficient arable land to satisfy the 3 demand levels. Expanding production to meet increased output requirements or to raise the amount in storage was feasible in all the polygons. In the A.D. 840-880 period, all of the polygons had sufficient arable land to supply 3.5 ha/household and 5.0 ha/household. Only the Grass Mesa and McPhee polygons could not supply 8.0 ha/household as modeled with the 50-percent fallow; Grass Mesa's polygon could supply 4.0 cultivated ha/household with a 21-percent fallow and McPhee's polygon could supply 4.0 cultivated ha/household with a 45-percent fallow. Expanding agricultural production, therefore, was possible in all the polygons, but would have required greater intensification at Grass Mesa and McPhee (fallowing less land). In the A.D. 880-920 period, all moderate-risk land becomes high-risk land 60 percent of the time so that for all practical purposes, only low-risk land is considered available during this period. Despite the loss of moderate risk land for agriculture, all polygons can supply 3.5 ha/household and all except Grass Mesa can supply 5.0 ha/household. Eight ha/household is possible in all the polygons except

Grass Mesa and McPhee. The Grass Mesa polygon could supply 2.5 cultivated ha/household with a 38-percent fallow, or 4.0 cultivated ha/household with a 1-percent fallow. The McPhee polygon could supply 4.0 cultivated ha/household with a 37-percent failow. As in previous periods, the potential for intensification of agricultural production exists in the Dolores area. Intensification at Grass Mesa and McPhee requires more effort because the fallow has to be reduced. Intensification to provide a higher storage buffer may have been necessary during this time period to survive the longer climatic stress episode (averaging 6 consecutive years in length, separated by an average of 2 years).

To understand the relationship between resource use and catchment composition, one aspect of field house location was examined. One expectation for habitation site catchments was that A.D. 800-840 and A.D. 840-880 catchments should show a preference for low- and moderate-risk land and A.D. 880-920 catchments should prefer low-risk land; the expectation was not borne out by the habitation catchment data. Because field houses probably were located adjacent to the land being cultivated, their locations may provide a better indication of the immediate concerns for maximizing production potential than do habitation site locations. The results of analyzing 250-m radius catchments for field houses indicated that the A.D. 880-920 locations showed a significant selection against moderate risk land.

Orcutt (1985a) developed expectations for subsistence change based on proxies for resource costs and then extended these expectations to composition and diversity of habitation site catchments. The catchment expectations were tested by examining differences in habitation site catchments between pairs of periods, and differences between habitation site catchments and random points catchments. Because the latter analysis compared 2 contrasting data sets, the results were easier to interpret in a selection versus nonselection context than were the comparisons among the habitation site catchments. Differences were obtained in both comparisons, but the differences were not always congruent with the expectations and probably reflect the pitfalls of too simplistic a model. The model focused on subsistence requirements as the prime mover in habitation location, and most of the results support this assumption; however, improvements could be made by modeling the contributions of social costs and nonsubsistence resources costs to habitation location decisions.

A study by Goulding (1985a) examined the relationships among catchment composition, types of catchments, and tool assemblage composition for 7 villages and 28 hamlets in the A.D. 840-920 period. Goulding's (1985a) framework for structuring the study included the following assumptions: (1) heterogeneous resource distributions will be exploited using logistic strategies; (2) resource structure close to a habitation will condition subsistence and organizational strategies more than the resource composition farther from the site; (3) differences in organizational strategies required to procure different resources should be reflected in artifact assemblage composition; and (4) some aspects of assemblages should correlate with environmental and cultural variables affecting subsistence strategies. Also of interest in the study was determining whether villages were organizationally different from smaller hamlet sites and whether these differences, if they existed, were reflected in assemblage composition.

An arability index was created for each site by multiplying the percent of each soil quality class in a site's catchment area (1-km radius for villages; 5-km radius for hamlets) by a land quality rank (1 to 4, worst to best). The ranks were summed for each catchment to obtain an overall index for the catchment (Montgomery 1983). Cold air drainage risk was considered separately from soil quality to avoid possible correlations between cold air risk and soil quality; in Goulding's study, cold air risk was measured as the percent of land subject to moderate or high cold air risk.

On the basis of the arability index and cold air risk index, the habitation site catchments appear to be very heterogeneous. If micro-environmental variation among catchments is important for site-specific subsistence strategies, assemblage variability should be broad. A possible separation between villages and hamlets is apparent in the arability and cold air risk indices – the majority of the villages have poorer arability indices than 96 percent of the hamlets. Also, the total number of households per site is negatively correlated with the arability index.

Assemblage composition was examined for 3 artifact classes – flaked lithic tools, flaked lithic debitage, and ceramics – and it was found that the relative frequencies of the artifact classes were similar for the villages. While the villages fall within the range of variation exhibited by the hamlets, the village frequencies cluster at the high end of the ceramics range and at the low end of the flaked lithic tools range.

The next step in the assemblage composition analysis was to examine relative frequencies of artifact types within the artifact classes. No distinct differences were apparent between villages and hamlets but some trends were discerned. Most notably, significant differences appeared between villages and hamlets in the percentage of cores and the percentage of debitage with cortex;

villages and hamlets also differed in the percentage of thick bifaces and the percentage of utilized flakes. Unfortunately, the differences in cores may be spurious because of the high number of zero values for this variable.

Villages and hamlets also were examined with respect to hypothesized differences in the scope of interaction. Village populations often are viewed as participants in social/exchange networks while hamlet populations are not. If so, there should be more nonlocal sherds and a higher diversity of lithic raw materials in village assemblages. Goulding found the percentage of nonlocal sherds did not differ among villages and hamlets, and lithic raw material diversity correlated significantly with sample size making this variable unsuitable for the analysis.

The relationships between arability and assemblage composition, and between cold air risk and assemblage composition were examined by Goulding (1985a) by grouping the habitation sites into 3 arability classes and 3 cold air risk classes and comparing the assemblages in the different classes. With respect to arability, only the percentage of cores was significantly different (at the 0.10 level); however, the high number of zero values may have created a spurious relationship. There is a trend for differences among the arability classes in the percentage of utilized flakes, thick bifaces, and jar sherds. The only significant (0.04 level) difference among the cold air risk classes was in the percentage of jar sherds.

Finally, assemblage composition and population size were examined. Only the percentage of cores correlates significantly (0.02 level) with the total number of households at a site and this relationship may be spurious. The deletion of 7 outliers from this analysis produced a significant (0.02 level) correlation between population and the percentage of utilized flakes.

Goulding (1985a) concludes that villages and hamlets do not differ in assemblage composition; thus, subsistence and organizational strategies were similar for villages and hamlets, and local environmental variation does not condition catchment-specific logistic strategies. He also suggests these conclusions might change if the data were subjected to a multivariate analysis. Based on the conclusions forced by this analysis, however, Goulding suggests that because the populations apparently were involved in similar subsistence strategies, regardless of catchment or habitat variation, risk-compensating strategies must have been employed. The most probable risk-compensating strategy would have been food sharing through local exchange.

Another study by Goulding (1985b) deals with the relationship between limited activity site location and assemblage diversity. Goulding assumed that limited activity sites represented a logistical strategy responding to the uneven spatial distributions and the seasonality of resources, that the sites were the locations of functionally discrete activities, and that the use-histories of the sites were functionally redundant (i.e., repeatedly used for the same activity or combination of activities). Artifact assemblage characteristics were expected to reflect the use-histories of the sites; sites repeatedly used for similar purposes should have similar assemblages, and assemblage variability should cluster into distinct groups representing the different use-histories. The goal of the study was not to identify functional subtypes of limited activity sites, but was to explicate the overall role of the limited activity strategy in the Dolores system (Goulding 1985b).

A total of 11 variables, consisting of flaked lithic tools, flaked lithic debitage, nonflaked lithic tools, and ceramics for 94 limited activity sites were used in the analysis. The 94 sites represent only a fraction of the limited activity sites recorded. The number was reduced because of surface collection comparability problems, historic disturbance (e.g., plowing), and statistical outliers. The 94 sites appear to be representative of the elevational distribution in the population of Dolores area limited activity sites; however, the site sizes in the sample are smaller than the site sizes in the population. Nonrepresentative site sizes probably result from eliminating sites with less than 100-percent surface artifact collection, thereby eliminating very large sites (greater than 50 000 m^2). Initial exploration of univariate and bivariate relationships, and attempts to measure organizational complexity and assemblage similarity using ratios did not reveal any patterns. Multi-variate analysis, particularly factor analysis, was thought to be the next appropriate step.

Goulding (1985b) believed that statistical relationships representing distinct dimensions of organizational variability needed to be isolated in the assemblages and that factor analysis was appropriate for such an analysis. The SPSS (statistical package for the social sciences) (Nie et al. 1975:468-514) factor procedure "PA2: Principal Factoring with Iteration" was used. PA2 replaces the main diagonal of the correlation matrix with communality estimates; in addition, default options were used, including VARIMAX criterion for orthogonal rotation and OBLIQUE with direct oblimin criterion for oblique rotation. The orthogonal and oblique rotations produced similar results in terms of factor composition and interpretation. Three significant factors were extracted in both rotations and were named according to the assemblage variables loading on the factors (biface factor, debitage factor, uniface factor).

The uniface factor accounts for the most variance in the oblique solution, followed by the biface factor and the debitage factor.

Composite variables based on the factor loadings were created so that additional limited activity sites could be used in subsequent analyses. The composite variables correlate significantly with the factor scores; thus, it was assumed that analyses using the composite variables would produce results similar to those that would be obtained using factor scores, with the advantage that additional sites could be included in the analyses. The composite variables are: (1) the frequency of bifaces, used cores/cobble tools, and projectile points; (2) the frequency of unifaces and utilized flakes; and (3) the frequency of debitage.

Goulding suggests the diversity of the composite variables in each assemblage should reflect the organizational variability in an assemblage and, when compared to environmental distributions of sites (and their diversity scores), should measure the relative differences in exploitation strategies among environmental zones. Diversity scores for 217 limited activity sites did not reveal obvious categories or groups of diversity, which Goulding interprets as indicating that the operation of the limited activity strategy involved activities within a normal day's foraging radius (Binford 1978:487).

One factor affecting the limited activity strategy is seasonality of resource availability. To investigate this further, the distribution of diversity scores in the predominant vegetation cover types (big sagebrush, pinyon-juniper, and oak) was examined. Differences in diversity trajectories were noted among the zones, but the greatest difference was only 10 percent and the differences in mean diversity between the possible pairs of cover types were not statistically significant. Thus, instead of discovering the expected differences in assemblage composition among supposedly distinct resource zones, the opposite was found. As a potential explanation, Goulding (1985b) proposed no significant differences occurred among resources because limited activity sites were locations for the exploitation of disturbed habitats; i.e., rather than exploiting wild resources unique to each zone, the sites represent the exploitation of resources in agriculturally disturbed habitats regardless of vegetation cover. Thus, limited activity sites were part of a logistically organized system, as modeled, but the resources exploited were associated with the agricultural system – plants and animals favoring disturbed habitats. Because the same resources were exploited in each vegetation zone, differences in the seasonality and spatial distribution of resources were not factors in site location or tool use.

A final study was initiated to tie up loose ends originating from Goulding's (1985b) study of limited activity sites and from Orcutt's (1985a) cursory examination of seasonal site locations. If limited activity sites and seasonal sites are components of the agricultural system – the former to exploit wild plants and animals favoring disturbed habitats (fields and fallow fields), and the latter to plant, tend, and harvest domestic crops – their locations should be similar and should exhibit selection for good agricultural locations. Conversely, if limited activity sites were located to exploit wild resources not associated with disturbed habitats, there should not be a selection for good agricultural locations. Good agricultural locations are characterized by good or adequate soil, low or moderate cold air drainage risk, and big sagebrush vegetation. Catchment radii of 250 m were used to identify the kinds of locations preferred for both site types; limited activity and seasonal catchments were compared to random point catchments and to each other. In total, 217 limited activity sites and 71 seasonal sites were used in this analysis.

The catchments were compared using the one-tailed Mann-Whitney U test. Compared to the random points catchments, the limited activity catchments have significantly more big sagebrush vegetation ($p < 0.002$) and good- and adequate-quality low- and moderate-risk land ($p < 0.0001$), and significantly less riparian vegetation ($p < 0.005$) and high-risk land ($p < 0.002$). Thus, the limited activity catchments appear to be located to maximize good agricultural locations and minimize poor agricultural locations (e.g., areas that have vegetation more difficult to clear, and areas that are high risk).

The seasonal catchments have significantly more riparian vegetation ($p < 0.04$), pinyon-juniper vegetation ($p < 0.008$), good- and adequate-quality low-risk land ($p < 0.06$), and nonagricultural quality land ($p < 0.06$) than the random catchments. Surprisingly, selection for good agricultural locations among seasonal sites is not as obvious as for limited activity sites. While the seasonal sites do maximize good locations in terms of soil quality and cold air drainage risk, selection also includes land with vegetation more difficult to clear and for nonagricultural land.

Comparing limited activity catchments to seasonal catchments, the limited activity catchments have significantly more big sagebrush vegetation ($p < 0.0002$), good- and adequate-quality low-risk land, and good- and adequate-quality low- and moderate-risk land ($p < 0.009$), and significantly less riparian vegetation ($p < 0.002$). The limited activity catchments appear to select for better agricultural locations than seasonal catchments.

The characteristics of the limited activity catchments would appear to support Goulding's (1985b) hypothesis that the function of these sites within the local Dolores system is to exploit the anthropogenic communities associated with agricultural activities. The seasonal site locations are a problem – these sites are supposed to be an integral part of the agricultural system, yet the expected selection for good agricultural locations is not as strong as that for limited activity sites and is almost contradictory to the expectation. The selection for good argricultural locations among seasonal sites does not appear to be as strong as that for the pre-A.D. 920 habitation sites (Orcutt 1985a).

Because seasonal sites presumably were occupied for longer periods of time than limited activity sites (hence the differences in the architectural remains associated with the 2 site types [Schlanger and Orcutt 1985]), location near water for domestic or agricultural purposes may have been an additional consideration for seasonal site locations. The differences in the water types present in the catchments were compared to the water types present in the Dolores area using the test of equality of percentages (Sokal and Rohlf 1969:607-610). The limited activity catchments have a higher percentage of cells with no water than are present in the Dolores area ($p < 0.001$). Also, the limited activity catchments have lower percentages of cells with permanent water ($p < 0.001$) and cells with permanent and intermittent water ($p < 0.001$) than the Dolores area. The seasonal catchments have higher percentages of cells with permanent water ($p < 0.001$) and cells with permanent and intermittent water ($p < 0.05$), and a lower percentage of cells with intermittent water ($p < 0.05$) than the Dolores area. It appears that the locations of seasonal sites are determined in part by the presence of water; thus, dual selection criteria may exist for the locations of these sites, i.e., good agricultural locations, at least in terms of soil quality and cold air drainage risk, in areas close to water. The apparent selection of land with difficult to clear vegetation, nonagricultural land, and high cold air drainage risk areas in seasonal catchments may reflect selection for locations with water rather than direct selection for those particular variables. The significant amount of permanent water in seasonal catchments suggests proximity to the Dolores River, to House Creek, or to Beaver Creek, all of which contain permanent water and are characterized by riparian vegetation on lower canyon walls, pinyon-juniper vegetation higher on the canyon walls, nonagricultural land, and high cold air drainage risk.

Aggregation and Spacing Studies

Orcutt (1985d) describes the changes that occurred in spatial aggregation, household aggregation, and spacing between population aggregates in the Dolores area. In trying to explain the changes in aggregation and spacing, 2 sets of relationships were examined: (1) the relationships among resource costs, resource mix, population density, and aggregation; and (2) the relationships among population density, aggregation, and spacing.

Based on the average number of households per rubble area (fig. 10.5), household aggregation increased 188 percent from A.D. 600 to A.D. 920. Household aggregation reached its first peak in the A.D. 880-920 period, with 5.16 households per rubble area. Aggregation decreased in the A.D. 920-980 period and increased again in the A.D. 980-1025 and A.D. 1025-1100 periods. In the latter period, household aggregation reached a high of 6.35 households per rubble area before decreasing 62 percent in the A.D. 1100-1175 period.

The characteristics of household aggregation can be seen in the percentage of rubble areas of each household size (fig. 10.6) and the percentage of households in rubble areas of each household size (fig. 10.7). One-household rubble areas were present in all periods except A.D. 920-980 and A.D. 1100-1175. In the A.D. 920-980 period, rubble areas ranged in size from 2 households to 6 households and in the A.D. 1100-1175 period, only rubble areas of 2 and 4 households have been identified. All of the population in the A.D. 600-720 period was in rubble areas of 5 households or less. From A.D. 720 through 800 the percentage of the population in rubble areas with less than 5 households declined, and from A.D. 800 through 880 the majority of the population had aggregated into larger rubble areas. In the A.D. 920-980 period, the majority of the population was in rubble areas of 4 to 6 households, and in the A.D. 980-1025 period the majority was in rubble areas of less than 8 households. More than 50 percent of the population in the A.D. 1025-1100 period was in rubble areas of greater than 14 households. In the A.D. 1100-1175 period the population was in rubble areas of less than 4 households.

Using the average distance between rubble areas in each period, spatial aggregation was most marked in the following periods: A.D. 720-800, 840-880, 880-920, and 1025-1100. In the A.D. 840-880 period the average distance to the nearest rubble area (136 m) was smaller than in any other period. The average number of households present at different distances from a rubble area indicate that spatial aggregation was highest in the A.D. 840-880 period, followed by either the A.D. 880-920 period or the A.D. 1025-1100 period, depending on the distance.

Other measures of spatial aggregation are household density for the entire study area (takeline) and for the

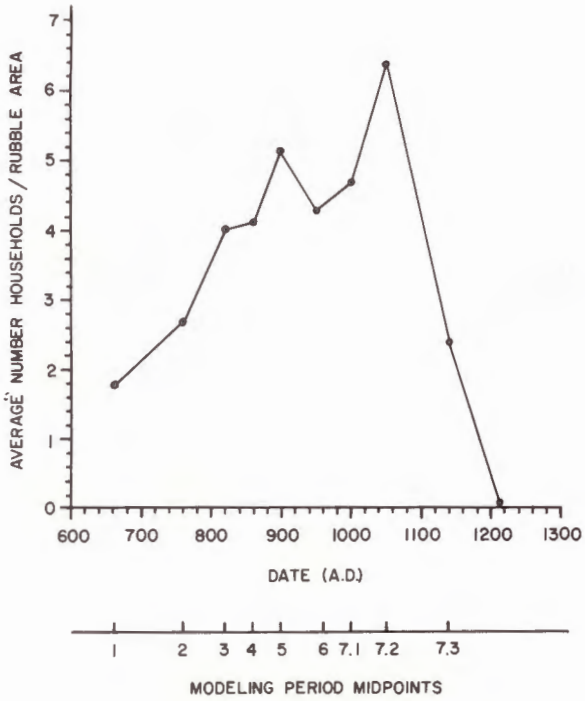

Figure 10.5 – Household aggregation curve (adapted from Orcutt 1985d:fig. 1).

area actually occupied during each period. In the study area, household density was highest in the A.D. 840-880 and 880-920 periods (fig. 10.8). The household densities for the area occupied (fig. 10.9) increased steadily through the A.D. 880-920 period. Density decreased in the A.D. 920-980 period but increased again in the following period. The increase continued in the A.D. 1025-1100 period when density was higher than in any other period. The density in the A.D. 1100-1175 period was low. The amount of area occupied in each period began to decrease dramatically in the A.D. 880-920 period and remained very low throughout the rest of the occupation.

The spatial distribution of population in the Dolores area was mapped using household densities per quarter section on USGS topographic maps. In the A.D. 600-720 period (fig. 10.10), population clusters are small and distributed throughout the area although household density is higher in the middle of the project area west of the river. Larger population clusters develop in the A.D. 720-800 period (fig. 10.11) and some of the occupation occurs in areas that previously were unoccupied. In the A.D. 800-840 period (fig. 10.12), population appears to contract into larger clusters, especially in the middle and southern areas. The more northern clusters remain fairly small and close together.

The A.D. 840-880 period (fig. 10.13), when population size is at its highest in the Dolores area, is characterized by population expansion into areas unoccupied in the previous period and the continued clustering of people into larger groups. In the A.D. 880-920 period (fig. 10.14), population again contracts by abandoning areas occupied previously, and is highly clustered, particularly in the northern areas. Relatively few of the clusters of 1 to 5 households exist during this period. The population in the A.D. 920-980 period (fig. 10.15) is located in the southern and middle areas in fairly small clusters compared to the previous periods. In the A.D. 980-1025 period (fig. 10.16) occupation continues in the southern and middle areas and larger clusters of households appear. The distribution of population in the A.D. 1025-1100 period (fig. 10.17) retains the pattern of the previous period but the clusters are larger. In the A.D. 1100-1175 period (fig. 10.18) the southern-most clusters are gone, a slight northerly shift in occupation has occurred, and the clusters are small compared to the previous period.

The changes described in household aggregation and spatial aggregation were examined in the context of the settlement and spatial model. Particularly, the modeled effects of population density and resource mix on aggregation were examined separately and together to determine whether actual aggregation and predicted aggregation correlated.

The model expects increasing population density to lead to aggregation. The time periods were ranked according to population density and that ranking was used to predict the corresponding aggregation rank order. The correlation between the 2 rankings was assessed with the Spearman rank correlation coefficient. The predicted aggregation rank order correlates significantly with the household and spatial aggregation rank orders (table 10.3).

Resource mix could not be measured directly so 6 different proxy measures of resource costs and resource mix were used to predict aggregation (table 10.3). These proxies were: (1) frequency of climatic stress; (2) frequency of short growing seasons; (3) climatic stress, population size, and population density; (4) short growing seasons, population size, and population density; (5) climatic stress and population density; and (6) short growing seasons and population density. These particular proxies were chosen on the basis of arguments derived from Earle (1980) regarding the effects of population density and climatic change on costs. Household aggregation correlates significantly with all of the proxy variables except the frequency of climatic stress (table 10.3). Spatial aggregation correlates significantly with 3 of the 6 proxy variables; the 3 variables with which it does not correlate are: (1) frequency of climatic stress; (2) frequency of short growing seasons; and (3) climatic stress and population density.

In the model, the variables that affect spacing among population aggregates are aggregation, population size,

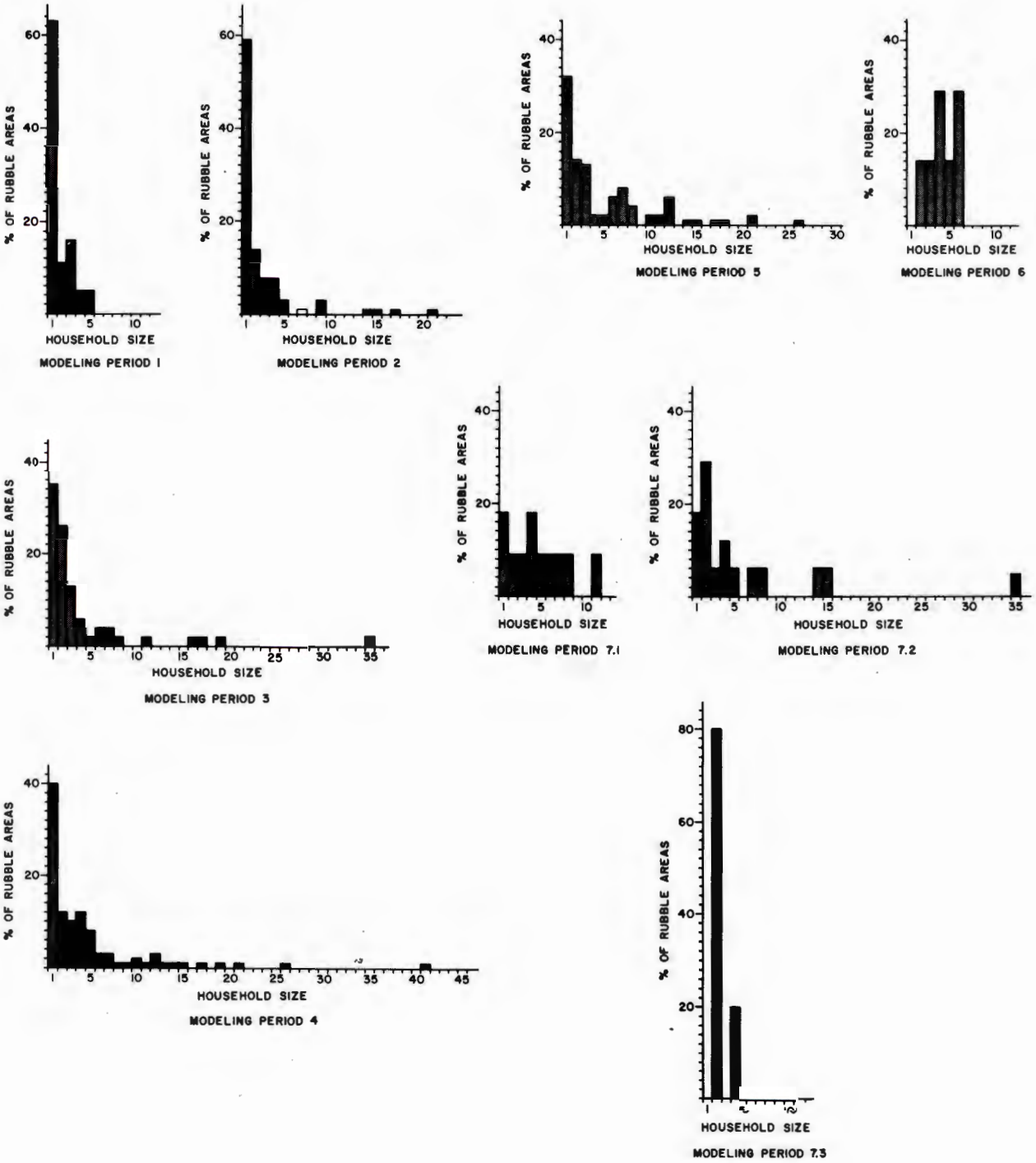

Figure 10.6 – Graph of the percent of rubble areas of each household size (adapted from Orcutt 1985d:fig. 2).

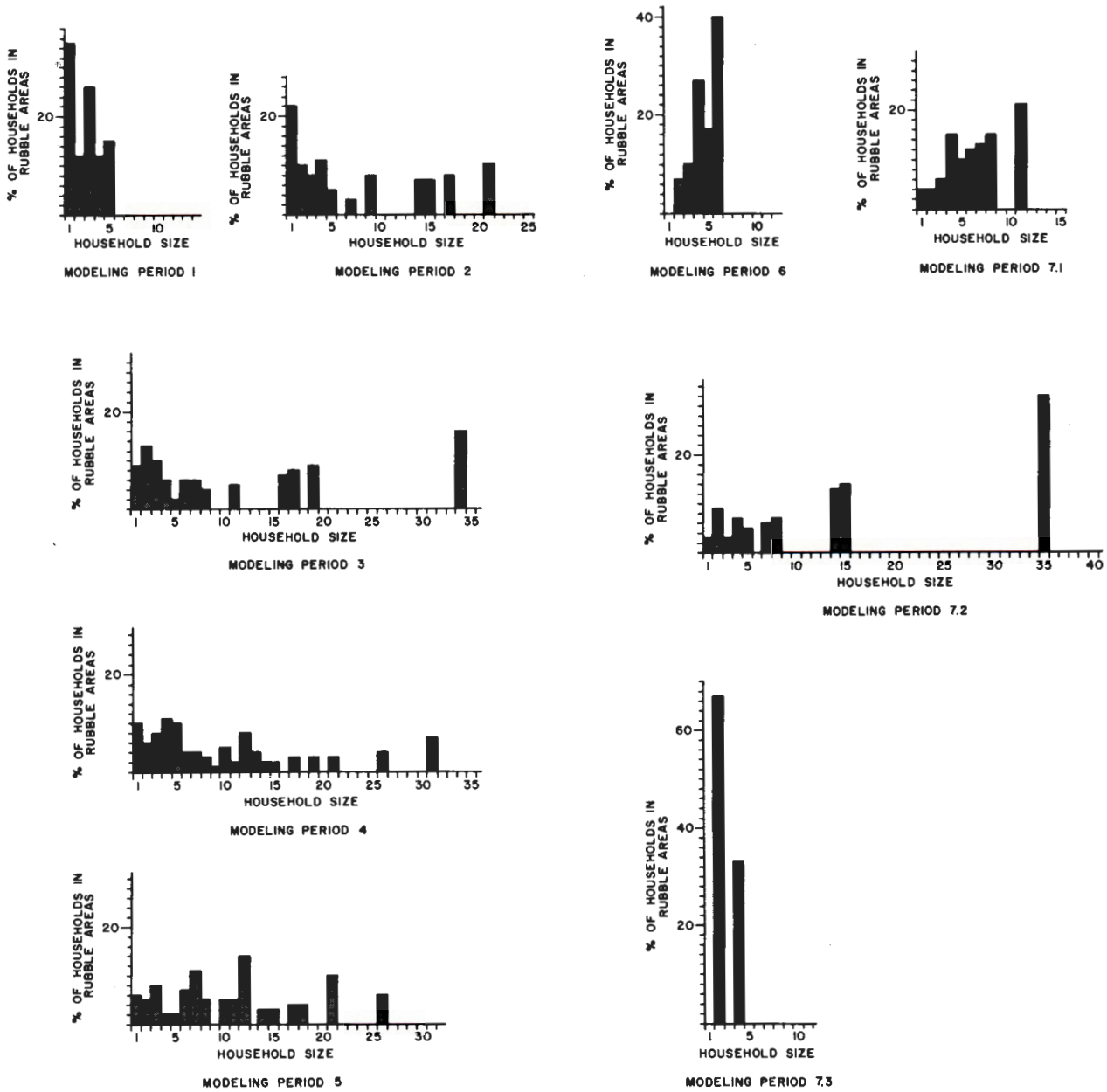

Figure 10.7 – Graph of the percent of households in rubble area of each household size (from Orcutt 1985d:fig. 3).

and population density. These variables were used to create a predicted rank order for spacing; the correlation between the predicted rank order and the actual spacing rank order (the average distance to the nearest rubble area) is significant (table 10.3).

EVALUATION OF THE SETTLEMENT BEHAVIOR MODEL

The studies designed to test aspects of the settlement behavior model provide some confirmation of the model, some deviations from the model, and revealed some interesting patterns suggestive of prehistoric resource use in the Dolores area. The settlement behavior model fared well in predicting changes in aggregation and spacing, and in some aspects of settlement location selection (hypothesized resource use). The studies indicate a better understanding of the function of limited activity sites, and some revisions of the proposed relationships among types of habitations (villages versus hamlets), types of agricultural catchments (potential resource use), and tool assemblages (subsistence strategy execution) are needed.

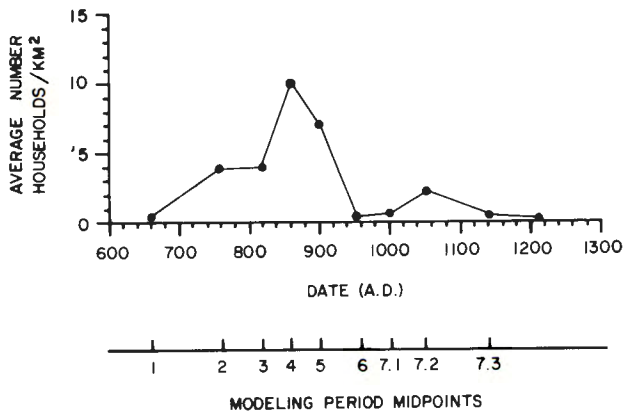

Figure 10.8 – Takeline population density (from Orcutt 1985d: fig. 4).

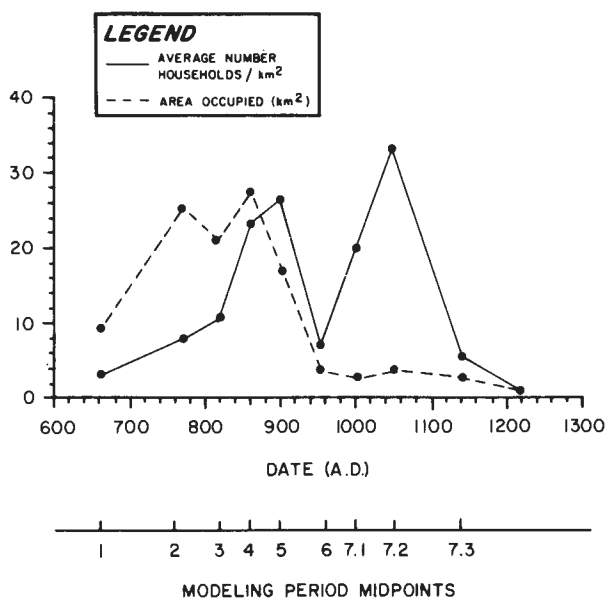

Figure 10.9 – Occupation area population density and total area occupied (from Orcutt 1985d:fig. 5).

THE SOCIOPOLITICAL MODEL

Lightfoot's (1984) version of a sociopolitical model was adopted by the DAP as an "alternative" to a perceived economic bias in the general model. The sociopolitical model (social model [Lipe, chap. 6]) is addressed briefly here because of the lateness in adopting this approach. Only one settlement study could be completed that specifically tested expectations derived from the social model.

With the social model, social hierarchies are expected to develop earlier and be independent of economic events or increases in population density that can be attributed to economic causes. If the developmental trajectory of complex social hierarchies coincides with changes in resource costs, intensification, and population density, the concepts of the social model can be considered suspect (this does not discount the importance of social factors in culture change, however). According to the social model, competition accompanies the development of complexity.

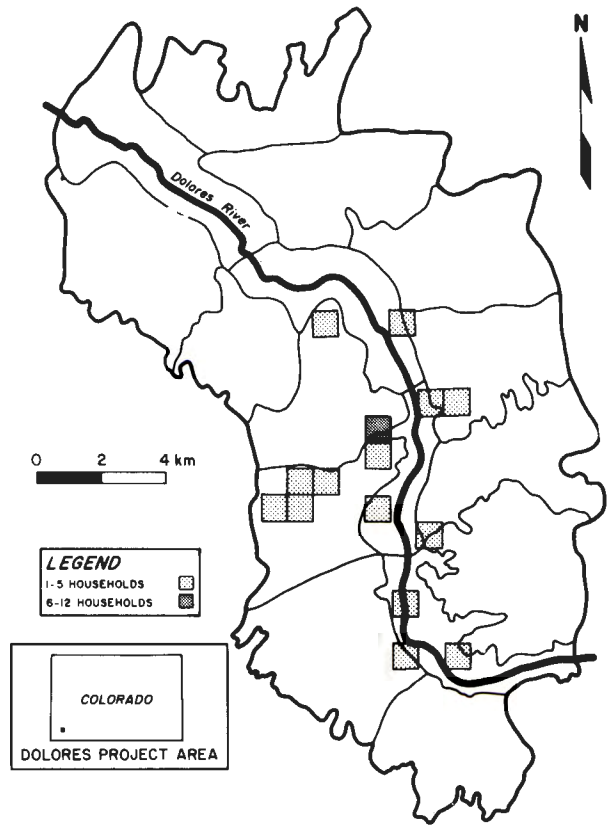

Figure 10.10 – Distribution of households by quarter section, A.D. 600-720 (from Orcutt 1985d:fig. 6).

Site size and rank-size distributions can be used to search for evidence of social hierarchies or complexity in settlement organization. Site size as a reflection of settlement organization complexity includes data on site size groups based on histograms, ranges of site sizes, site size diversity, the number of settlement organization tiers (based on site size groups), and a weighted value for settlement tiers (the number of tiers times the site size range). Simply stated, we would expect multi-tiered settlement organizations to develop early in the Dolores area; accompanying the development of these hierarchies should be a greater range of site sizes and a higher diversity of site sizes. It is expected that if the development of complex organizations is not economic it will occur early and quickly.

Although not dealt with by Lightfoot (1984), one might expect the hierarchical system to disintegrate quickly

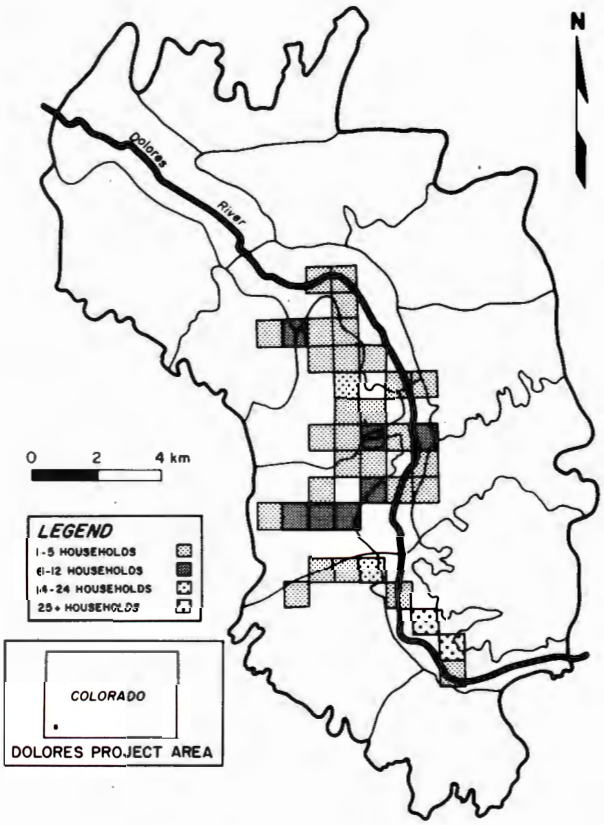

Figure 10.11 – Distribution of households by quarter section, A.D. 720-800 (from Orcutt 1985d:fig. 7).

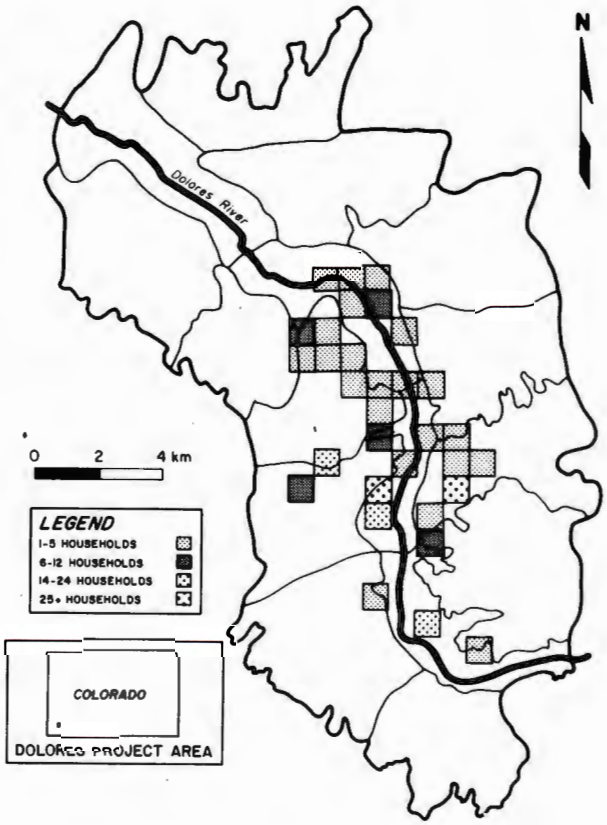

Figure 10.12 – Distribution of households by quarter section, A.D. 800-840 (from Orcutt 1985d:fig. 8).

under stress for the following reasons: because the leadership system's perpetuation depends on the leader's ability to amass food surpluses and serve as an exchange node, thus providing incentives for his followers to stick with him. As soon as he is unable to support his position, the followers will quickly abandon him in search of another leader. If a complex set of social and economic relationships binds the group together (beyond the leader's influence), the complexity should persist beyond the time of the leader's downfall (cf. Firth 1959). Thus, a quick decline in complexity after A.D. 880 would be expected by the social model because environmental stress – consecutive years of reduced crop yields – would use up the surpluses and undermine the leader's power.

Evidence of competition should be manifested in site locations, especially the locations of the "centers." Nearest neighbor analysis is used for testing this assertion (Lightfoot 1984) and one expects these "centers" to be evenly distributed if competition were a factor influencing habitation locations (Lightfoot 1984).

Histograms of the number of households at habitation sites in each period were examined for evidence of site size groups (fig. 10.19; table 10.4). Obvious breaks in the histograms (Lightfoot 1984) were used to define the groups. The development of complex settlement organizations appears to be slow. The simple, two-tiered settlement organization present in the A.D. 720-800 period is more complex than in the A.D. 600-720 period; however, the decision-making hierarchy in the A.D. 920-980 period remains simple. A three-tiered settlement organization appears in the A.D. 840-880 period and continues to exist in the A.D. 880-920 period. A return to a simple, two-tiered settlement hierarchy in the A.D. 920-980 period is in some ways a surprise, given the small number of sites in the area (6 sites as compared to the A.D. 600-720 period with no decision-making hierarchy and 16 sites, and the A.D. 720-800 period with a simple hierarchy and 69 sites). Complexity declines in the A.D. 980-1025 period with no indication of a decision-making hierarchy. A three-tiered settlement hierarchy appears again in the A.D. 1025-1100 period; a return to no hierarchy occurs in the A.D. 1100-1175 period. The latter 4 periods in the Dolores area are represented by a small number of sites in each period and interpretation is difficult. The A.D. 1025-1100 occupation of the Dolores area, though sparse, may have been part of a complex regional system of which we know little.

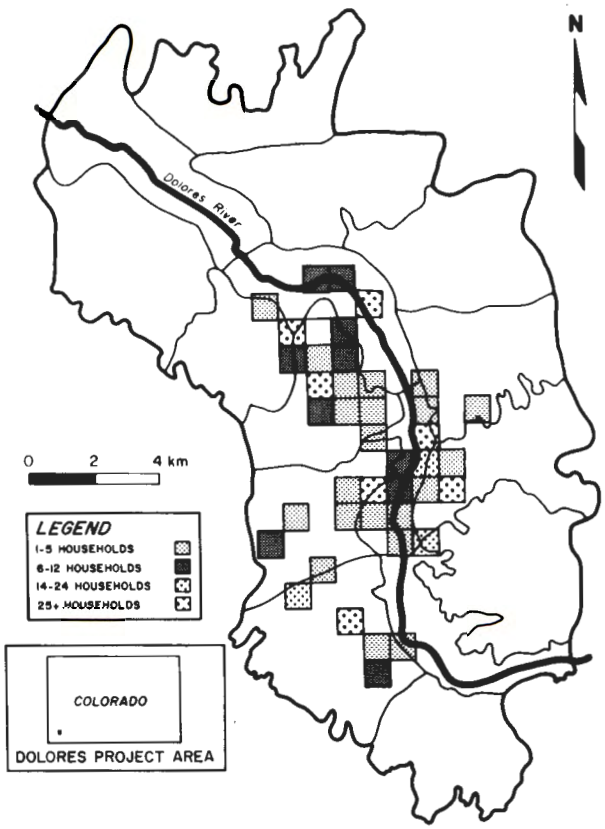

Figure 10.13 – Distribution of households by quarter section, A.D. 840-880 (from Orcutt 1985d:fig. 9).

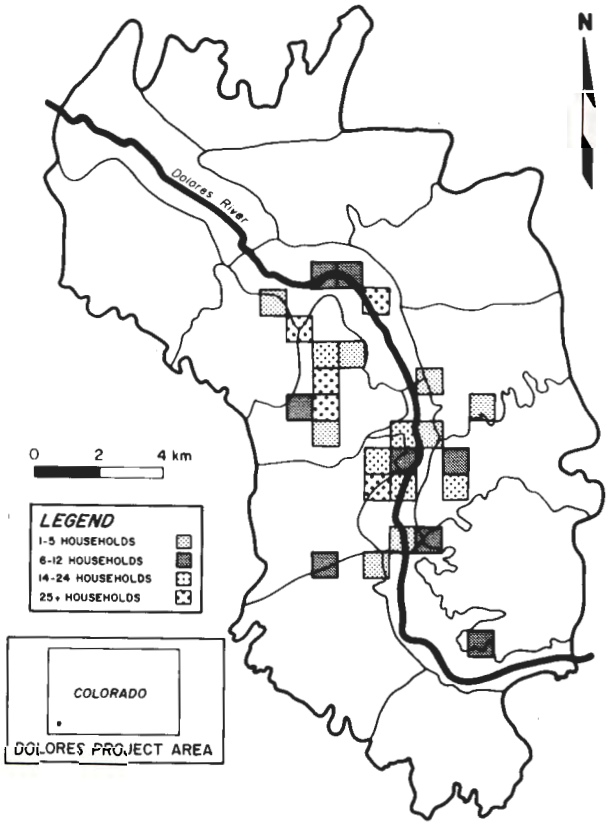

Figure 10.14 – Distribution of households by quarter section, A.D. 880-920 (from Orcutt 1985d:fig. 10).

The development of decision-making hierarchies does not seem to correspond to the expectation that hierarchies would develop early and quickly – although simple hierarchies appear in the A.D. 720-800 period, they do not become more complex in the subsequent period – and the hierarchies do not disintegrate quickly. The A.D. 880-920 population retains the three-tiered settlement hierarchy despite extreme climatic conditions (and later in that period the area is abandoned). If site size range, site size diversity, and weighted settlement tier values increase as complexity increases, these data may help clarify the processes occurring within periods as well as between periods.

The range of site sizes (table 10.5; fig. 10.20) is small in the A.D. 600-720 period, increases in the A.D. 720-800 period, and remains the same in the A.D. 800-840 period. These data seem to confirm that the initial development of complexity was slow. The ranges are large in the A.D. 840-880 and 880-920 periods, although a smaller range exists for the latter period, suggesting the decline of the hierarchy system in A.D. 880-920 was not as rapid as expected. Site size range is small in the A.D. 920-980 period but increases in the A.D. 980-1025 and 1025-1100 periods. The A.D. 1100-1175 period has the smallest site size range of all the time periods.

The site size diversity data (table 10.5; fig. 10.21) indicates that complexity increased in the A.D. 720-800 period and 800-840 periods. Because the site hierarchy data, site size data, and weighted tier values show no increases in complexity in the latter period, the diversity data may be indicating that the decision-making hierarchy remained simple and that a number of internal developments were occurring, particularly the addition of population to existing sites through natural growth and the budding off of households into new sites. Site size diversity increases in the A.D. 840-880 period and reaches a peak in the A.D. 880-920 period. The high diversity during the latter period may reflect diverse attempts to cope with stress, or differential rates at which different sizes of sites were abandoned. Site size diversity decreases through A.D. 1025, increases in the 1025-1100 period, and reaches a low in the A.D. 1100-1175 period.

The weighted tier values (table 10.6; fig. 10.22) reinforce the hierarchy and site size range data. In addition,

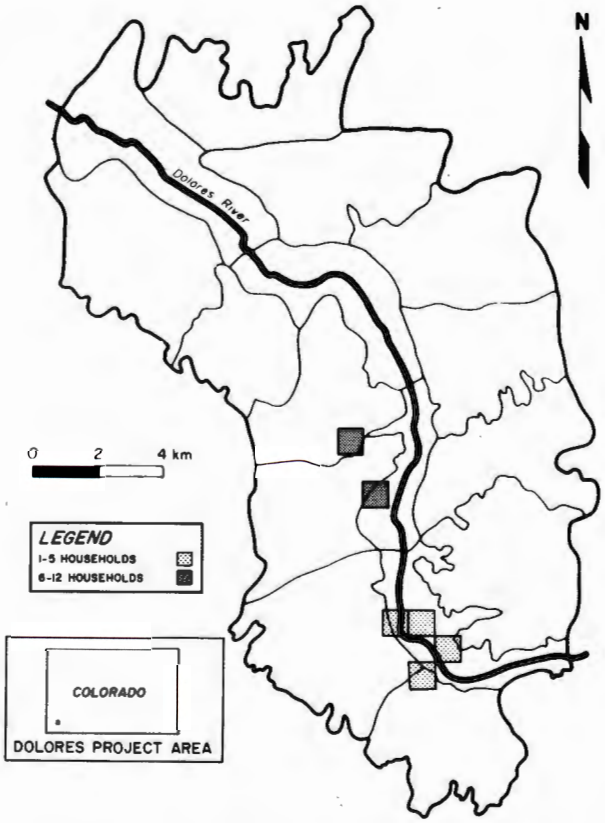

Figure 10.15 – Distribution of households by quarter section, A.D. 920-980 (from Orcutt 1985d:fig. 11).

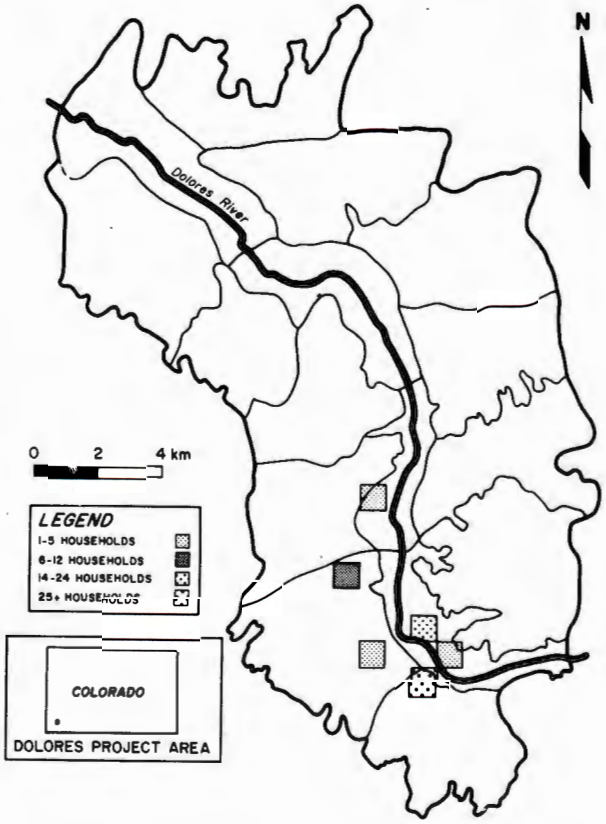

Figure 10.16 – Distribution of households by quarter section, A.D. 980-1025 (from Orcutt 1985d:fig. 12).

these values serve as relative measures of the range of complexity in time periods with two-tiered settlement organizations (A.D. 720-800, 800-840, 920-980, and 980-1025). The complexity within these organizations appears to be the least in A.D. 920-980 and the greatest in A.D. 980-1025.

The settlement data present a picture of slowly developing complexity, with changes closely mirroring those in population size and the narrowing of the farming belt in the A.D. 600-920 period (a closer examination of these relationships is presented in the next section). The post-A.D. 920 developments are not as easy to understand and demand a better handle on the regional system of which the Dolores area apparently was a minor part. In other words, complexity during the major occupation of the Dolores area (A.D. 600-920) does not appear to conform to the expectations of the social model. Despite this conclusion, analysis continued along another line of settlement organization.

Rank-size distributions can be used to describe and interpret settlement system organization (Lightfoot 1984). Lightfoot presents the following discussion of the types of rank-size distributions:

> A primate distribution, indicating that one large site dominates all others in size, suggests that major functional differences existed between it and all other sites in the settlement system. A convex distribution . . . might suggest that several independent units existed in an area . . . [A] log-normal distribution would most likely indicate a well-integrated political system composed of more than one decision-making level (1984:70).

Rank-size distributions can be difficult to interpret, so to be consistent with Lightfoot, his rank-size distributions and identifications of such were used as templates for identifying the types of distributions in the Dolores data. It is difficult to develop expectations for the Dolores area with respect to expected changes in rank-size distributions; however, one might expect that if Lightfoot-type sociopolitical development occurred here, but it developed late as indicated by the settlement hierarchy data, the periods of greater complexity (A.D. 840-880 and 880-920) would exhibit convex distributions indicating the larger sites were independent, competing units.

The rank-size distributions (figs. 10.23 through 10.30; table 10.7) do not confirm the expectations; the convex

Figure 10.17 – Distribution of households by quarter section, A.D. 1025-1100 (from Orcutt 1985d:fig. 13).

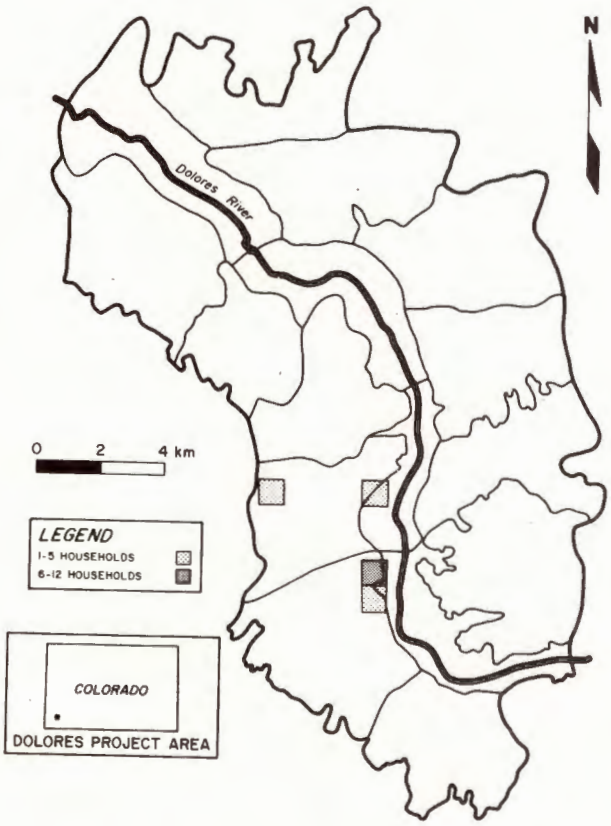

Figure 10.18 – Distribution of households by quarter section, A.D. 1100-1175 (from Orcutt 1985d:fig. 14).

distributions occur early when the decision-making hierarchies were simple. The 2 periods with multitiered organizations (A.D. 840-880 and 880-920) suggest a well-integrated system in which communication, goods, services, and information flowed freely. The periods between A.D. 920 and A.D. 1100 exhibit a primate distribution, indicating the presence of one center in each of those periods.

The convex distributions in the earlier periods may reflect a settlement pattern of clusters of interacting farmsteads developing through "interdependent immigration" (Warren and O'Brien 1984:44). As population density reached a level that required management of activities and movements, the independent units had to become more integrated and more decision-making units were necessitated; thus, the appearance of integrated multitiered hierarchies instead of competing hierarchies.

Competition is an expectation of the sociopolitical model, and can be measured using nearest neighbor analysis. Lightfoot (1984:48) presents the following expectations for competition among decision-making hierarchies.

> Regions characterized by competitive one-tiered decision-making organizations [two-tiered settlement organization] will contain settlement clusters uniformly distributed across space . . . Two-tiered decision-making organizations [three-tiered settlement organization] will be characterized by settlement clusters . . . evenly distributed across a region.

Based on Lightfoot's statement, one would expect that in the periods in which decision-making hierarchies are present, the largest sites will be evenly distributed (regular distribution). Lightfoot's argument must be carried further, however, to consider the implications of the rank-size distributions in proposing the nature of competition in an area. One expects convex distributions to be characterized by competition among the independent units; thus, the larger sites should be evenly distributed with smaller sites clustered around them. Log-normal distributions, if they represent well-integrated systems, should not be characterized by even site distributions but by clustered or random distributions, depending on the factors influencing location. With primate distributions, smaller sites should cluster around the large center. One might expect that the absence of

Table 10.3 – Summary of results of Spearman rank correlation coefficient tests

Variables	Spearman's rank order correlation coefficient and significance	
	Household aggregation	Spatial aggregation
Population density ranking with aggregation ranking	$r_s = 0.87$ $p < 0.01$	$r_s = 0.95$ $p < 0.01$
Climatic stress ranking with aggregation ranking	$r_s = 0.45$ not significant	$r_s = -0.03$ not significant
Short growing season ranking with aggregation ranking	$r_s = 0.70$ $p < 0.05$	$r_s = 0.28$ not significant
Climatic stress, population size, and population density ranking with aggregation ranking	$r_s = 0.88$ $p < 0.01$	$r_s = 0.88$ $p < 0.01$
Short growing season, population size, and population density ranking with aggregation ranking	$r_s = 0.82$ $p < 0.01$	$r_s = 0.90$ $p < 0.01$
Climatic stress and population density ranking with aggregation ranking	$r_s = 0.81$ $p < 0.01$	$r_s = 0.57$ not significant
Short growing season and population density ranking with aggregation ranking	$r_s = 0.91$ $p < 0.01$	$r_s = 0.91$ $p < 0.01$
Population size, population density, and household aggregation ranking with spacing ranking	$r_s = 0.87$ $p < 0.01$	

r_s – Spearman rank correlation coefficient.
p – Probability.

decision-making hierarchies would favor random site distributions related to the locations of resources.

Table 10.8 presents the results of the nearest neighbor analysis using the Clark and Evans (1954) formula, following Lightfoot's (1984:72) lead, and Pinder et al. (1979) to assess the type of distribution (random, clustered, or regular). Sites closer to the border of the surveyed area than to a site within the surveyed area were eliminated from the analysis (Lightfoot 1984:72).

The periods without evidence of decision-making hierarchies (A.D. 600-720 and 1100-1175) were expected to have random site distributions. The nearest neighbor analysis could not be performed for the A.D. 1100-1175 period because of the small number of sites and high number of border sites. The A.D. 600-720 habitations are clustered rather than randomly distributed. If this represents a colonization situation, the pattern may reflect interdependent immigration and locational considerations for the benefits of living near familiar groups in small clusters, as opposed to being isolated (Warren and O'Brien 1984:53).

The periods characterized by two-tiered settlement organizations and convex rank-size distributions should show even spacing among the larger "centers" (A.D. 720-800 and 800-840). During both these periods, the distribution of all habitations is clustered, the distribution of medium habitations is clustered when bordered sites are eliminated and are random when border sites are included, and the distribution of small habitations is clustered. The distribution of small habitations could be an indication of clustering around the

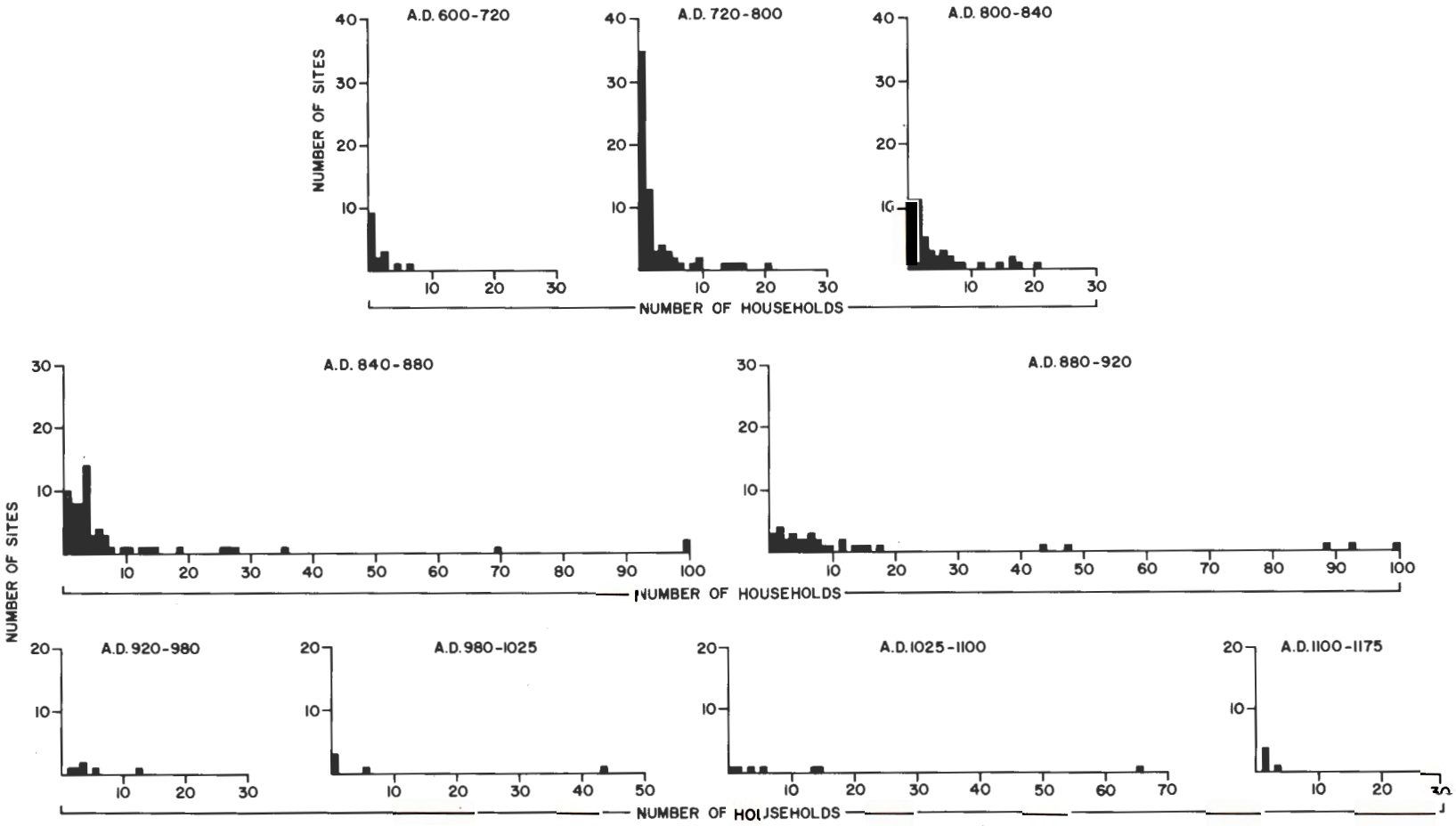

Figure 10.19 – Site size histograms.

Table 10.4 – Site size groups

	Size (number of households)								
	Period (years A.D.)								
Group	600-720	720-800	800-840	840-880	880-920	920-980	980-1025	1025-1100	1100-1175
Small	1-7	1-10	1-9	1-15	1-18	1-6	1-6	1-6	2-4
Medium		14-21	12-21	25-36	44-48	13		14-15	—
Large				70-159	89-112		44	66	

Table 10.5 – Site size range and diversity

Variable	Period (years A.D.)								
	600-720	720-800	800-840	840-880	880-920	920-980	980-1025	1025-1100	1100-1175
Size range	6	20	20	158	111	12	43	65	2
Size diversity	0.540	0.756	0.964	1.079	1.196	0.679	0.413	0.847	0.218

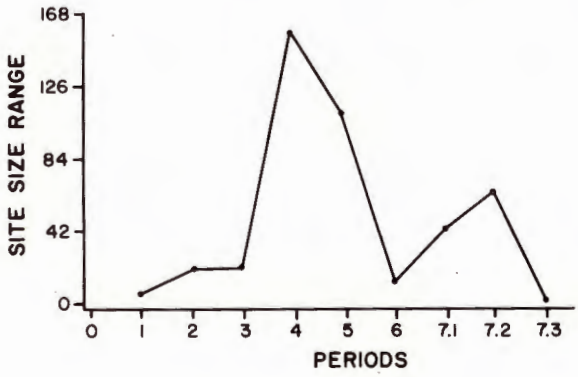

Figure 10.20 – Site size ranges.

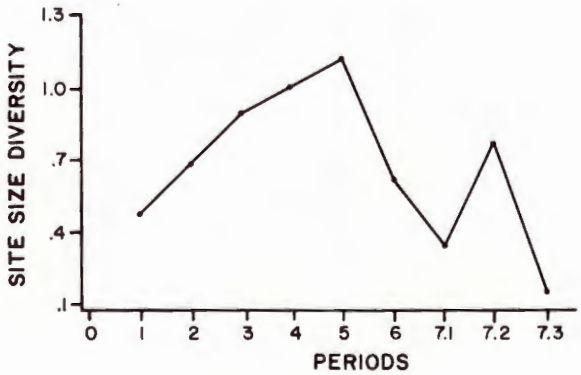

Figure 10.21 – Site size diversity.

larger habitations; however, the clustered (or random when border sites are included) distribution for the larger habitations implies the absence of competition, contrary to the expectations.

Three-tiered settlement organizations and log-normal distributions should be characterized by clustering around the largest settlements, and random or clustered distributions of the larger sites. During these periods (A.D. 840-880 and 880-920), 2 large or medium villages are known to have existed outside the area surveyed; however, the exact location of one is not known (only to the quarter section), and the sizes of these sites in each period are not known. The majority of the large and medium sites in the surveyed area are closer to a comparable site in the surveyed area than to one outside the surveyed area. To be conservative, when a site in the surveyed area was closer to one of the outside sites, these measurements were taken and the nearest neighbor statistic was calculated for both scenarios. In all but one case where this was done, no differences resulted, and in the one instance where a difference was involved, the site did not have good locational data. The nearest neighbor analysis shows all habitations are clustered in both periods, large habitations are randomly distributed (regardless of sites outside the surveyed area), medium habitation are randomly distributed (regardless of sites outside the surveyed area), and small habitations are clustered. Large and medium habitations together are randomly distributed in the A.D. 840-880 period, regardless of sites outside the surveyed area, and in the A.D. 880-920 period when distances are measured to the nearest comparable site within the surveyed

Table 10.6 – Weighted settlement tier values*

	Period (years A.D.)								
	600-720	720-800	800-840	840-880	880-920	920-980	980-1025	1025-1100	1100-1175
Weighted tiers	6	40	40	474	333	24	86	195	2

* Number of settlement tiers times site size range.

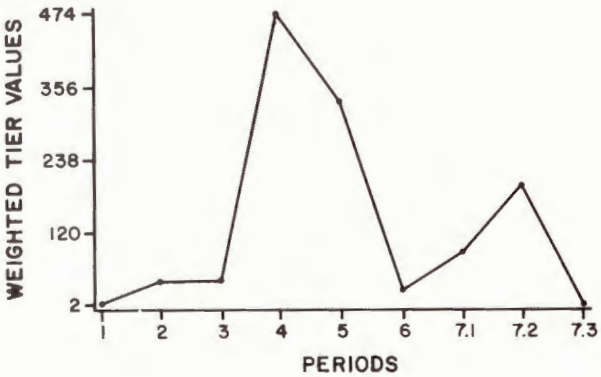

Figure 10.22 – Weighted tier values.

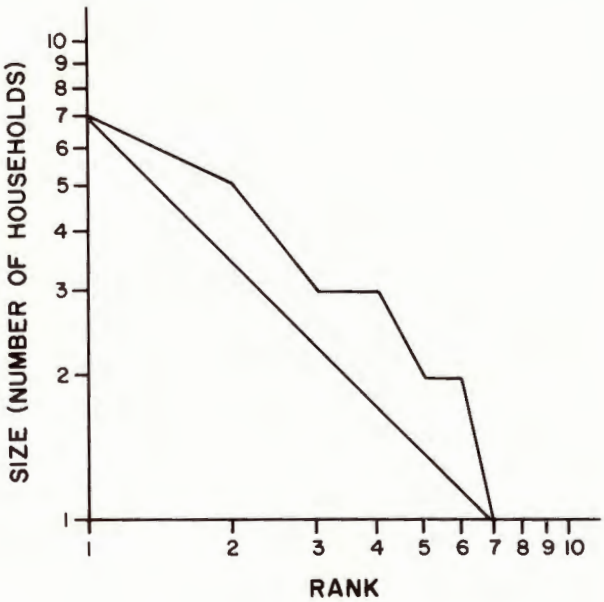

Figure 10.23 – Rank-size distributions, A.D. 600-720.

area. The large and medium A.D. 880-920 habitations are regularly distributed when a site in the surveyed area is closer to one outside than inside the area. The expectations for the A.D. 840-880 and 880-920 periods are confirmed with small habitations being clustered around larger sites, and the larger sites (large, medium, and large and medium combined) being randomly distributed, indicating the absence of competition in a well-integrated system.

The one possible deviation from the expectations, the regular distribution of large and medium sites when one distance was calculated to a site outside the surveyed area in the A.D. 880-920 period, may hint at potential competition. The rank-size distribution for this period was characterized as log-normal, and Lightfoot labels similar distributions as log-normal; however, when compared to the log-normal distribution for the A.D. 840-880 period, the distribution departs more from the log-normal than the A.D. 840-880 period, and is closer to a convex distribution. The greater deviation in the convex direction and the weak possibility of a regular distribution in the large and medium sites may suggest a low level of competition was present in this period. With the amount of climatic stress in the A.D. 880-920 period, competition over resources might be expected. Other analyses would be necessary to clarify this situation.

The primate rank-size distributions in the A.D. 920-980, 980-1025, and 1025-1100 periods with two-tiered settlement organizations in the first 2 period and a three-tiered settlement organization in the last period, suggest the presence of a central site with smaller sites clustered around it in the Dolores area. The nearest neighbor statistic cannot be used to evaluate the expectations because of the small number of sites and too many of the sites are closer to the surveyed border than to a site within the surveyed area.

The settlement data presented suggests that social factors are not substantiated as the primary drivers of change. The picture appears to be one of small, autonomous, colonizing groups entering the area and locating in small clusters of (related?) households. As more colonizers move into the area in the early periods, simple decision-making hierarchies develop and the groups remain somewhat autonomous, but not actively competitive; this situation remains stable until another wave of colonization creates a high density situation necessitating the development of more complex decision-making hierarchies. The Dolores inhabitants then become involved in an integrated system rather than maintaining the autonomous system present earlier. That this was an integrated system is supported by the

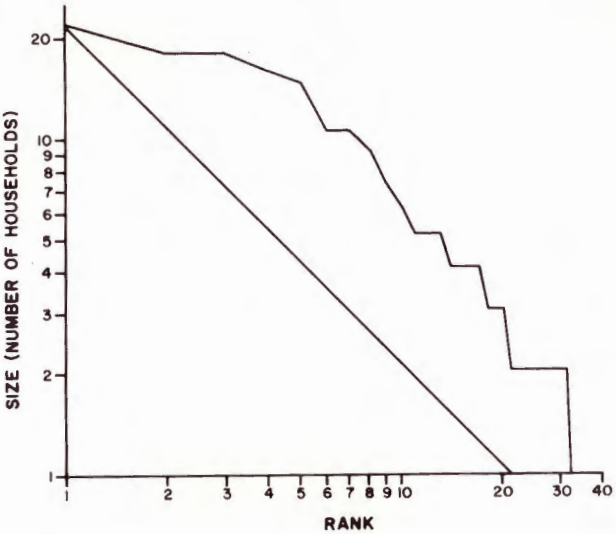

Figure 10.24 – Rank-size distributions, A.D. 720-800.

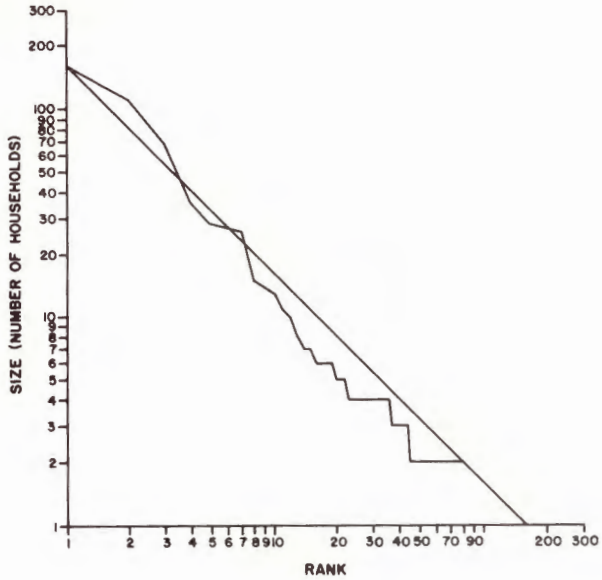

Figure 10.26 – Rank-size distributions, A.D. 840-880.

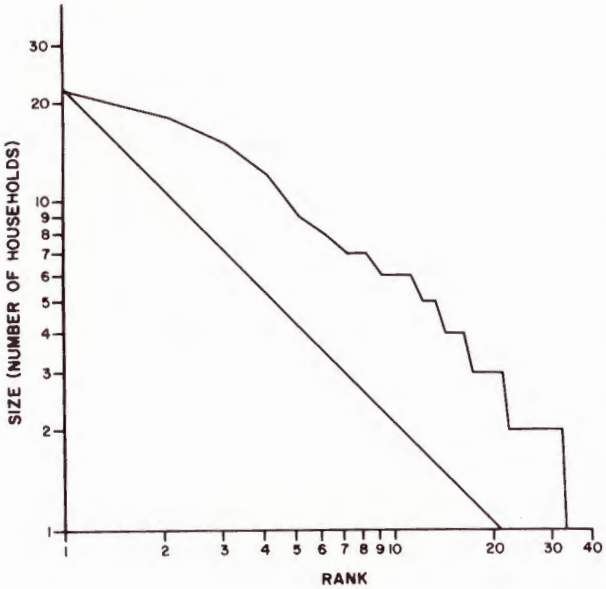

Figure 10.25 – Rank-size distributions, A.D. 800-840.

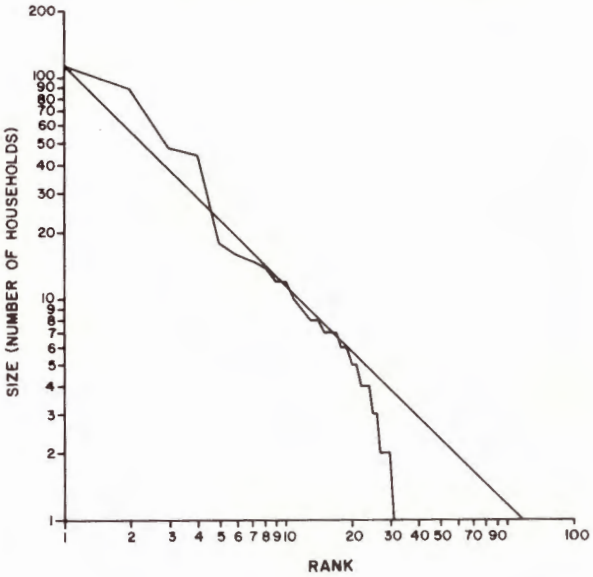

Figure 10.27 – Rank-size distributions, A.D. 880-920.

rank-size distributions and the nearest neighbor analysis, with the weak suggestion of some competition in the A.D. 880-920 period. Between A.D. 920 and 1100, complex decision-making organizations apparently were present in the Dolores area but the data are insufficient to pursue an analysis of these periods.

SOCIOPOLITICAL VARIABLES AND THE SETTLEMENT BEHAVIOR MODEL

Lightfoot's sociopolitical variables – sedentarism, agricultural intensification, regional exchange, leadership development, competition, and surplus accumulation – can be integrated into the settlement behavior model (fig. 10.31). The first 3 variables already were in the model as settlement permanence, resource mix, and exchange. Only those new relationships related to the previous section are explicated in the following discussion.

Leadership development and competition are affected by a number of variables (fig. 10.31), some of which can be measured using DAP data. Leadership development is implied in the settlement hierarchies presented earlier, so they are used as the proxy for

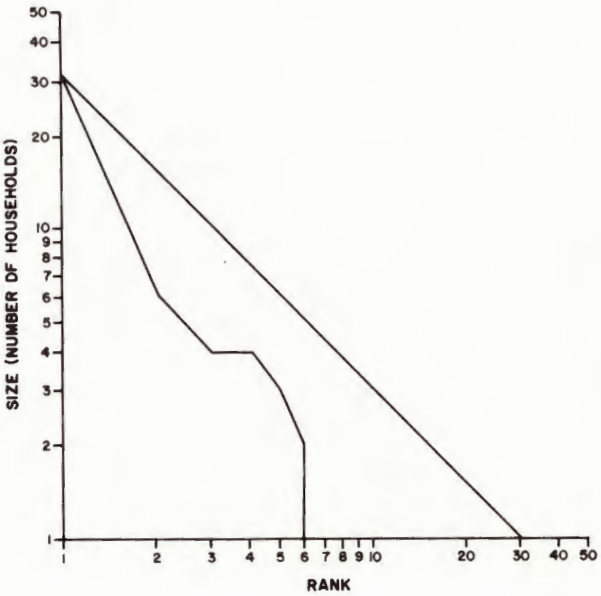

Figure 10.28 – Rank-size distributions, A.D. 920-980.

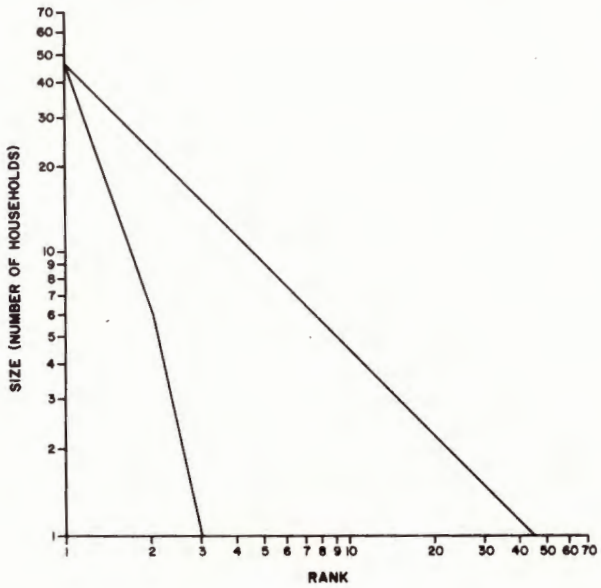

Figure 10.29 – Rank-size distributions, A.D. 980-1025.

increasingly complex leadership situations. The nearest neighbor statistic can be used to measure competition; although not the only statistic that can be used, it is the only one for which data have been gathered. Of the variables directly or indirectly contributing to leadership development and competition, the ones for which data are available are population density, aggregation, and agricultural intensification (fig. 10.31).

As explained earlier in the presentation of the settlement behavior model, population density is affected by

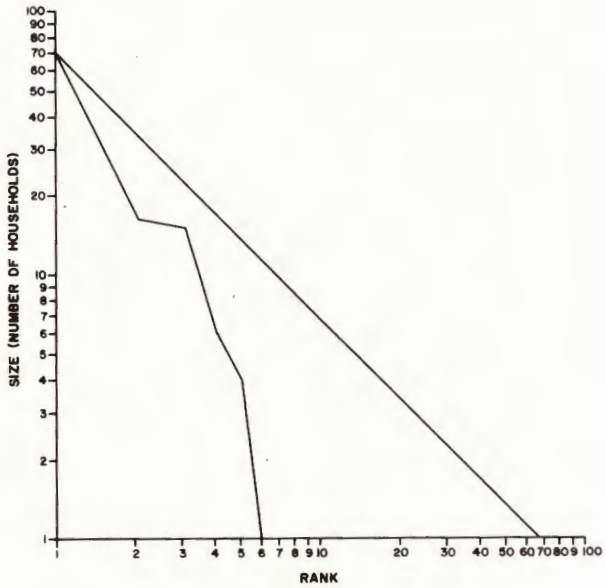

Figure 10.30 – Rank-size distributions, A.D. 1025-1100.

Table 10.7 – Rank-size distribution

Period (years A.D.)	Rank size
600-720	Convex
720-800	Convex
800-840	Convex
840-880	Log-normal
880-920	Log-normal
920-980	Primate
980-1025	Primate
1025-1100	Primate
1100-1175	*

* Range of site sizes too small to interpret rank size distribution.

resource costs and settlement permanence (sedentarism). If resource costs are lower in an area, population might be expected to move to those more "attractive" areas, creating higher population densities; conversely, higher cost areas should be less attractive and should lose population to lower cost areas. Higher densities can create a situation in which unwanted interaction in overlapping territories becomes more frequent. Overlapping catchments present the potential for arguments over resource priorities and "ownership," thus creating a situation requiring at least a minimal level of management. One way to solve the problem of overlapping catchments is to aggregate into large groups, put more space between these groups, and coordinate activities within the catchments (integration) and perhaps between the catchments (also a form of integration). The coordination of activities is accomplished

Table 10.8 – Nearest neightbor analysis summary

Site groupings	Periods (years A.D.)					
	600-720	720-800	800-840	840-880	880-920	post-920
All habitations	Clustered	Clustered	Clustered	Clustered	Clustered	Too few sites and too many border sites
Large habitations				Random	Random	—
Medium habitations		Clustered (without border sites) Random (with border sites)	Clustered (without border sites) Random (with border sites)	Random	Random	
Large and medium habitations				Random	Random (sites within surveyed area) Regular (site outside surveyed area)	
Small habitations			Clustered	Clustered	Clustered	

through some form of leadership. Competition is minimized by creating larger catchments for the aggregates, thereby facilitating integration and interaction among the aggregates.

The expectations are that as population density increases because of the "attractiveness" (Petersen 1985c) of the Dolores area (i.e., the higher boundary for the lower edge of the farming belt probably makes Dolores a lower cost area) from A.D. 720 through 880, settlement organization should become more complex and this complexity should mirror the increases in population density. Settlement organization complexity also should correlate with increasing aggregation and increasing agricultural intensification. (Agricultural intensification is proxied rather than measured directly using spatial aggregation, household aggregation, population density, and human disturbance [Orcutt 1985a]. The study of agricultural costs by Kohler et al. [chap. 9] did not occur until after all modeling studies were complete and the final report was underway. The average agricultural cost index developed by Kohler et al. agrees closely with Orcutt's proxied agricultural intensification.)

Competition should be absent at low population densities, should increase along with population density, and should decrease again as spatial aggregation increases.

To determine whether settlement organization complexity accompanied changes in population density, proxied agricultural intensification, and aggregation, the Spearman rank correlation coefficient was calculated (table 10.9). Only the correlation between site size diversity and household aggregation is not significant. Population density, proxied agricultural intensification, and spatial aggregation influenced the development of settlement organization complexity as expected from the model. Household aggregation was not as good a predictor of complexity as the other variables, but the correlation with spatial aggregation lends credence to the proposition that problems with the frequency of unwanted interaction was a factor in the development of decision-making hierarchies.

The differences in ranks used to compute the Spearman rank correlation coefficients were summed across all the correlations in a period to produce a total difference in ranks for each period (table 10.10) A positive total rank indicates the settlement complexity variables ranked higher overall than the settlement behavior variables, and that complexity was higher than expected based on the model. A negative total rank indicates the settlement complexity variables ranked lower overall than the settlement behavior variables, and that complexity was lower than expected based on the model. Equal ranks indicate agreement between the expectations and the data.

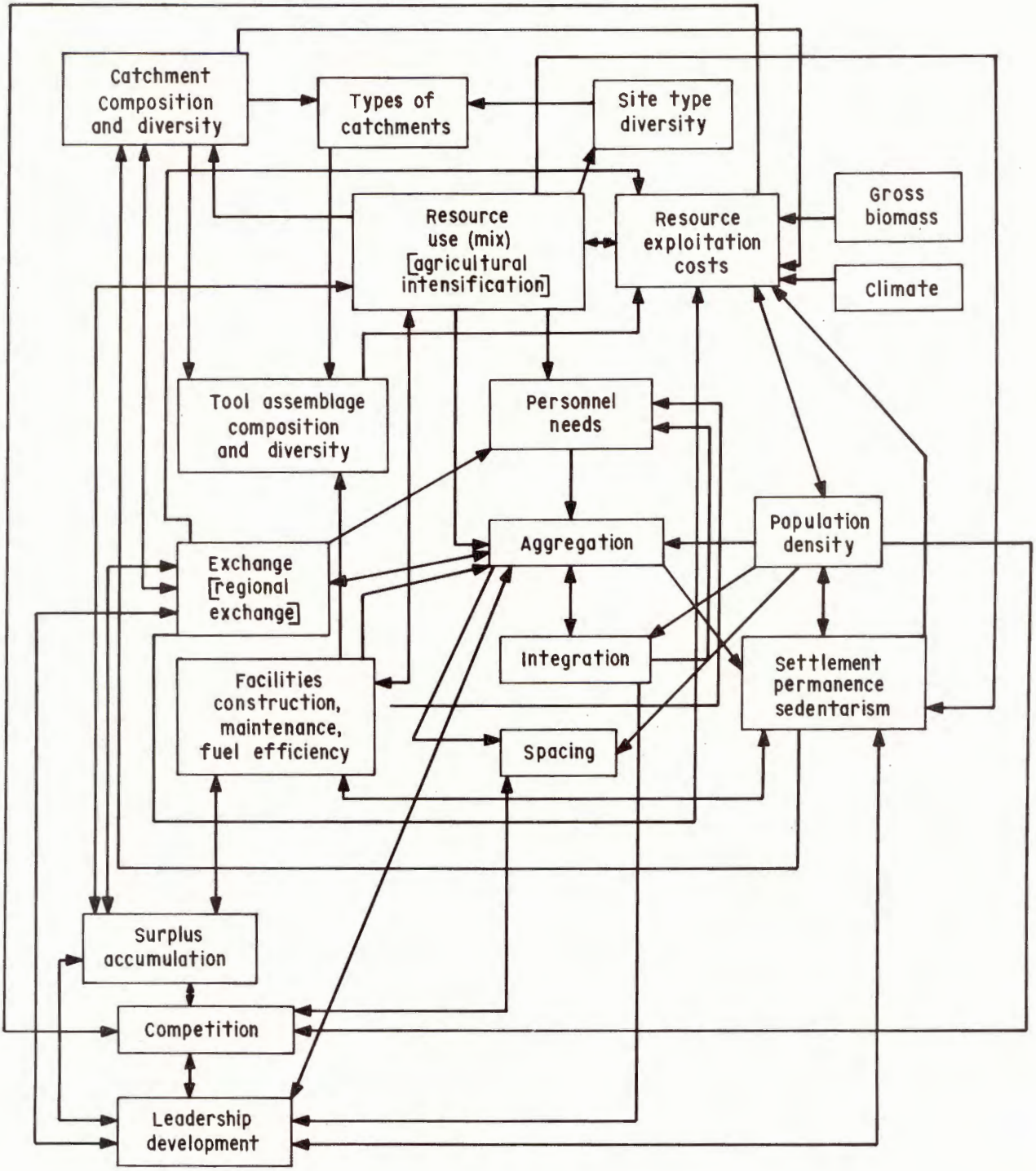

Figure 10.31 – The settlement behavior model with the sociopolitical variables.

Table 10.9 – Spearman rank correlation coefficients

	Site size range				Site size diversity				No. of settlement tiers				No. of settlement tiers x site size range			
	Population density	Ag int index	Household agg	Spatial agg	Population density	Ag int index	Household agg	Spatial agg	Population density	Ag int index	Household agg	Spatial agg	Population density	Ag int index	Household agg	Spatial agg
A.D. 600-1175	$r_s = 0.8458$ $p < 0.01$	$r_s = 0.8917$ $p < 0.01$	$r_s = 0.7125$ $p < 0.05$	$r_s = 0.9625$ $p < 0.01$	$r_s = 0.9000$ $p < 0.01$	$r_s = 0.6042$ $p < 0.05$	$r_s = 0.4500$ $p < 0.05$	$r_s = 0.7000$ $p < 0.05$	$r_s = 0.7708$ $p < 0.05$	$r_s = 0.8542$ $p < 0.01$	$r_s = 0.8208$ $p < 0.01$	$r_s = 0.9375$ $p < 0.01$	$r_s = 0.8458$ $p < 0.01$	$r_s = 0.8917$ $p < 0.01$	$r_s = 0.7125$ $p < 0.05$	$r_s = 0.9625$ $p < 0.01$

r_s – Spearman rank correlation coefficient.
p – Probability.
Ag int – Agricultural intensification.
agg – Aggregation.

Table 10.10 – Difference of ranks for significant correlations

Period (years A.D.)	Site size range and pop density	Site size range and ag int	Site size range and household agg	Site size range and spatial agg	Site size diversity and pop density	Site size diversity and ag int	Site size diversity and spatial agg	No. of settlement tiers and pop density	No. of settlement tiers and ag int	No. of settlement tiers and household agg	No. of settlement tiers and spatial agg	Weighted settlement tiers and pop density	Weighted settlement tiers and ag int	Weighted settlement tiers and household agg	Weighted settlement tiers and spatial agg	Total difference of ranks
600-720	-1.0	0.0	1.0	1.0	0.0	1.0	2.0	-1.5	-0.5	0.5	0.5	-1.0	0.0	1.0	1.0	4.0
720-800	-1.5	-0.5	1.5	0.5	-1.0	0.0	1.0	-1.5	-0.5	1.5	0.5	-1.5	-0.5	1.5	0.5	0.0
800-840	-2.5	0.5	0.5	-0.5	0.0	3.0	2.0	-2.5	0.5	0.5	-0.5	-2.5	0.5	0.5	-0.5	-1.0
840-880	0.0	3.0	4.0	0.0	-1.0	2.0	-1.0	-1.0	2.0	3.0	-1.0	0.0	3.0	4.0	0.0	17.0
880-920	0.0	-1.0	0.0	1.0	1.0	0.0	2.0	0.0	-1.0	0.0	1.0	0.0	-1.0	0.0	1.0	3.0
920-980	1.0	0.0	-3.0	0.0	2.0	1.0	1.0	2.5	1.5	-1.5	1.5	1.0	0.0	-3.0	0.0	4.0
980-1025	2.0	-1.5	-1.0	0.0	-2.0	-5.5	-4.0	0.5	-3.0	-2.5	-1.5	2.0	-1.5	-1.0	0.0	-19.0
1025-1100	2.0	-0.5	-2.0	-1.0	1.0	-1.5	-2.0	3.0	0.5	-1.0	0.0	2.0	-0.5	-2.0	-1.0	-3.0
1100-1175	0.0	0.0	-1.0	-1.0	0.0	0.0	-1.0	0.5	0.5	-0.5	-0.5	0.0	0.0	-1.0	-1.0	-5.0

agg – Aggregation.
ag int – Agricultural intensification.
pop – Population.

The A.D. 600-720 period is more complex than expected from the settlement behavior model. The A.D. 720-800 period shows agreement between expected and measured complexity, but the A.D. 800-840 period is less complex than expected. Settlement complexity in the A.D. 840-880 period is much higher than expected and is slightly higher than expected in the A.D. 880-920 and 920-980 periods. The A.D. 980-1025, 1025-1100, and 1100-1175 periods are less complex than expected.

The higher-than-expected complexity for the A.D. 600-720 period is difficult to explain, given the apparent lack of complexity indicated by all the measures used. More internal variability must be present during this period than in other periods with low population. The agreement in ranks in the A.D. 720-800 period supports the model in assuming complexity developed along with population density, aggregation, and intensification. The lower-than-predicted rank in the A.D. 800-840 period indicates while the level of complexity does not match that expected, based on the settlement behavior variables, neither does it support the existence of some "power" drive to recruit personnel in a competitive leadership situation.

The high complexity during the A.D. 840-880 period probably was the product of a number of factors, including population density, aggregation, and intensification. Related to population density, but not measured (and not dealt with in the social organization modeling studies), are certain social costs that contribute to changes in organization. If population grows but remains dispersed, the potential for overlapping catchments becomes greater and greater. While it probably is "cheaper" to remain dispersed, the efficiency of this type of organization should decline as catchment overlap increases; the costs of maintaining this organization with its attendant problems of unwanted interaction must, at some point, have to be evaluated against the costs of aggregation. The latter offers a more efficient organization for mobilizing extrahousehold groups and provides for management of daily movements and territory, but comes with a price tag involving intensification and the maintenance of a weightier social system.

The lack of convincing evidence for competition in the nearest neighbor analysis would suggest that whatever reorganization occurred, and for whatever reason(s) it occurred, the result was a well-integrated system with communication among the aggregates. Although Kane (1985) attributes higher status to villages with larger populations, the settlement data do not suggest these villages were involved in competitive recruitment related to status or leadership.

SUMMARY AND CONCLUSIONS

The model of settlement behavior was presented and modeling studies summarized. While the results of the studies support the general framework of the settlement behavior model, interesting discrepancies regarding preconceived ideas of the role of limited activity sites in the Dolores settlement system and of the differences between hamlets and villages were noted. The attempt to test the "alternative" social model produced results more consistent with the expectations of the economically based settlement behavior model.

Because one goal of modeling is to learn how cultural systems operate, the modeling effort has been productive. Results that deviate from expectations, or are ambivalent, provide the greatest opportunity to learn as they supply the challenge to pursue model refinement.

Sociopolitical development and economic development should occur together through multiple avenues of cause, effect, and feedback, and neither can be understood without recognizing the **linkages** among social and economic variables. In more complex sociopolitical systems such as chiefdoms and states, subsistence economy and political **economy** are linked in their operation.[1] There is no reason to suggest that similar relationships do not exist in simpler systems – they just do not produce the complexity observed in systems supporting larger population.

[1]Timothy K. Earle, University of California, Los Angeles; personal communication as discussant in the 50th Annual Meeting of the Society for American Archaeology, Denver.

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Chapter 11

TECHNOLOGY: LITHIC TOOLS

Carl J. Phagan

The research orientation and data acquisition of the DAP was initially guided by the program general research design, which outlines a series of relevant questions within a set of 5 problem domains: economy and adaptation, paleodemography, social organization, extra-regional relationships, and cultural process (Kane et al. 1983). Many DAP descriptive, synthetic, and supporting studies have dealt in varying ways with these problem domains, particularly the first 4. However, explaining the processes of Dolores Anasazi cultural change, rather than simply describing such change, is recognized as a complex analytic task of a higher order, requiring an appropriately multi-variate theoretical and methodological approach. This analytic approach has come to be called the DAP "modeling effort" because of its dependence on the development and use of a general model of cultural change.

Selecting and developing a cultural change model sufficiently general to encompass a wide range of data and research interests, yet sufficiently detailed to provide effective and consistent interpretive cohesion has been a difficult and lengthy process. Several distinct stages in arriving at an acceptable concensus modeling posture are identifiable. First, a summary statement was prepared by Lipe (1984a:250-256), which identified several primary variables involved in Dolores Anasazi culture change and established a largely economic system of interrelationships among them, based primarily on the marginal cost and least cost principles outlined by Christenson (1980) and Earle (1980).

This economic modeling approach was considerably elaborated upon during a planning seminar held at Mesa Verde National Park, November 1 to 5, 1982. During this seminar, methodological approaches were planned for each major area of data responsibility, and summary statements were prepared. An alternative to this economic model was then introduced by Kane (1983) and summarized by Lipe (1984b). This alternative model of Anasazi cultural change was based on the concept of developing "power cycles" or social "growth" similar to that proposed by Stuart and Gauthier (1981), though economics was still viewed as critical in that it motivated culture change through the accumulation of resources in excess of immediate consumption needs. Finally, a further adjustment was made to the power cycles modeling alternative; this included more overtly social causes of important culture change, as proposed by Lightfoot (1984), and resulted in a rather clear distinction between an economic least cost model and an alternative social growth model of Dolores Anasazi culture change (Lipe 1985).

Resulting from this continuing development of the DAP modeling posture is a considerable degree of synchronic and diachronic variability in theoretical approach, data structure, and interpretive emphasis among DAP modeling-based reports. Because of the recent introduction of the social growth modeling alternative, most study results – including this one on the interpretation of technological changes in tools – tend to emphasize responses based on the economic least cost model. This should not be viewed, however, as an a priori theoretical or methodological preference, but simply as a limited opportunity to organize appropriate responses to the social growth, or sociopolitical model.

A least cost economic response model suggests that major cultural changes occur in response to economic stresses in the demand-supply balance, which are produced largely by population growth, negative subsistence condition, or both. For the Dolores Anasazi, such negative subsistence conditions are most likely to have resulted from climatic deterioration that adversely affected agricultural production. Cultural changes that occurred during, or immediately following, periods of rapid population growth or declining agricultural suitability may therefore be tentatively considered as supporting such a least cost model.

A sociopolitical development model, on the other hand, supposes that major culture change results from stresses, primarily those that operate on a group's information-processing, decision-making structure. Such

stresses promote the development of leadership hierarchies, ranked social structures, and competition within and among communities. Such changes normally result in higher overhead costs, even for rather small groups, and might be expected to occur when these higher costs may be more easily borne; i.e., during periods of relatively secure economic productivity. Major cultural changes occurring during such periods may therefore be better explained by the social model than by the economic model.

Tools of various sorts are always involved in human systems of adaptation to the environment, and they constitute much of the archaeological record. The relationships between certain categories of adaptive behavior and tool categories are often rather direct, and kinds and intensities of behavior may often be inferred from tools. Such relationships, however, should be explicitly defined as intermediate or bridging arguments that link some interpretive structure (a model) with observed data. This normally involves a series of "if . . ., then . . ." propositions.The more linking arguments, and the more reasonable they are, the more thoroughly and convincingly the interpretive structure can be addressed. Most of this chapter is devoted to the construction of such linking arguments and their examination in the light of observed variation in lithic tools. Such technological data are arranged and interpreted as dependent variability among categories of independently established variability such as time, space, organizational complexity, or site size.

Three broad cultural aspects or variables have emerged as particularly useful in observing and understanding Anasazi cultural change within this analytic framework. They are agricultural intensification, resource diversification, and organizational differentiation (chap. 6). Each serves as a core around which bridging arguments can be constructed to link observed data variability with modeled expectation. Of particular concern are technological changes having to do with rather broad-scale variation in the production and use of lithic tools, particularly the extracting and processing of subsistence resources. Initial expectations are this technological change will be somewhat limited for the Dolores Anasazi, since their basic subsistence pattern appears to change very little during the period A.D. 600-1000. No fundamentally new tool forms or techniques for their production are introduced, not even stone- or bone-tipped earth-working implements; only slight evidence possibly suggests systems may have been used; and new varieties of corn are only minimally involved, if at all. The most observable changes in subsistence technology should therefore occur as changes in the relative importance of various resources and their associated production or processing equipment, and as changes in the organization of labor.

AGRICULTURAL INTENSIFICATION

The term "intensification" is subject to some latitude of definition, but here it is intended to convey the general notion of increased input invested in the agricultural component of subsistence. The tacit assumption is that increased output (production) should result; or, at least, significantly increased output is not likely to occur without increased input. In addition, observing changes in agricultural intensification from assemblages of lithic artifacts is even more indirect in this case because no Anasazi artifacts in the DAP assemblages can definitely be associated with agricultural production. However, several kinds of lithic implements can be associated with various kinds of resource processing. The relationship between production and processing is expected to be particularly strong in the case of corn, which in its dried and storage form requires some type of processing prior to consumption. The argument that links processing tools with agricutural intensification consists of several steps, but nevertheless seems rather convincing. Of particular importance in this argument concerning agricultural intensification are indications that corn either increases or decreases as a proportion of the total Anasazi diet, or at least of its vegetative component. Considerable attention will be given to this relative dietary importance of corn.

The ratio of flaked lithic tools to nonflaked, or ground, stone tools may be considered a general indication of the relative proportions of plant and animal products in the subsistence structure. Flaked lithic technology produces most of the tool edges necessary for cutting and scraping tasks, including those associated with processing animal products. Ground stone technology, on the other hand, produces most tool surfaces associated with the crushing and grinding tasks of plant processing. Certainly this technological dichotomy is stated here in an extreme form, and there are exceptions, but the generalization is expected to be sufficiently strong to support broad comparisions of animal and plant processing activities. In this ratio of flaked to ground stone tools, lower ratios mean relatively more ground stone tools and should indicate relatively more plant processing.

The flaked stone tool/ground stone tool ratio for all DAP data asssignable with reasonable confidence and integrity to temporally ordered subphases (fig. 11.1) indicates a marked relative decrease in plant processing during the environmentally comfortable Dos Casas Subphase, which corresponds roughly to Period 3 (see chap. 1 for period definitions). This is followed by relative increases in plant processing during the populous and climatically difficult Periman and Grass Mesa Subphases, which correspond approximately to Periods 4 and 5, respectively. Finally, a relative decrease in plant

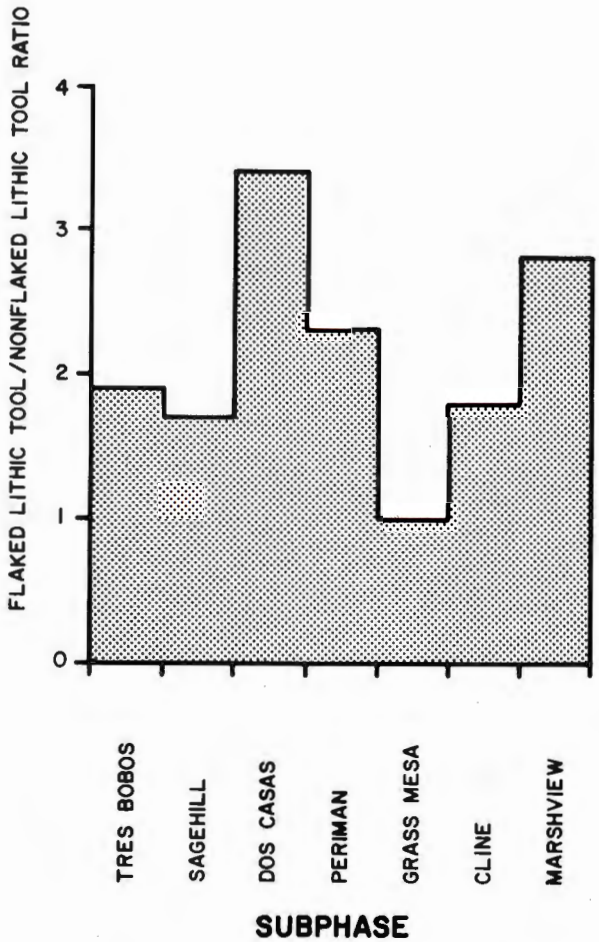

Figure 11.1 – Flaked lithic tool/nonflaked lithic tool ratio for subphases.

processing is noted for the Cline and Marshview Subphases, or Periods 6 and 7, respectively. The correspondence of the major increase in plant processing with the increasing economic stresses during the Periman and Grass Mesa Subphases suggests a general level of support for the economic model of culture change. In addition, the lowest relative levels of plant processing during the economically comfortable Dos Casas Subphase indicates a possible economic subsistence "deintensification" response to a greater range of resources, which would be an unlikely response under the social model, but completely consistent with expectations of the economic model. The decreased plant processing during the Cline and Marshview Subphases simply reflects the inadequacy of any agricultural intensification efforts to alleviate subsistence stress during Periods 6 and 7; in addition, it reflects the necessity for diversification to include more animal products, which is also consistent with economic least cost expectations.

Perhaps the most direct indication of the relative importance of corn grinding and other plant processing is the proportion of manos and metates in nonflaked lithic tools assemblages. One-hand manos and basin metates are interpreted as representing a generalized plant processing complex, though certainly animal or mineral products could have been manipulated as well. Two-hand manos and trough metates, on the other hand, are assumed to represent a system virtually restricted to corn grinding. In examining these data, attention is focused on manos as the better indicator of the amount of grinding or plant processing represented. Metates are thought to be less useful indicators because they exist in far fewer numbers, they tend to be tools or artifacts in something of a site furniture sense, and they demonstrate an amazing propensity to find their way into dubious contextual situations such as wall or storage bin construction. Figure 11.2 presents the proportions of one-hand manos, two-hand manos, and trough metates in subphase nonflaked lithic tools assemblages.

The proportion of one-hand manos is a constant 2 to 5 percent of the nonflaked lithic assemblages for all subphases. This indicates a consistent pattern of generalized plant processing throughout the entire sequence, against which the levels of corn processing vary noticeably. Two-hand manos make up a rather constant 11 to 13 percent of nonflaked tool assemblages for the 3 initial subphases (those assigned to the Sagehen Phase). Then, a marked increase to 21 percent occurs during the Periman Subphase and a further increase to 33 percent in the Grass Mesa Subphase. This is followed by an abrupt decrease to 25 percent and 22 percent during the Cline and Marshview Subphases. These data are a rather clear indication that corn grinding increased significantly, relative to generalized plant processing, during the period A.D. 840-920, the time of maximum population size and environmental stress. The lithic data indicate this increase was followed by a decrease in corn processing after A.D. 920, during the Cline and Marshview Subphases. The economic model of culture change, rather than the social model, would seem to provide the best explanation for this data variability.

Two additional and closely related measures of the relative intensity of corn processing are the combined proportions of two-hand manos and trough metates (fig. 11.3) and the ratio of generalized plant processing one-hand manos to specialized corn processing two-hand manos (fig. 11.4). Both demonstrate rather unambiguous evidence for a major increase in corn processing intensity relative to more generalized plant processing between the Dos Casas and Periman Subphases, which roughly corresponds with the major population increase in the project area, the development of large villages, and the likely onset of major subsistence stress. This is also seen as clear support for the economic model of culture change.

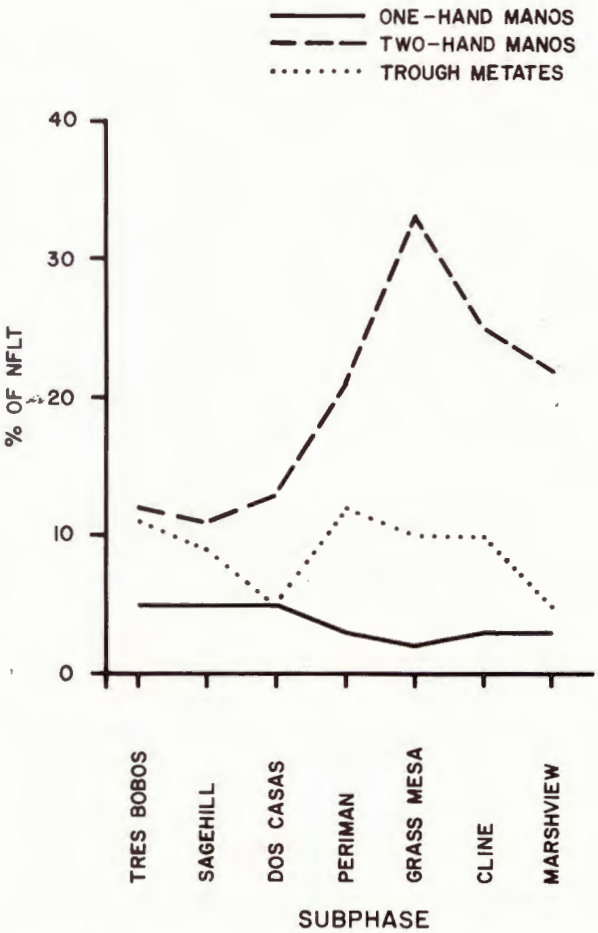

Figure 11.2 – Proportions of manos and trough metates within the nonflaked lithic tool (NFLT) assemblage for subphases.

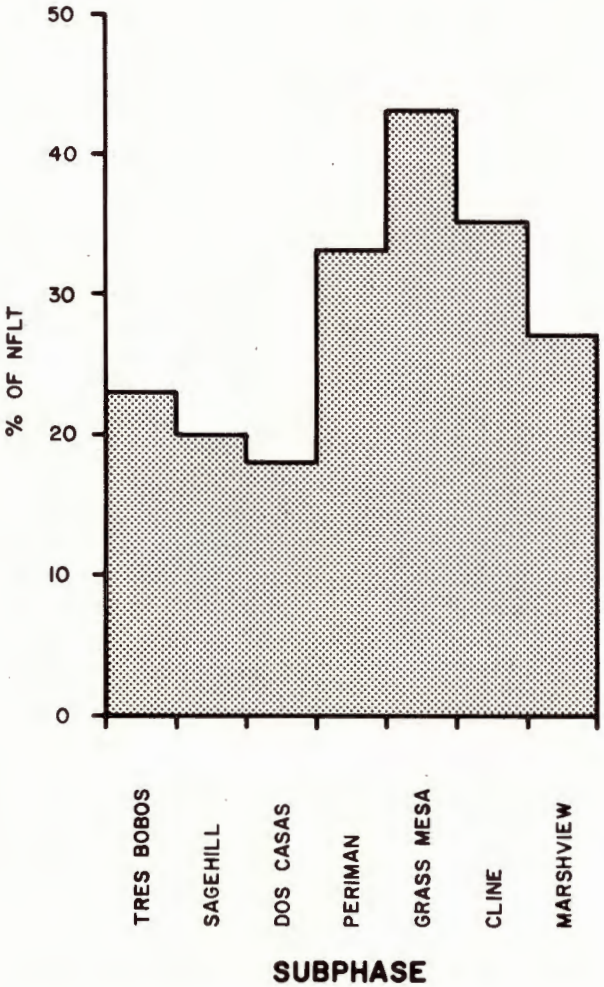

Figure 11.3 – Proportions of two-hand manos and trough metates within the nonflaked lithic tool (NFLT) assemblage for subphases.

If corn processing increases as a percent of all plant processing, or becomes more important and specialized, then equipment associated with this corn processing should increasingly dominate the nonflaked lithic assemblage, and measures of nonflaked lithic tool diversity should decrease. Both Shannon-Wiener and equitability measures of this diversity (fig. 11.5) demonstrate a generally increasing value through the Periman Subphase, followed by a marked decline to beginning levels at the Grass Mesa Subphase. The variability in these diversity measures is not great, ranging only from 0.90 to 0.97 for the Shannon-Wiener index and 0.77 to 0.83 for the equitability measure (see Phagan and Hruby [1984] for an explanation of the calculation and interpretation of diversity measures). The slight suggestion, however, is for an increasingly more even distribution of nonflaked lithic tool types through A.D. 880, after which some indications show a few tool types dominate the assemblage. This is almost certainly the result of the increased use of two-hand manos during the Grass Mesa Subphase.

The preceding measures of agricultural intensification, most of which focus on organization or temporal variability in nonflaked lithic plant processing equipment, consistently tend to support expectations of the economic model of culture change. Major changes in plant processing appear to coincide with or to follow periods of likely economic stress, which are induced by population increase, climatic deterioration, or both. Changes during the economically good times predicted by the social model, particularly during the Dos Casas Subphase, seem not to occur, at least insofar as they are apparent from such nonflaked lithic measures of plant processing intensity.

RESOURCE DIVERSIFICATION

The second aspect of culture change that structures the interpretation of artifact data in the modeling context

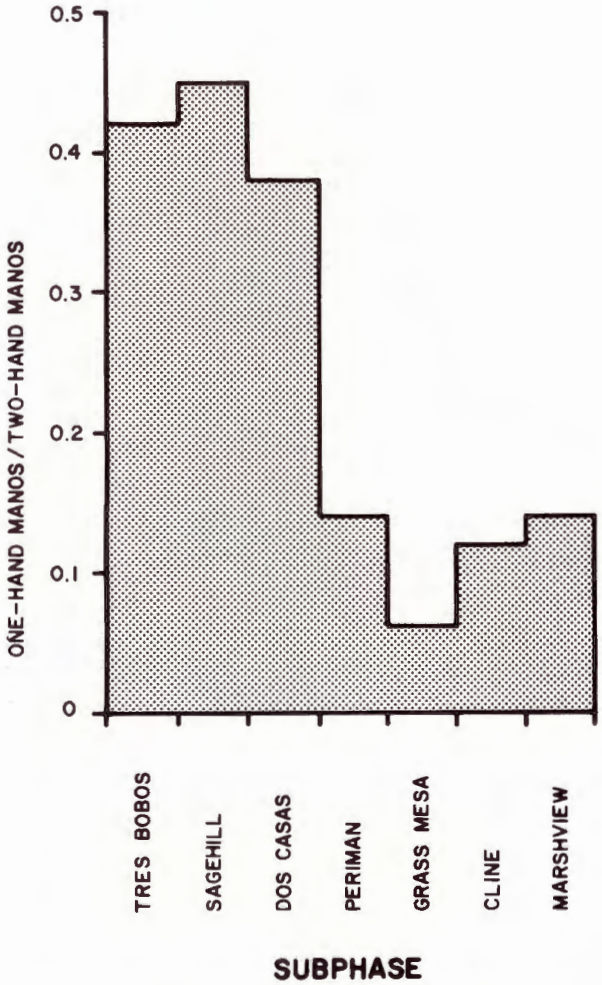

Figure 11.4 – One-hand mano/two-hand mano ratio for subphases.

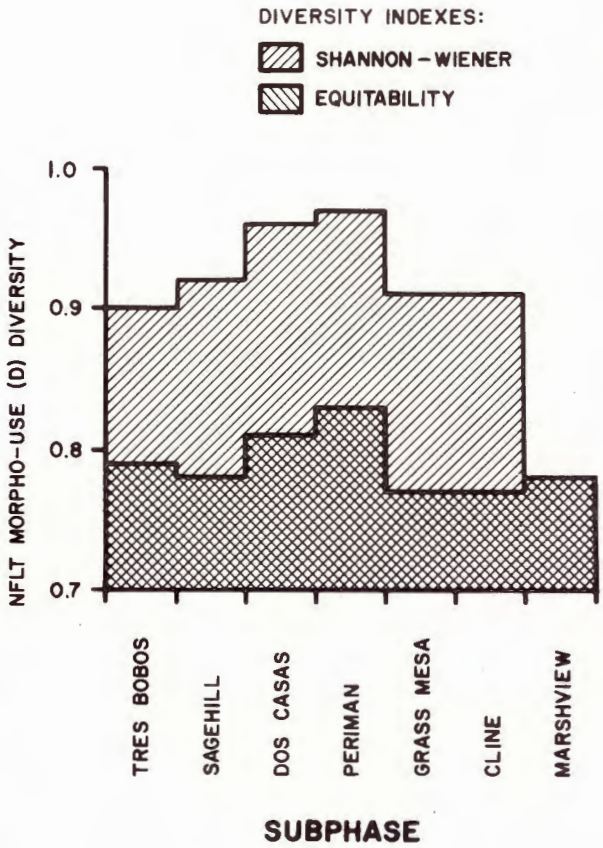

Figure 11.5 – Nonflaked lithic tool (NFLT) morpho-use (*D*) diversity index measures for subphase assemblages.

is subsistence resource diversification, or an increase in the number of plant and animal species used regularly in the subsistence system. Lipe (chap. 6) indicates resource diversification across the entire subsistence structure may sometimes accompany intensification in one portion of that structure (i.e., along with intensification of corn production may be an increase in the range of other plant and animal species regularly harvested). However, if agricultural intensification produced a significantly increasing proportion of corn in the Anasazi diet as suggested by the preceding data, then diversification of other resources will be restricted to the remaining, decreasing proportion of the diet. In other words, good reason exists to expect that if both intensification and diversification are operating simultaneously, they must do so counter-actively and to a relatively restricted degree. As with agricultural intensification, resource diversification must be recognized somewhat indirectly in lithic artifact assemblages as varying tool types or raw material proportions.

Expanding the number of regularly collected species should be accompanied by some increase in the effective catchment area of economic groups, and together with an increased scope of procurement strategies and associated equipment, it should affect tool assemblages in predictable ways. For example, procuring lithic raw materials for flaked tool production has been identified, probably correctly, as behavior largely embedded in other subsistence activities (Binford 1979; Binford and Stone 1985). An expanded area from which subsistence resources are regularly collected might then also provide opportunity for collecting an increased variety of lithic materials, either from geologic exposures or as relic items from the surface of earlier sites. As a result, the proportion of nonlocal materials in flaked tool assemblages might be expected to increase, the total raw material diversity may increase, and the cost of obtaining those raw materials should increase.

The proportions of nonlocal raw materials in subphase flaked lithic tool assemblages are presented in figure 11.6. The proportion of nonlocal material increases slightly, from 2 to 5 percent, from the Sagehill through the Grass Mesa Subphase, after which it remains fairly

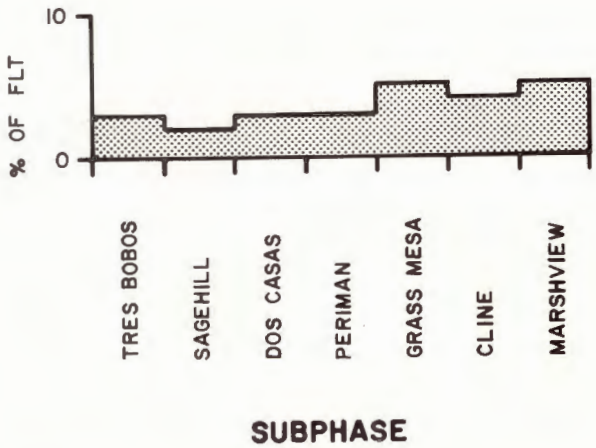

Figure 11.6 – Proportions of nonlocal raw material in subphase flaked lithic tool (FLT) assemblages.

stable. In interpreting this variability in a location such as the Dolores River valley, where a wide range of suitable lithic raw material is readily available, even rather small variations in nonlocal materials may be important. This increase in the proportion of nonlocal materials throughout an increasingly stressful period may suggest an increasing range of activities within which procurement is embedded.

Flaked lithic tool raw material diversity is presented in figure 11.7. Slight overall diversity variability is not particularly patterned in the subphase sequence, suggesting that formal diversity measures may not be appropriate to indicate catchment size variation, at least for the Dolores Anasazi. However, ample evidence of significant between-subphase variability exists in the proportions of individual raw material categories (chap. 3); this may be due to spatially differential subsistence activities within which raw material procurement is embedded, differential patterns of settlement aggregation and the concentrated use of the closest suitable raw materials, or both.

The relative cost of acquiring raw materials for flaked lithic tools has been calculated using assessments of quality, amount, and especially distance from its closest geologic source (Phagan and Maloney 1983). This flaked lithic tool raw material acquisition cost is presented for subphase assemblages in figure 11.8. Raw material acquisition cost is greatest during the earliest 2 subphases, drops quite sharply during the Dos Casas Subphase, and is much lower during the Periman Subphase. It then increases to moderate levels during the final 3 subphases. This suggests a focus on relatively cheaper, closer, and perhaps poorer quality raw materials during the Dos Casas and Periman Subphases, and an agriculturally favorable period with low population growth and it may also reflect the beginning stages of

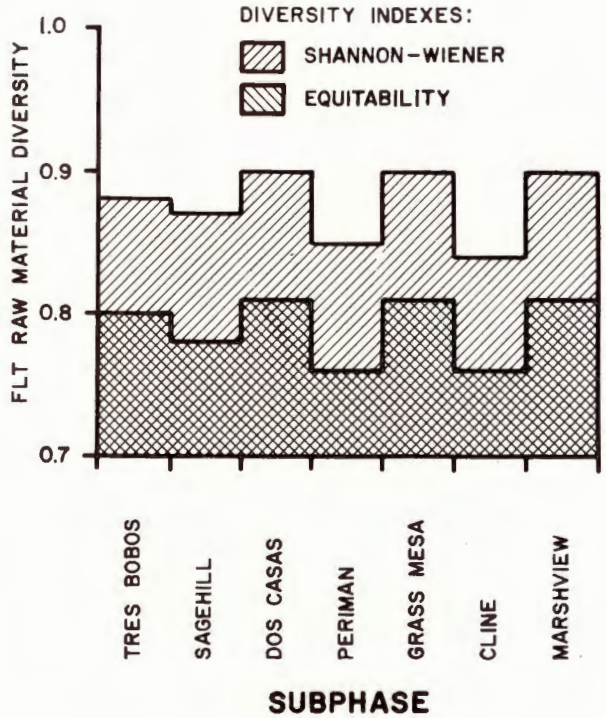

Figure 11.7 – Flaked lithic tool (FLT) raw material diversity index measures for subphase assemblages.

settlement aggregation in the early A.D. 800's. This is one of the few instances of marked change in Period 3 artifact assemblages, supporting the social model rather than the economic model of culture change. The increased raw material acquisition costs after A.D. 880, however, are most likely to be related to procuring slightly better quality materials from greater distances, perhaps in conjunction with an expanded resource catchment area, and they tend to support the economic model.

Another general indication of subsistence resource diversification, particularly with reference to the exploitation of animal resources, may be an increase in the diversity of flaked lithic tools used to procure or process such an increased resource diversity. The proportion of projectile points in flaked lithic tool assemblages may be a rather direct indication of changing animal resource procurement.

Flaked lithic tool type diversity measures are presented in figure 11.9. A marked diversity decrease occurs during the Dos Casas Subphase, a period when economic stress was likely to be relatively low, suggesting a flaked lithic tool assemblage somewhat more dominated by a few artifact classes. The typically dominating flaked lithic tool class in Dolores Anasazi assemblages is the functionally and technologically very generalized "utilized flake"; therefore, such a diversity decrease may

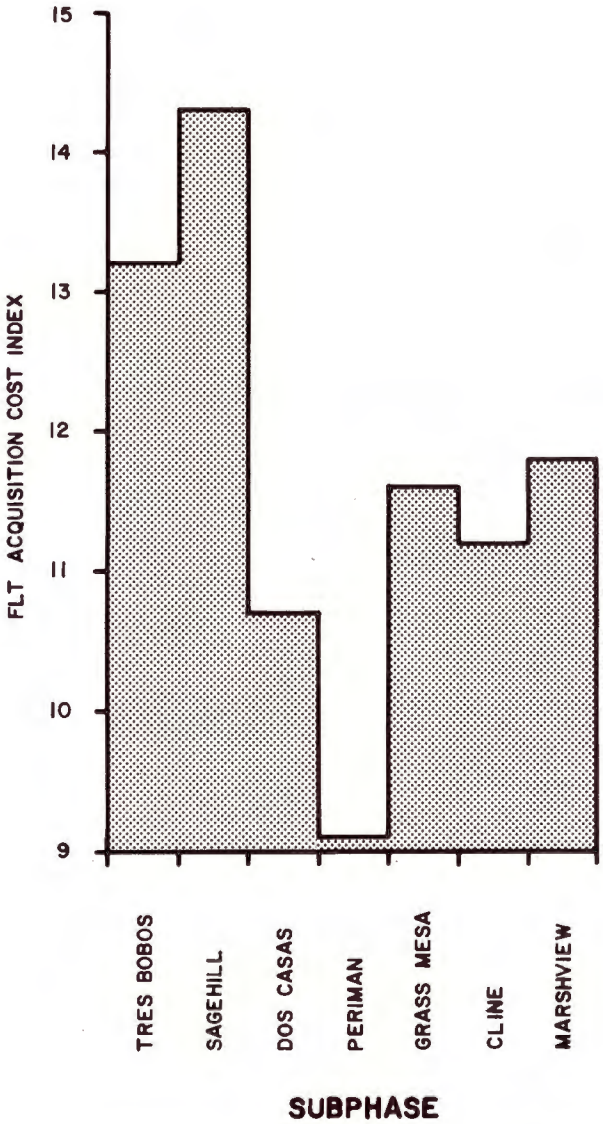

Figure 11.8 – Flaked lithic tool (FLT) acquisition cost index for subphase assemblages.

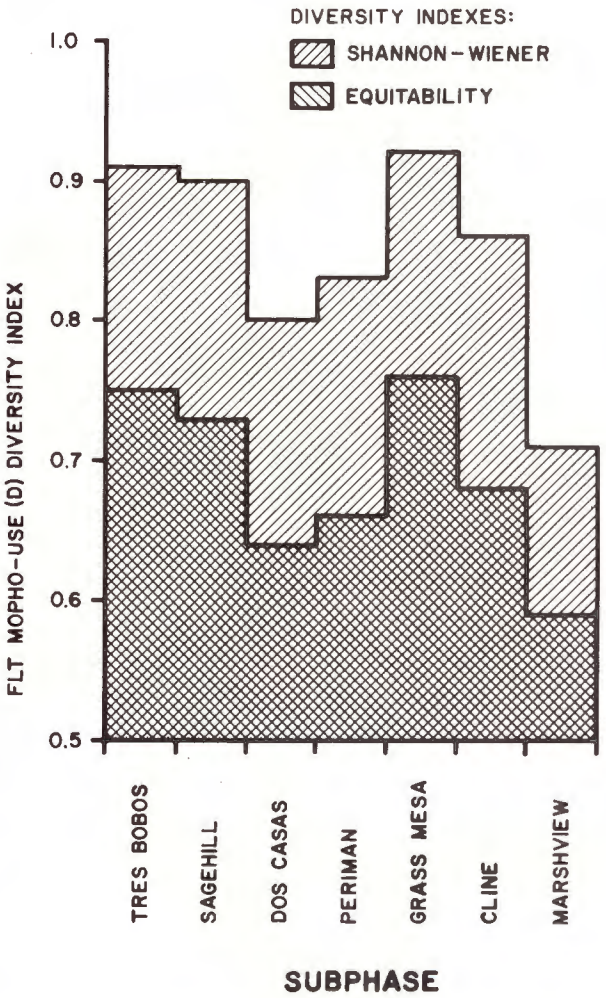

Figure 11.9 – Flaked lithic tool (FLT) morpho-use (*D*) diversity index measures for subphase assemblages.

indicate the increased presence of this more generalized tool form, and a less specialized animal resource procurement strategy during this low stress period. This would be consistent with the expectations of the economic model. Flaked lithic tool diversity increases slightly during the Periman Subphase and significantly during the Grass Mesa Subphase, as economic stress increases. Animal resource procurement and its associated toolkit again appear to be more evenly balanced, with more specialized tools and the increased resource variability they imply. Diversity declines during the Cline and Marshview Subphases, suggesting a return to a less specialized pattern of animal resource procurement. This evidence from flaked lithic tool diversity is not considered to be particularly strong or convincing, but seem to be consistent with the expectations of the economic model.

The proportions of projectile points in subphase flaked lithic tool assemblages are presented in figure 11.10. This proportion decreases steadily through the Dos Casas Subphase, increases through the Periman and Grass Mesa Subphases, and again declines during the Cline and Marshview Subphases. This variability pattern rather closely parallels that of decreasing, increasing, and decreasing economic stress induced by combinations of population levels and climatic conditions. It therefore tends to support the economic model of culture change, particularly in the earlier portions of the DAP sequence. Incidentally, projectile points are interpreted principally as indicators of animal procurement rather than warfare. Occam's razor virtually requires such an interpretation, especially

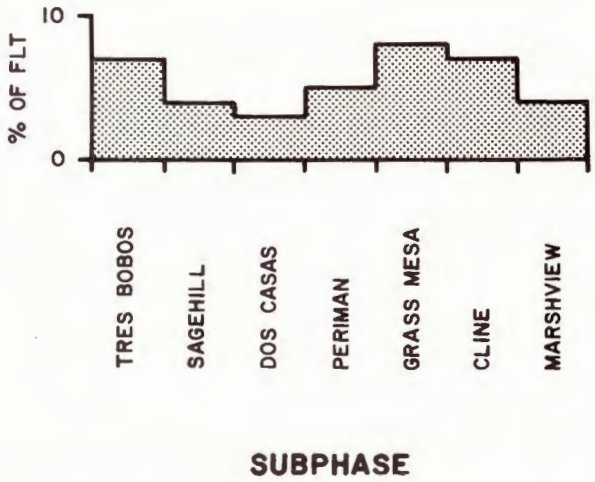

Figure 11.10 – Proportions of projectile points in subphase flaked lithic tool (FLT) assemblages.

since Anasazi warfare is simply not otherwise supported in the DAP data.

ORGANIZATIONAL DIFFERENTIATION

Both models of culture change address the development of organizational differentiation – the economic model as a response to economic supply-demand imbalance and the social model as a response to the opportunity for leadership development. If economic factors are the cause, developing differentiation should be rather low in cost, characterized generally by economic cooperation, and primarily horizontal in nature without much indication of within- or between-group status ranking. On the other hand, if causal factors are sociopolitical, developing differentiation should be characterized by competition and relatively high economic costs, and should be largely vertical in nature, with clear indications of within- and between-group status ranking.

Recognizing potential status differentiation in artifact assemblages requires an additional independent data structuring mechanism that serves as a framework for interpreting artifact variability. In chapter 10, Orcutt has provided one such structuring mechanism by dividing DAP habitations assigned to Period 1 through 6 into a maximum of 3 size categories. A critical interpretive assumption is that any vertical ranking of sites should appear as an indicator of increased status in larger sites. Tables 11.1, 11.2, and 11.3 present flaked lithic tool, nonflaked lithic tool, and flaked lithic debitage data for these site size categories for Periods 1 through 6. Note that the assemblages from medium-sized sites assigned to Period 2 are rather small, particularly the nonflaked lithic tools.

Several lithic tool variables already interpreted in this report as functional indicators demonstrate rather extreme period and site-size variability, suggesting again the organization of certain subsistence tasks may change a great deal, not only with time, but also with site size. For example, flaked lithic tool/nonflaked lithic tool ratio demonstrates significant changes between Periods 3 and 4 and again between Periods 4 and 5. Determining the nature of these organizational changes is complex and is not as important for this study as are the timing and magnitude of the changes. Such changes in the organization of subsistence tasks have already been demonstrated and discussed, and this data structure indicates subsistence-related functional variability extends to site-size categories as well.

The proportions of two-hand manos in nonflaked lithic tool assemblages also demonstrate major changes between Periods 3 and 4 and between Periods 4 and 5. The ratios of one-hand manos to two-hand manos also indicate a major change between Periods 3 and 4, though not between Periods 4 and 5. Both flaked and nonflaked lithic tool diversity measures indicate marked change between Periods 3 and 4. All of these variables tend to confirm major changes in Dolores Anasazi subsistence behavior closely associated with major population expansion and the development of large villages during Period 4 (A.D. 840-880), followed rather quickly by climatic deterioration, probable severe economic stress, and depopulation. However, while these variables tend to confirm an economic model of culture change from the perspective of functional differentiation, they are not particularly appropriate to indicate any vertical status differentiation that may exist between site-size categories. To indicate such possible status differentiation, 4 lithic variables are used: the proportion of nonlocal materials in flaked tool assemblages, the flaked tool raw material acquisition cost index, and the proportion of extremely well worked items in both flaked and nonflaked tool assemblages. All may be interpreted on the assumption that increased status may be accompanied by such indicators as an increased proportion of nonlocally acquired or better quality materials, into which increased amounts of tool production input have been invested.

The proportions of nonlocal raw materials for the site-size groupings varies only from 2 to 5 percent (table 11.1), with no indication that larger sites yield higher proportions than smaller ones. The acquisition cost index (Phagan and Maloney [1983]) for the site-size groups is presented in figure 11.11. During Periods 4 and 5, acquisition costs appear somewhat higher at larger sites, though this could easily be related to technological or functional variability associated with the

Table 11.1 – Flaked lithic tool variables, by period and site size

	Period 1	Period 2		Period 3		Period 4			Period 5		Period 6
	Small sites (N=702) %	Small sites (N=1558) %	Medium sites (N=101) %	Small sites (N=1515) %	Medium sites (N=231) %	Small sites (N=625) %	Medium sites (N=348) %	Large sites (N=762) %	Small sites (N=286) %	Large sites (N=2407) %	Medium sites (N=1456) %
Morpho-use (*A*)											
Utilized flake	33	31	53	40	48	62	30	42	28	35	37
Core	8	9	9	13	5	5	8	8	7	9	5
Used core, cobble tool	19	19	14	11	14	11	14	15	18	18	15
Thick uniface	10	11	5	11	8	8	16	10	13	9	11
Thin uniface	5	6	1	5	4	2	4	2	5	3	3
Specialized form	2	2		3	3	1	1	2	2	2	2
Thick biface	8	10	7	6	10	5	7	8	13	11	9
Thin biface	3	5	2	5	3	1	1	3	5	3	5
Projectile point	8	5	9	3	4	3	7	7	7	6	7
Raw material identification (*B*)											
Nonlocal	4	2	3	5	2	3	2	3	4	4	4
Morrison quartzite	22	32	57	19	40	30	24	34	19	31	20
Morrison chert	5	6	6	4	4	2	3	7	1	5	4
Burro Canyon quartzite	14	8	4	13	7	9	14	5	14	6	9
Burro Canyon chert	10	12	11	27	11	22	30	11	26	9	7
Local cobbles (hornfels)	27	17	10	12	20	14	16	23	22	30	30
Local, unspecified	17	19	9	15	15	20	11	16	14	13	10
Dorsal face evaluation											
Items with cortex	34	36	39	41	33	42	47	44	41	45	48
Unworked	54	55	67	63	67	72	56	65	52	58	51
Edged	8	11	2	10	10	10	16	8	15	11	15
Primarily thinned	2	2	4	2	1	1	2	2	3	1	3
Secondarily thinned	4	2	5	2	3	1	2	3	4	3	3
Well shaped	5	2	2	2	1	2	3	3	5	3	8
Stylized	1	1		<1		1		1	<1	1	1
Morpho-use (*D*) diversity											
Shannon-Wiener Index	0.91	0.91	0.73	0.86	0.80	0.63	0.86	0.86	0.94	0.90	0.90
Equitability Index	0.74	0.72	0.68	0.70	0.68	0.54	0.73	0.68	0.80	0.72	0.72
Raw material diversity											
Shannon Wiener Index	0.80	0.79	0.61	0.83	0.71	0.74	0.74	0.75	0.76	0.76	0.81
Equitability Index	0.89	0.88	0.72	0.92	0.79	0.82	0.87	0.83	0.84	0.84	0.90
Acquisition cost index	13.5	14.4	9.8	11.4	11.7	7.0	7.1	10.0	8.0	10.4	12.2
Production cost index	9.4	8.8	8.6	8.7	8.8	8.4	9.3	9.1	10.0	9.1	10.2
Mean weight (g)	113	89	89	86	86	91	85	124	129	134	101
Standard deviation	188	129	97	114	103	190	158	209	230	215	167

Values presented in this table are percents, unless otherwise indicated. The values in the category "Dorsal face evaluation" are not mutually exclusive (i.e., an item may belong to more than one category). For some variables, the values "not applicable" and "indeterminate" have been omitted from the data presentation; thus, some columns may total less than 100 percent. Letters in parentheses identify variable recodes (see Phagan and Hruby 1984).

Table 11.2 – Nonflaked lithic tool variables, by period and site size

	Period 1	Period 2		Period 3		Period 4			Period 5		Period 6
	Small sites (N=343) %	Small sites (N=929) %	Medium sites (N=46) %	Small sites (N=627) %	Medium sites (N=136) %	Small sites (N=139) %	Medium sites (N=140) %	Large sites (N=537) %	Small sites (N=260) %	Large sites (N=2065) %	Medium sites (N=964) %
Morpho-use (*A*)											
Hammerstone	15	25	9	16	15	17	5	12	10	18	21
One-hand mano	4	8		2	7	2	1	2	6	3	3
Two-hand mano	12	11	7	15	10	8	19	26	26	23	25
Trough metate	13	7		8	10	9	13	11	12	12	10
Hafted tool	2	3	7	5	2	4	6	4	4	6	4
Ornament	2	1	7	2	2	1	1	2	<1	2	2
Production evaluation											
Unmodified	53	59	67	53	46	63	40	42	35	45	45
Minimally modified	13	22	13	19	13	12	14	18	17	16	13
Well shaped	18	8	7	17	16	12	23	28	34	27	31
Stylized	1	<1	4	1	2	1		2		2	1
Morpho-use (*D*) diversity											
Shannon-Wiener index	0.95	0.92	0.75	0.98	0.88	0.89	0.90	0.95	0.95	0.97	0.90
Equitability index	0.80	0.78	0.79	0.84	0.75	0.83	0.81	0.81	0.81	0.82	0.76
One-hand mano/two-hand mano ratio	0.37	0.75		0.14	0.64	0.27	0.07	0.09	0.22	0.11	0.12
Two-hand mano/trough metate ratio	0.91	1.48		1.84	1.08	0.92	1.50	2.38	2.19	1.93	2.38
Two-hand mano and trough metate/NFLT ratio	0.25	0.18		0.23	0.20	0.17	0.32	0.36	0.38	0.35	0.35
FLT/NFLT ratio	2.0	1.7	2.2	2.4	1.7	4.5	2.5	1.4	1.1	1.2	1.5

Values presented in this table are percents unless otherwise indicated. Some variables (e.g., "indeterminate") have been omitted from the data presentation; thus, some columns total less than 100 percent. Letters in parentheses identify variable recodes (see Phagan and Hruby 1984).
NFLT – Nonflaked lithic tool.
FLT – Flaked lithic tool.

Table 11.3 – Flaked lithic debitage variables, by period and site size

	Period 1	Period 2		Period 3		Period 4			Period 5		Period 6
	Small sites (N=5446) %	Small sites (N=17 410) %	Medium sites (N=852) %	Small sites (N=11 278) %	Medium sites (N=1820) %	Small sites (N=4591) %	Medium sites (N=3505) %	Large sites (N=6193) %	Small sites (N=3448) %	Large sites (N=17 598) %	Medium sites (N=10 572) %
Flakes/flake frags:											
Grain size											
Fine	22	18	37	14	45	29	29	33	30	36	40
Very fine	56	45	50	47	43	52	37	49	45	46	26
Microscopic	19	35	13	37	10	14	32	15	21	17	32
Nonlocal items	0.50	0.50	0.35	0.16	0.16	0.24	0.26	0.32	0.26	0.58	1.48
Items with cortex	26	19	24	31	27	30	34	29	35	32	31
Mean weight (g)	8.8	6.6	3.4	7.6	8.3	7.9	5.5	6.1	6.8	7.5	7.1
FLD/FLT ratio	7.8	11.2	8.4	7.4	7.9	7.3	10.1	8.1	12.1	7.3	7.3

Values presented in this table are percents unless otherwise indicated. Some variable values (e.g., medium grain size) have been omitted from the data presentation; thus, the grain size columns do not total 100 percent.

frags – Fragments.
FLD – Flaked lithic debitage.
FLT – Flaked lithic tool.

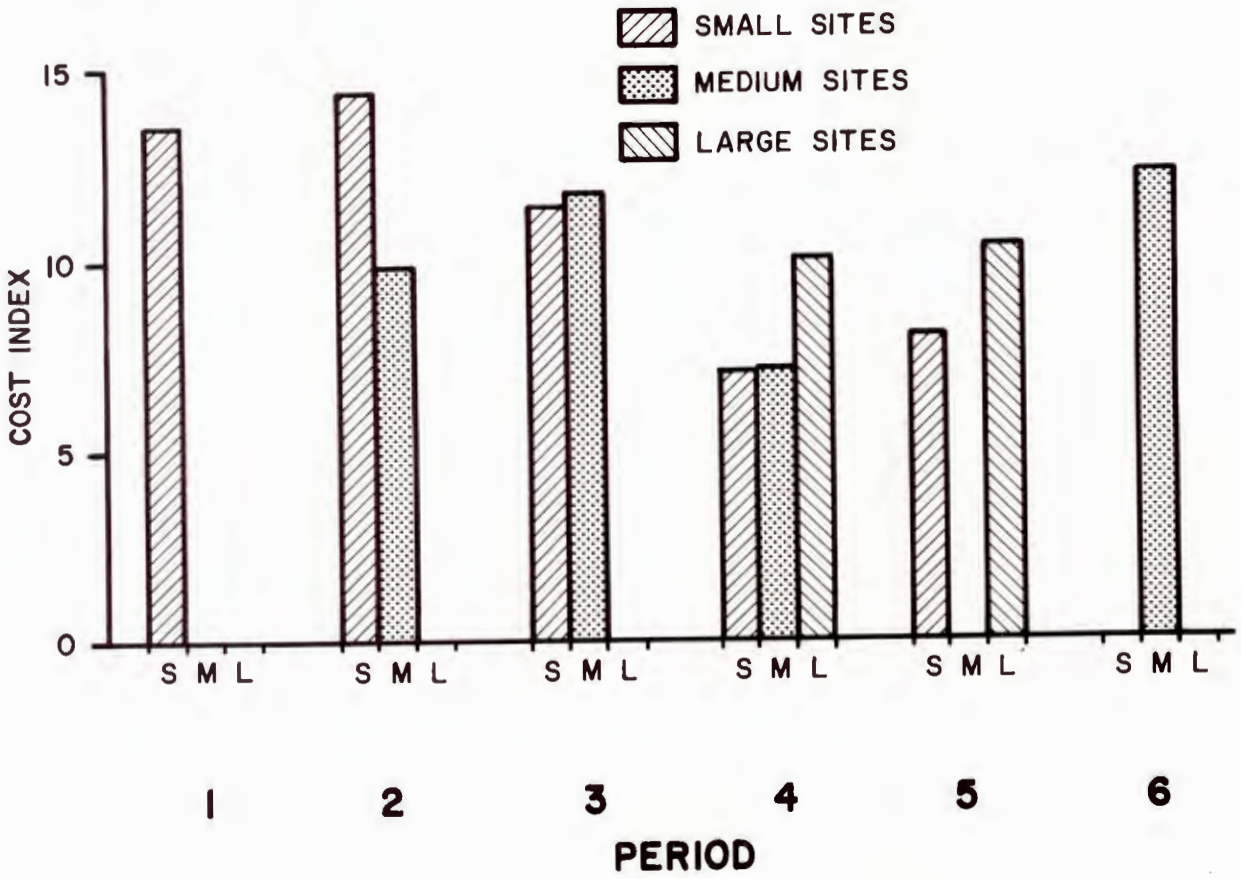

Figure 11.11 – Flaked lithic tool (FLT) acquisition cost for site size groups.

development of large villages rather than with any status differentiation. There is no suggestion of status differentiation prior to Period 4.

Figure 11.12 presents the combined proportion of well-shaped and stylized nonflaked lithic tools in site-size assemblages (see Phagan and Hruby [1984] for definitions of these technological categories). No production-input differentiation is indicated for Period 3. Production input increases significantly with site-size increase during Period 4, but during Period 5 this trend is reversed. The Period 4 pattern could be related, of course, to functional subsistence variability as easily as to status differentiation. The occurrence of high-production-input items during Period 4 rather than Period 3 tends to support the economic model rather than the social model. The proportions of well-shaped and stylized items in the flaked lithic tool assemblages (table 11.1) demonstrate no clear indication of increased production input at larger sites in any period.

The preceding suggests rather clearly that little lithic data supports the development of important status differentiation among site-size categories, particularly as early as Period 3 (i.e., prior to A.D. 840). Differences appear to be at least as explainable in an economic context as in a social development context, and not particularly high in cost. If status differences occur, they are not apparent in these lithic data structured by site size within each temporal period. A second independent data structuring mechanism used to examine the possible development of status differentiation has been developed by Kane (chap. 14) using a hierarchy of architecturally defined units within larger habitations from Periods 4 and 5. This is synchronic rather than diachronic and simply responds to the question, "Is status differentiation apparent in the hierarchy of architectural complexity by the period A.D. 840-920?" If so, it should be evident to greater degree in the more complex architectural units. Four increasingly complex groupings of architectural units, labeled I through IV, were used to structure flaked lithic tools, nonflaked lithic tools, and flaked lithic debitage; these data are presented in tables 11.4, 11.5, and 11.6, respectively. (Refer to chap. 14 for definition and justification of these data groups).

Figure 11.13 presents the ratio of flaked to nonflaked lithic tools for the 4 architectural groups, and flaked lithic tools from the simplest group (I) are considerably more numerous, perhaps indicating a relatively reduced attention to plant processing. In figure 11.14, the proportion of nonflaked lithic tool types in the architectural complexity groupings indicates considerable between-group variability, most of which is likely to be associated with functional rather than status differentiation. However, in the most complex group (IV), ornaments comprise 4 percent of the assemblage, whereas in groups I, II, and III, ornaments make up only 1 percent. This is tentative indication of slightly higher group IV status.

Figure 11.15, which illustrates the ratios of one-hand manos to two-hand manos, indicates a functional distinction between group I and the 3 more complex groupings. Whether this may also be associated with some status differentiation is conjectural.

Figure 11.16 presents the distribution of flaked lithic tool morpho-use type and the proportion of nonlocal raw materials. There is no suggestion of status differentiation; of particular note is the lack of increase in nonlocal items. The acquisition cost of the flaked tool assemblages is given in figure 11.17, and shows a slight increase for groups III and IV. This could indicate either a slight status increase or it could be related to a number of possible functional distinctions.

The combined proportion of well-shaped and stylized tools from flaked and nonflaked lithic tool assemblages is presented in figure 11.18. The nonflaked lithic tool assemblage displays a marked increase in production input that, in addition to functional implications, may suggest some status increase with increasing architectural complexity. Diversity measures for both flaked and nonflaked tool assemblages are presented in figure 11.19. The only significant variation is a reduced flaked tool diversity in group I, suggesting an assemblage dominated more by a few flaked tool types. Table 11.14 data clearly indicate this to be domination of the assemblage by utilized flakes, which is clearly related to functional variability, but may also have indirect implications for status differentiation.

The arrangement of lithic data in these synchronic architectural complexity categories provides little indication of important status differentiation among categories, and therefore fails to provide support for the social model of culture change in the Dolores Anasazi situation. However, this may be due largely to the likelihood the lithic variables considered are simply more suitable for assessing economic (i.e., functional and technological) factors rather than social factors.

Two DAP studies are useful in recognizing differentiations among Anasazi household and interhousehold clusters. A techno-functional analysis of reductively produced tools (stone and bone) from household and interhousehold clusters (Hruby 1985) demonstrates a high degree of homogeneity among household toolkits from Periods 1 and 2. This household toolkit standardization decreases considerably during Periods 3 and 4, as indicated by a reduced number of significantly correlated tool pairs (Hruby 1985), and this may indicate some degree of household specialization or dif-

ferentiation within interhouseholds. Toolkits from the larger interhousehold clusters of Periods 3 and 4 exhibit roughly the same kind and degree of standardization observed in toolkits from the earlier, smaller household clusters. This is perhaps best viewed as a shift in the basic Anasazi economic unit from the smaller household to the larger interhousehold at around A.D. 800. This shift clearly has implications for an economic model of culture change, but its initiation during a period of relatively low economic stress (Period 3) also suggests some support for the sociopolitical model.

A microwear analysis of flaked lithic tools from many of the same household and interhousehold clusters (Neusius 1985) indicates all of these assemblages are quite similar with respect to the kinds and relative proportions of edges produced. Within these rather homogeneous sets of edges, however, major use-wear variability is quite apparent, and it seems clearly associated with a functional distinction, especially between habitations and field houses, as well as between household and interhousehold clusters. Also, indications of increased use-wear differentiation appear between interhousehold clusters assigned to Period 4, suggesting the greater horizontal (functional) differentiation predicted by the economic model of culture change.

SUMMARY

Indications of technological change in Dolores Anasazi lithic assemblages tend to support the economic model, in which cultural changes occur as responses to economic stress accompanying population growth and/or climatic deterioration in the immediate area. However, some indications from these assemblages show that some technological change may occur during periods of little economic stress, suggesting that not all change is economically induced, or at least that some change may be associated with the development of social hierarchies.

Insofar as lithic artifact variability is a reliable indicator of ranked status and relative cost, there is good indication that Dolores Anasazi social and economic differentiation is a relatively low-cost phenomenon, with little indication of within- or between-group status rankings. Differentiation appears to be primarily horizontal in nature, cooperative rather than competitive, and related functionally to subsistence behavior. Evidence for diversification of plant resources other than corn is mixed and rather weak, but it is perhaps best understood in an economic least cost context. Lithic artifact variability associated with changes in agricultural intensification provides rather convincing support for the economic model.

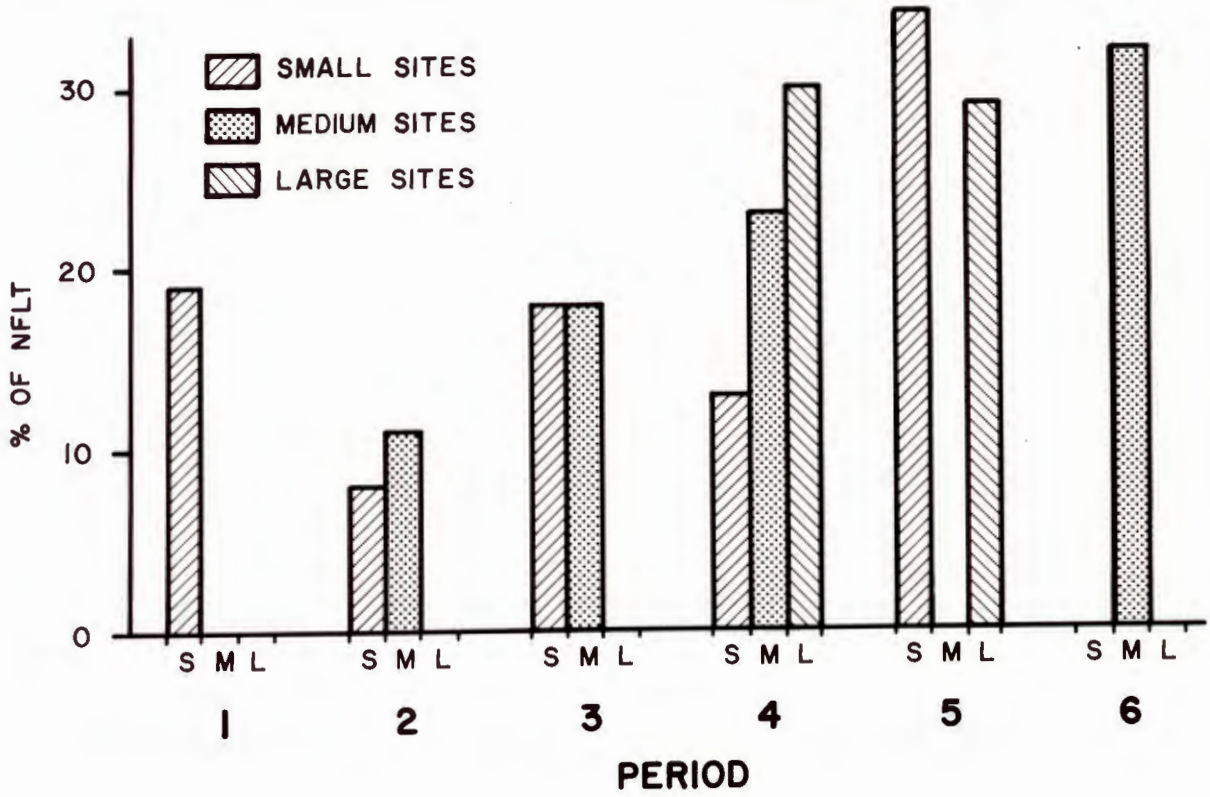

Figure 11.12 – Proportions of well-shaped and stylized nonflaked lithic tools (NFLT) for site size groups.

Table 11.4 – Flaked lithic tool variables, by architectural complexity group, Periods 4 and 5

	Group I N = 1003 %	Group II N = 1641 %	Group III N = 691 %	Group IV N = 504 %
Morpho-use (*A*)				
Utilized flake	53	31	40	32
Core	8	11	9	2
Used core, cobble tool	12	18	16	23
Thick uniface	9	12	10	11
Thin uniface	3	4	3	2
Specialized form	1	2	3	2
Thick biface	5	11	9	14
Thin biface	4	3	3	2
Projectile point	3	5	5	5
Raw material identification (*B*)				
Nonlocal	4	3	5	5
Morrison quartzite	27	24	31	27
Morrison chert	2	3	5	3
Burro Canyon quartzite	11	8	8	5
Burro Canyon chert	23	14	12	11
Local cobbles, hornfels	14	33	26	36
Local, unspecified	17	13	12	14
Dorsal face evaluation				
Items with cortex	40	46	35	55
Unworked	67	56	57	62
Edged	9	12	14	10
Primarily thinned	2	2	2	1
Secondarily thinned	1	2	3	3
Well shaped	2	3	3	3
Stylized	<1	<1	<1	1
Morpho-use (*D*) diversity				
Shannon-Wiener index	0.73	0.90	0.87	0.87
Equitability index	0.59	0.73	0.71	0.74
Raw material diversity				
Shannon-Wiener index	0.79	0.76	0.76	0.72
Equitability index	0.87	0.84	0.84	0.80
Acquisition cost index	9.0	8.2	10.9	10.7
Production cost index	8.4	8.9	9.2	9.2
Mean weight (g)	113	130	119	162
Standard deviation	258	206	204	240

Values presented in this table are percents unless otherwise indicated. The values in the category "Dorsal face evaluation" are not mutually exclusive (i.e., an item may belong to more than one category). For some variables, the values "not applicable" and "indeterminate" have been omitted from the data presentation; thus, some columns may total less than 100 percent. Letters in parentheses identify variable recodes (Phagan and Hruby [1984]).

Table 11.5 – Nonflaked lithic tool variables, by architectural complexity group, Periods 4 and 5

	Group I N = 281 %	Group II N = 1219 %	Group III N = 560 %	Group IV N = 503 %
Morpho-use (*A*)				
Hammerstone	14	16	15	15
One-hand mano	1	3	3	3
Two-hand mano	13	22	20	23
Trough metate	14	11	11	14
Hafted tool	6	7	7	3
Ornament	1	1	1	4
Production evaluation				
Unmodified	46	44	43	46
Minimally modified	20	16	16	12
Well shaped	21	27	30	32
Stylized	1	1	1	4
Morpho-use (*D*) diversity				
Shannon-Wiener index	0.99	0.97	0.99	0.95
Equitability index	0.84	0.82	0.84	0.83
One-hand/two-hand mano ratio	0.08	0.13	0.15	0.13
Two-hand mano/trough metate ratio	0.97	2.05	1.84	1.72
Two-hand mano and trough metate/NFLT ratio	0.27	0.33	0.31	0.37
FLT/NFLT ratio	3.6	1.3	1.2	1.0

Values presented in this table are percents unless otherwise indicated. Some variable values (e.g., "indeterminate") have been omitted from the data presentation; thus, some columns total less than 100 percent. Letters in parentheses identify variable recodes (Phagan and Hruby [1984]).
NFLT – Nonflaked lithic tool.
FLT – Flaked lithic tool.

Table 11.6 – Flaked lithic debitage variables, by architectural complexity group, Periods 4 and 5

	Group I N = 6166 %	Group II N = 12 439 %	Group III N = 5022 %	Group IV N = 2806 %
Flakes/flake frags:				
Grain size				
Fine	20	35	28	39
Very fine	53	42	56	37
Microscopic	24	23	14	22
Nonlocal items	0.28	0.28	0.70	0.96
Items with cortex	30	37	28	31
Mean weight (g)	7.7	8.0	8.0	6.3
FLD/FLT ratio	6.1	7.6	7.3	5.6

Values presented in this table are percents unless otherwise indicated. Some variable values (e.g., medium grain size) have been omitted from the data presentation; thus, the grain size columns do not total 100 percent.
frags – Fragments.
FLD – Flaked lithic debitage.
FLT – Flaked lithic tool.

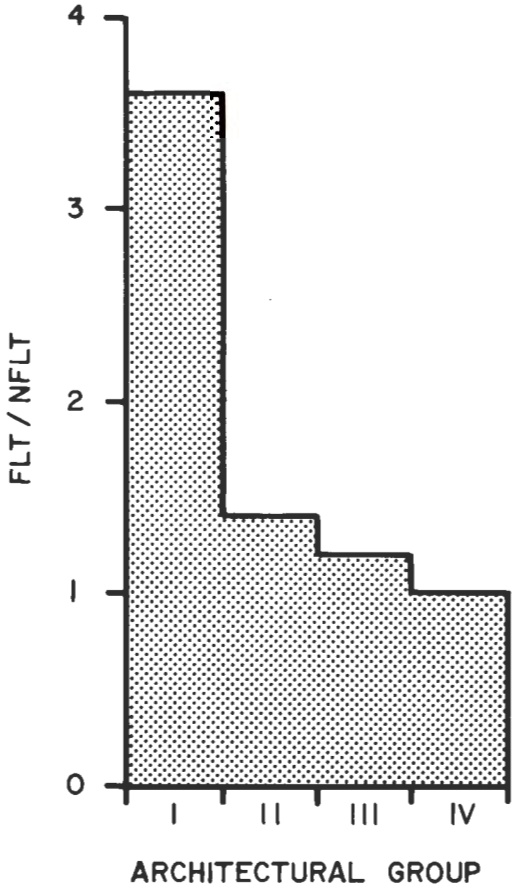

Figure 11.13 – Flaked lithic tool/nonflaked lithic tool (FLT/NFLT) ratio for Period 4 and 5 architectural groups.

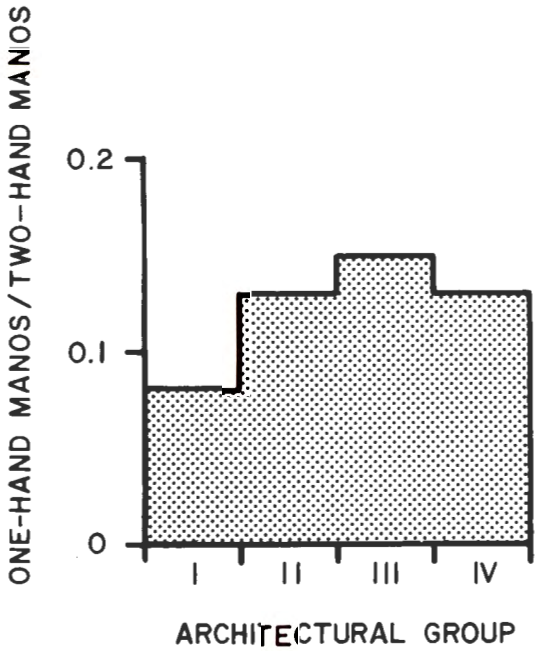

Figure 11.15 – One-hand mano/two-hand mano ratio for Period 4 and 5 architectural groups.

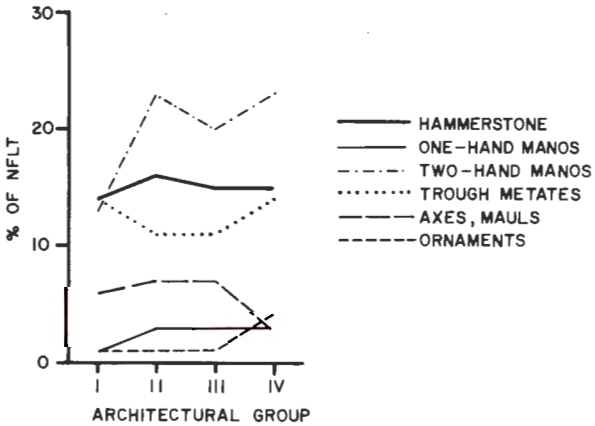

Figure 11.14 – Proportions of nonflaked lithic tool (NFLT) morpho-use types for Period 4 and 5 architectural groups.

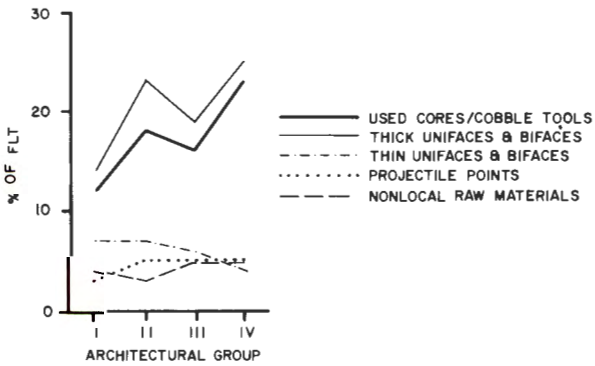

Figure 11.16 – Proportions of flaked lithic tool (FLT) morpho-use types and nonlocal raw materials for Period 4 and 5 architectural groups.

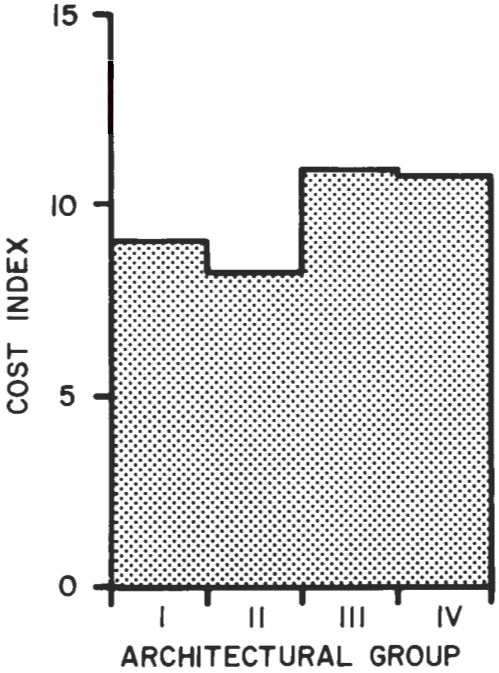

Figure 11.17 – Flaked lithic tool acquisition cost for Period 4 and 5 architectural groups.

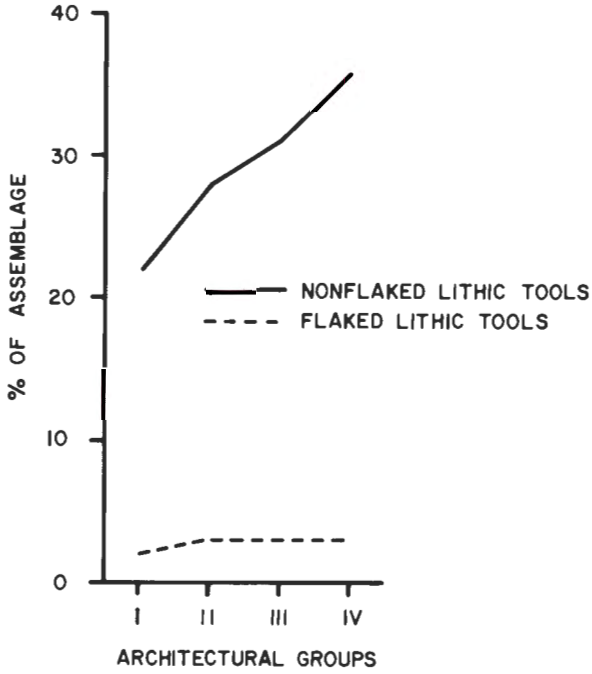

Figure 11.18 – Proportions of well-shaped and stylized tools for Period 4 and 5 architectural groups.

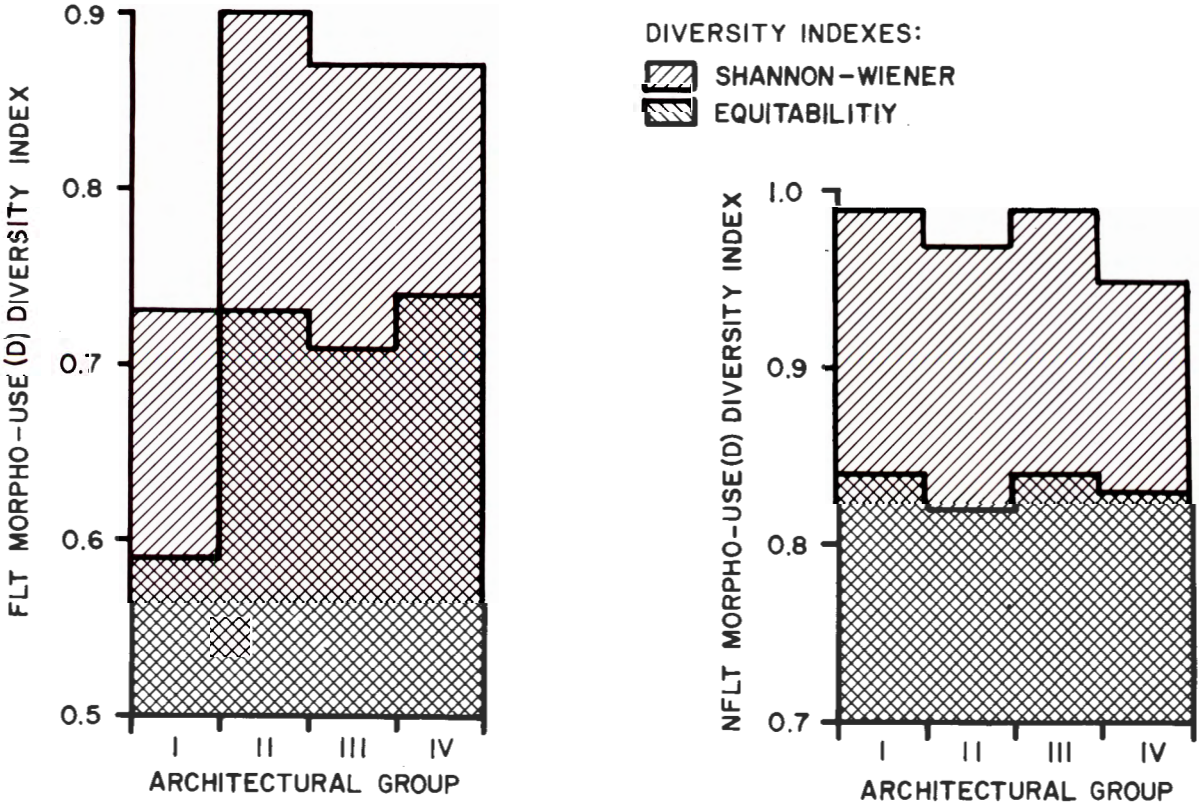

Figure 11.19 – Morpho-use (*D*) diversity index measures for flaked (FLT) and nonflaked (NFLT) lithic tools, Period 4 and 5 architectural groups.

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† This report has been published in the volume entitled *Dolores Archaeological Program: Synthetic Report 1978-1981*, Bureau of Reclamation, Engineering and Research Center, Denver, June 1984.

Chapter 12

TECHNOLOGY: CERAMIC CONTAINERS

Eric Blinman

Portable containers comprise diverse category of Dolores Anasazi material culture, including baskets, bags, and pottery vessels. These containers serve functions of storage, transportation, and various aspects of manipulation, the latter dominated by food preparation. Containers are generally assembled in their construction, with a correspondingly greater control of form than is true of other types of tools (e.g., flaked stone tools). Container attributes such as shape and volumes can be interpreted directly as designed features reflecting intended functions (Smith and Hargrave 1984). Functional inferences from container and container assemblage data can then be used in the evaluation of change in technology and in broader aspects of economic and social organization.

The archaeological perception of containers in the Dolores area collections is practically limited to the ceramic data set. Baskets and textile containers have been recovered as charred, or rarely uncharred, fragments from some Dolores area sites, but basketry assemblages are at best partial due to generally poor preservation (chap. 2). This incomplete representation, coupled with their scarcity, precludes detailed evaluations of variability in space or time. Hide containers may have existed, based on their presence in other areas of the Southwest and on the recovery from DAP sites of awls not appropriate for basketry construction, but no specimens of hide have been recovered. Containers of wood or stone are also absent from the archaeological material inventory, and these absences effectively limit archaeological studies to pottery vessels.

Although representing a single material subset of the portable container class, ceramic materials provide a strong data set for interpretations. Potsherds are the single most abundant archaeological material class in Dolores area sites, and their abundance increases the ability to evaluate the significance of systemic as opposed to sampling-error sources for observed variation. Ceramic vessels also play diverse functional roles in subsistence systems, allowing comparisons between roles while avoiding potential variation associated with crossing boundaries of material classes (e.g., archaeological recovery bias). However, some limitations are present due to the probable existence of functions not represented in ceramic containers (e.g., long distance transport or winnowing) and, therefore, cannot be addressed in DAP studies of technological change.

Close ties are assumed to exist between technology and subsistence behavior (chap. 6). Change within the Dolores area cultural system that affects subsistence behavior is expected to affect containers, and innovation within technology (new techniques, tools, or containers) should in turn influence other aspects of the cultural system. The basic principles of container technology (types of containers [Blinman 1985]) appear to be relatively stable through the A.D. 600-980 period in the Dolores area, and change in containers is not expected to be a significant independent variable engendering change in other aspects of the cultural system. Thus, change in containers is treated as a dependent variable, responsive to, rather than determinate of, change in the Dolores cultural system.

Possible motivations for broader systemic change in the Dolores area include economic (least cost) decision structures and social forces associated with the development of leadership hierarchies (Earle 1980; Lightfoot 1984; Lipe, chap. 6). Both motivational constructs are assumed to affect containers through changes in the content and organization of the subsistence system. Content changes are subsumed under the concept of intensification, which is used in the sense of increase in labor or in energy expenditure to achieve a given level of per capita resource output. Within the content of limited nonagricultural subsistence resources of the Dolores area, the practical expression of intensification is increased reliance on agricultural products in the diet. Organizational changes include both changes in the organization of production and changes in the patterns of consumption.

MEASURES OF SUBSISTENCE INTENSIFICATION

Several of the observed changes in ceramic vessel forms can be related to changes in the level of reliance on

cultigens in the subsistence mix within the Dolores Project area. Some of these changes are detectable in the types and sizes of particular vessel forms, some are present as ratios of sherds assignable to form classes, and some are detectable as changes in relationship between ceramic materials and other artifact classes.

Comestible Storage in Containers

Vessels designed for the storage of dry and perishable materials are labeled as seed jars in DAP collections (Blinman 1985). These vessels are associated with the long term storage of seeds (especially cultigens), and often have holes or lugs in the vicinity of the rim to facilitate secure closure. This form is present in both gray and decorated wares throughout the A.D. 600-980 period, and reconstructible examples in DAP collections range in volume from less than 250 mL to more than 7500 mL. Small seed jars are assumed to have been used to store small quantities of valuable perishable materials (ranging from feathers to seed corn), and only large seed jars (greater than 4 L in volume) are likely to have functioned as storage facilities for quantities of comestibles.

These large seed jars are numerically scarce relative to other size classes, they are confined to the gray ware category, and reconstructible vessels of this size only occur in pre-A.D. 840 contexts. Since inferences based on observed variability within the reconstructible vessel data set are limited by the small number of vessels and the high probability of sampling error, the relative frequencies of gray ware vessel forms in well-dated, screened refuse sherd collections were examined. Screened refuse collections were chosen for the comparison because they are less likely to reflect high variance due to the occasional inclusion of reconstructible vessels. Rim sherds of gray ware seed jars are reliably distinguishable from rim sherds of other gray ware jar forms (predominantly cooking jars, but also including some ollas), and similar numbers of rim sherds are produced upon the breakage of seed jars and cooking jars. Thus, a ratio of seed jar sherds to other gray ware jar sherds (cooking jar sherds) in refuse should provide a comparison of the changing relative importance of ceramic storage of comestibles through time.

Ratios of seed jar sherds to cooking jar sherds through the A.D. 600-980 period are presented in figure 12.1. For Period 1 refuse, approximately 1.0 seed jar sherd is found for every 1.7 cooking jar sherds. This ratio declines dramatically after A.D. 720 to 1 seed jar sherd for 83 or more cooking jar sherds. The sample size (total number of sherds in the dated refuse collections) for Period 1 is the smallest of those used in this comparison, and some of the discrepancy between the pre-A.D. 720 and post-A.D. 720 ratios could be due to sampling error. However, multiple vessels are represented in the early collections, and the number of seed jars sherds in the early collection (N = 15) is equal to the largest number of seed jar sherds in any of the other larger collections.

This changing ratio reflects the deletion of the large, gray ware seed jar from the Dolores area ceramic vessel assemblage after A.D. 720. Based on the assumed function of this size class of seed jars (storage of large quantities of comestibles), storage technology appears to have undergone a change at this time. The population density within the Dolores area increased dramatically from Period 1 to Period 2 (Schlanger 1985; chap. 8). Exploitive pressure on the availability of nonagricultural resources is assumed to have increased, resulting in an increased reliance on cultigens, and creating an increased demand for long term storage facilities. Such a demand could have been satisfied by an increase in the number and size of large seed jar vessels, but it appears to have been satisfied instead by a transition to architectural storage facilities (chap. 13) and a sharp decline in the use of ceramic vessels for comestible storage.

Temporal Changes in Diet and Food Preparation

A correlate of the predicted changes in reliance on agriculture through the occupation of the Dolores area is a change in the proportion of meat in the diet. Food boiling in ceramic vessels encompasses much of the preparation of both meat and cultigens, and the rate of breakage and discard of cooking jars can be used as an index of food preparation activity. This index itself may be subject to change as dietary composition changes due to a potentially greater use of boiling (as opposed to roasting or baking) in conjunction with cultigen preparation. Although possibly invalidating the use of cooking jar sherds as a constant index of food preparation, the direction of such a bias within the index would tend to improve the utility of the contrast between cooking jar sherds and animal bones as an index of the reliance on cultigens.

The ratios of nonhuman bone to cooking jar sherds for well-dated, screened refuse collections are presented in figure 12.2. Refuse collections were chosen because they should minimize variance within the ceramic materials that can result from the recovery of reconstructible vessels (often encountered in structure surface proveniences), and because the vessel form proportions in refuse are more likely to approximate the intensity of vessel use than are the proportions in structure surface assemblages, which are more likely to reflect momentary vessel inventories. Screened proveniences were chosen to reduce the possibility that recovery bias would under-represent either nonhuman bones or

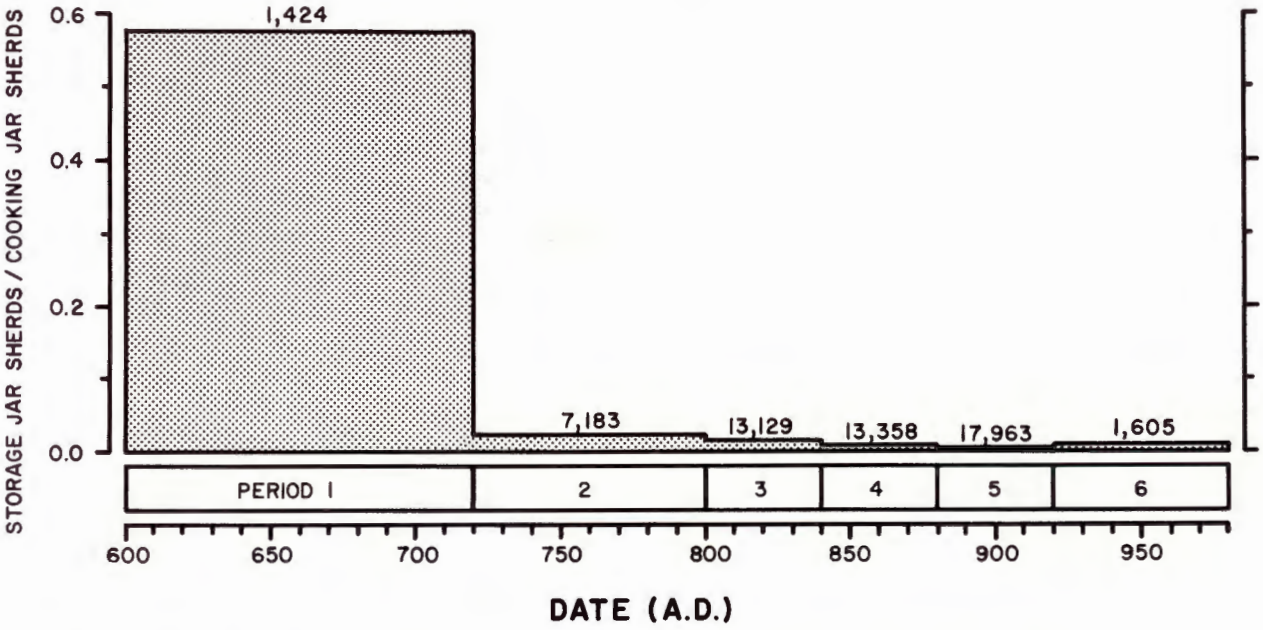

Figure 12.1 – Ratios of gray ware storage jar sherds to gray ware cooking jar sherds in screened refuse collections. Numbers above the graph represent the total collection sizes (all forms and all wares) that are the basis for the ratio calculations.

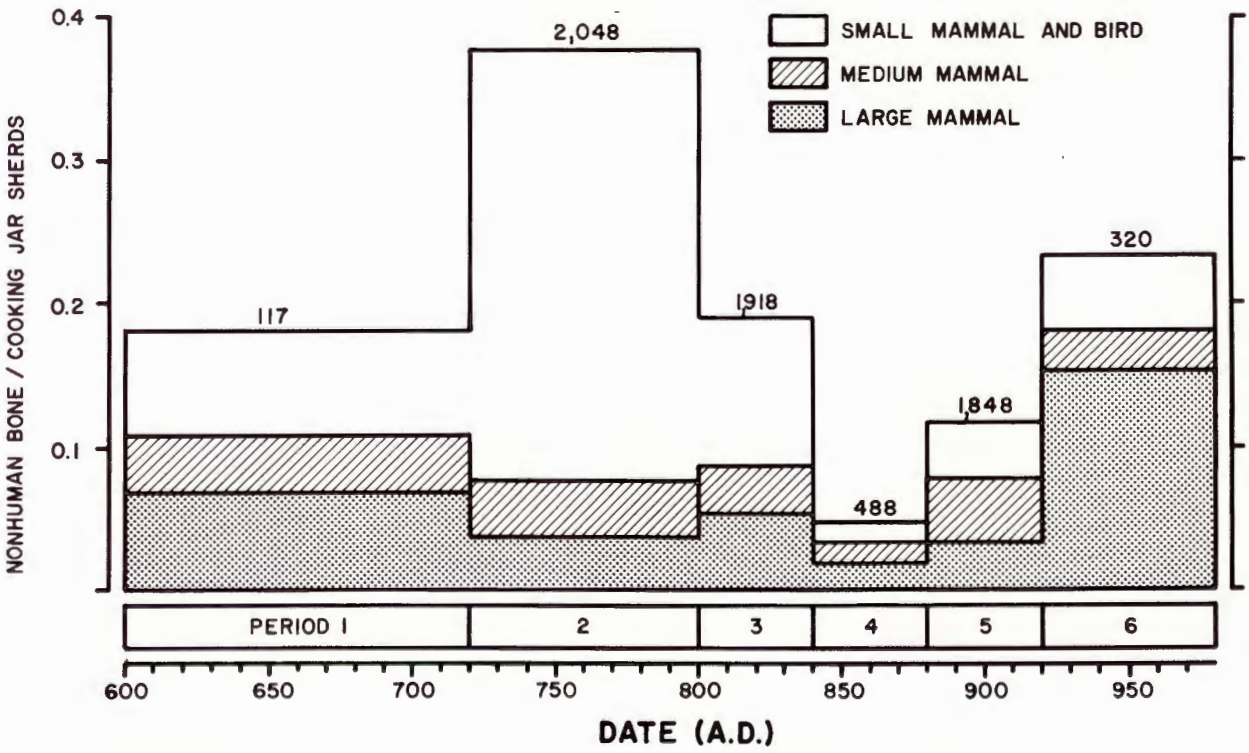

Figure 12.2 – Ratios of bones (number of individual specimens) to gray ware cooking jar sherds in screened refuse collections. Numbers above the graph represent the numbers of bones recovered and provide an indication of the stability of the individual ratios. Subdivisions of the graph reflect the relative contributions of small mammal (and bird), medium mammal, and large mammal taxa to the total bone category.

sherds relative to each other. Numbers of bones or bone fragments, rather than minimum numbers of individuals or estimates of edible meat weight, are used in ratio calculation, and thus the ratio cannot be interpreted directly as representing the meat contribution to the diet. To mediate this limitation, the relative contributions of animal size classes to the bone/cooking jar sherd ratios are shown in the histogram (fig. 12.2). The numbers of bones in the Period 1, 4, and 6 collections are small, and although the ratios of bones to sherds are likely to be relatively stable, the proportionate contributions of the 3 animal size classes may be unstable.

The highest bone/sherd ratio occurs in the Period 2 collection, due in part to an extremely large contribution of small mammal bone. The ratio declines for Periods 3 and 4 and then increases for Periods 5 and 6, with more even representations of the 3 animal size classes (large mammals are proportionately most abundant in the small Period 6 collection). The changes in the ratio after Period 2 are inverse to the observed changes in the human population in the Dolores area, with the smallest ratio corresponding to the greatest human population. Since the ratio is based on bones rather than meat, and much of the meat consumed is likely to have been concentrated within the large mammal category, it is important that the large mammal bone/sherd ratio also roughly parallels the inverse of the human population curve (with the exception of Period 2).

These trends are consistent with the interpretation that dietary change accompanied human population increase within the Dolores area. Using cooking jar sherds as a stable proxy for total food consumption, the changes in the meat protein contribution to the diet are dramatic and are presumably replaced by cultigens. If boiling and soaking activities are positively correlated with cultigen preparation, then the index of food preparation is biased, and the observed changes in the bone/sherd ratio support the increase in reliance on cultigens but overestimate the relative decrease in meat consumption.

Another potential index of food consumption is the ratio between cooking jar sherds and bowl sherds. This ratio is a weaker index of food consumption than the ratio between bones and cooking jar sherds for 2 major reasons. Ritual activities (hosting of gatherings or potlucks) appear to influence sherd collections by inflating the numbers of bowl sherds spatially associated with collections from ritual activity loci (chap. 15). This source of variation appears to be restricted to larger sites and to specific roomblocks within sites that have architectural evidence of ritual complexity, and the effect of this variation would be to decrease the observed ratio of cooking jar to bowl sherds. The second constraint associated with this index is that its use requires the assumption that cooking jar use is positively related to cultigen preparation. This assumption receives circumstantial support from a lack of evidence for baking, roasting, or frying corn products, but the negative evidence for alternatives to boiling is a weak basis for accepting the assumption due to the limited preservation of perishable food materials in Dolores area sites.

However, since vessel breakage is assumed to be proportional to vessel use, and since food consumption (bowl breakage) is likely to be relatively constant per person or per household regardless of material consumed, then a changing cooking jar to bowl sherd ratio should indicate a change in the emphasis on boiling as a preparation technique. In the presence of evidence that meat content in the diet was varying inversely with cooking jar sherd discard, it is reasonable to assume that cultigen preparation and consumption co-varies with cooking jar frequency and that a ratio of cooking jar to bowl sherds in refuse will reflect gross variation in cultigen contribution to the diet.

No increase is apparent across the Period 1-Period 2 boundary even though both a relatively large population increase and a change in the level of cultigen reliance occurs, as measured by the demand for storage facilities. The increase in the ratio during Period 5 suggests continued agricultural intensification as population falls. This is a surficial contradiction when population alone is used as a proxy for intensification, but the apparent increase in intensification of agriculture may be appropriate given the increased stress on the subsistence system expected for that time period, based on climatic fluctuations (Orcutt 1985a). The lack of significant decrease in Period 6 is also a contradiction, based on a dramatically reduced population within the Dolores area, but the collection size that represents Period 6 is small (see fig. 12.1 for collection sizes), and the observed ratio may be subject to sampling error.

Spatial Variation in Agricultural Intensification

If the bone/sherd and cooking jar/bowl ratios do reflect changing proportions of cultigens in the diet, then variation in the ratios from community cluster to community cluster within the project area may reflect variation in agricultural intensification. Evaluation of community cluster catchments within the Dolores area indicates considerable range in the quality of adjacent land for agricultural purposes (Orcutt 1985a). This variation is reflected in the very different costs of practicing agriculture between the varying community clusters (chap. 9), and, given marginal cost theory (Earle 1980), the consequence should be variation in the degree of reliance on agriculture.

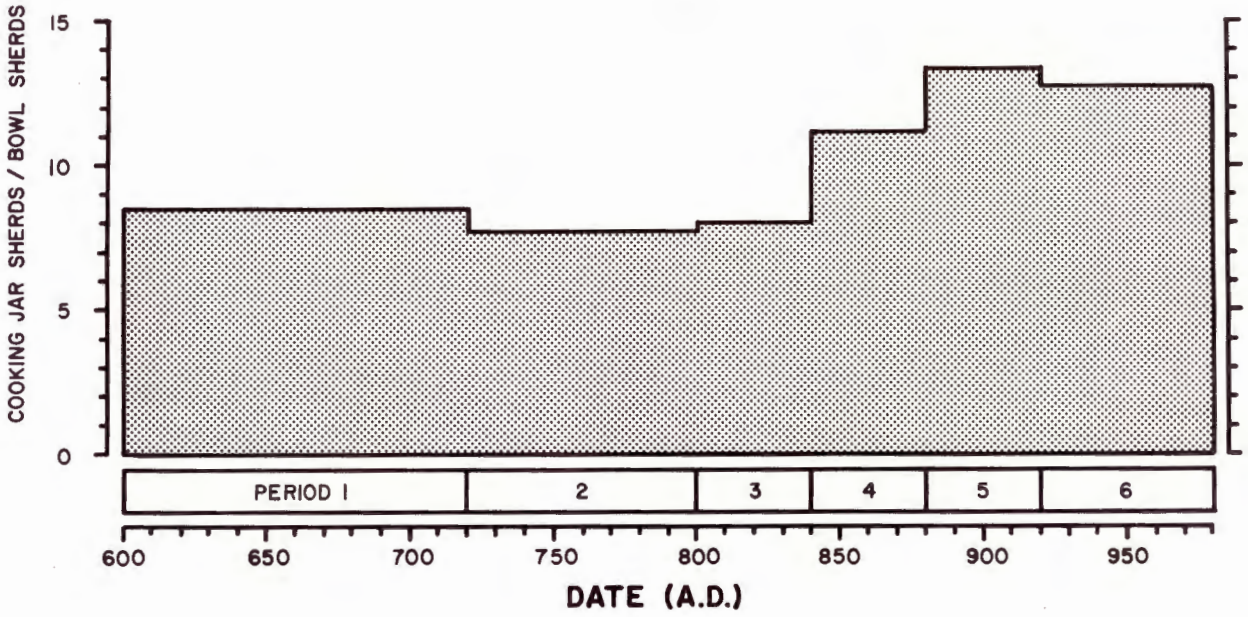

Figure 12.3 – Ratios of cooking jar sherds to bowl sherds in screened refuse collections. Collection sizes upon which the ratios are based are the same as those used in figure 12.1.

The relative agricultural quality of catchments for portions of the Dolores area have been calculated by Orcutt (1985a:57-58) based on soil quality, growing season length (edaphic effects of cold air drainage), and climatic fluctuations. Excavated collections of refuse are available from sites within 4 of these community clusters, but data have been lumped for 2 adjacent community clusters (Rio Vista Village, Site 5MT2182 [Wilshusen 1985], and House Creek Village, Site 5MT2320 [Robinson and Brisbin 1984]), and these data are used to represent the Middle Canyon portion of the project area. Orcutt's agricultural quality ranks are presented in figure 12.4 for Periods 3, 4, and 5. The slight changes in ranks between Periods 3 and 4 are due to catchment readjustments resulting from the large population growth and aggregation during Period 4, and the stronger changes after A.D. 880 are due to climatic fluctuations that reduce the length of the growing season in some portions of the Dolores area.

The ranks cannot be interpreted on an absolute scale, but they do provide a relative measure of changes in marginal costs associated with agriculture in the different catchments. In all cases, agricultural intensification should be more expensive in the vicinity of Grass Mesa Village than at the other community clusters. The McPhee Community Cluster is somewhat better situated for agricultural intensification than the Middle Canyon area until Period 5, when shortened growing seasons affect a greater proportion of the McPhee Community Cluster catchment. These ranks should be predictors of the relative values of bone/sherd and cooking jar/bowl ratios in the different portions of the Dolores Project area.

Bone/sherd ratios for the different portions of the Dolores area are presented in figure 12.5. The ratios are based on screened collections from well-dated refuse deposits. (The definition of refuse used here is slightly broader than that used in the discussion of temporal trends in the project area. This results in slightly larger sample sizes, and although magnitudes are comparable, direct comparisons between these ratios and those presented in figure 12.2 are not appropriate.) The direction of temporal variation in all of the ratios conforms to that seen for the project area as a whole (fig. 12.2) with the exception of the Period 2 collection from the vicinity of Grass Mesa Village. Investigation of this discrepancy indicates the Period 2 collection for the project area as a whole is dominated by a single collection with an unusually high concentration of small mammal remains, and the Grass Mesa Village collection is representative of the majority of the site collections from that time period.

In comparison with contemporary collections from the other portions of the Dolores area, collections from the vicinity of Grass Mesa Village contain consistently more nonhuman bone. In those cases for which Period 5 collections are available from both the Middle Canyon area and the McPhee Community Cluster, there is slightly less bone from the Middle Canyon. Period 6 refuse is only represented by collections from the

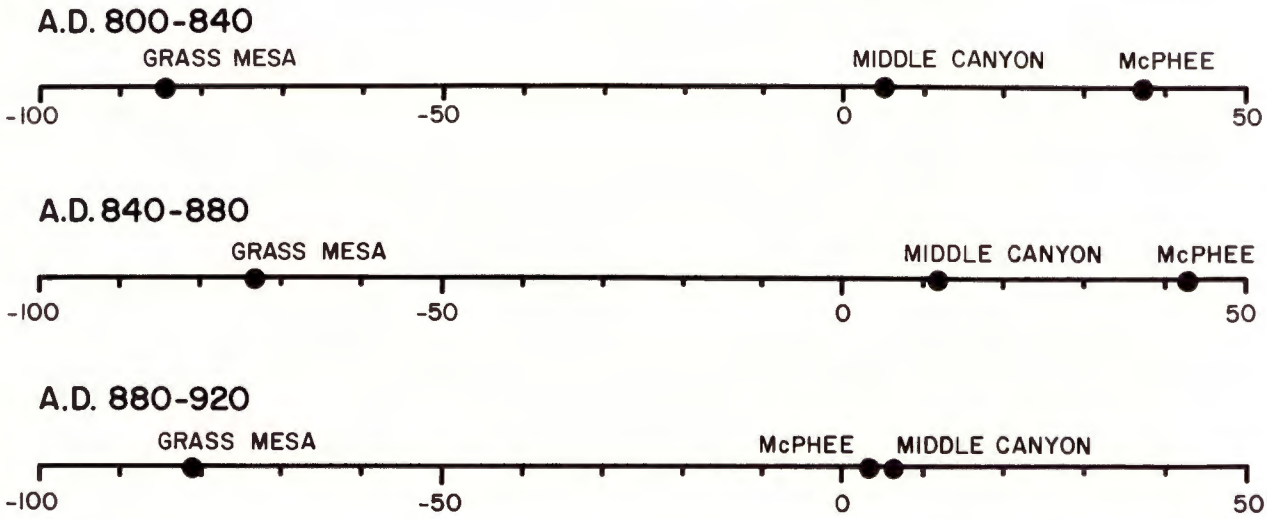

Figure 12.4 – Relative agricultural quality of three Dolores area community catchments (adapted from Orcutt 1985a:57-58). The larger values reflect better quality soils and lower risk due to cold air drainage than the smaller values. Values used for the Middle Canyon area are averages for the values calculated for Rio Vista Village and House Creek Village.

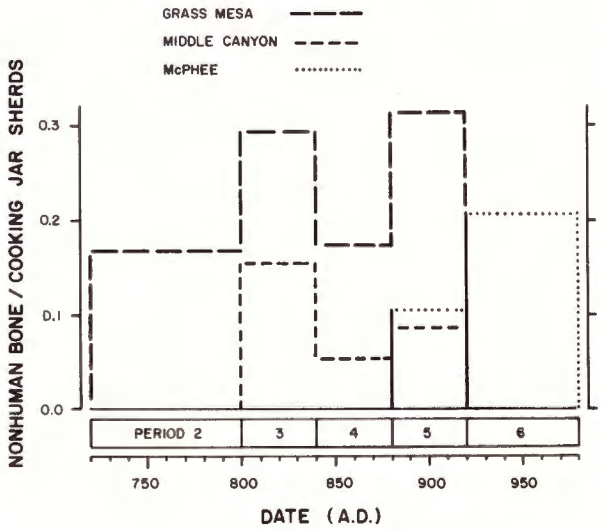

Figure 12.5 – Ratios of nonhuman bone to cooking jar sherds in screened refuse deposits from different portions of the Dolores area.

McPhee Community Cluster. Rankings based on decreasing ratio value conform well to the rankings based on increasing quality of the associated agricultural catchment. In addition, the closeness of Period 5 ratios for the Middle Canyon area and McPhee Community Cluster, as well as their distance from the Grass Mesa Village ratio, suggests a quantitative inverse relationship may exist between the agricultural quality measures and the observed reliance on game animals in the diet.

Cooking jar/bowl ratios for the different portions of the Dolores area should also reflect this variability in agricultural intensification; higher ratios should coincide with higher agricultural quality ranks. Figure 12.6 presents the cooking jar/bowl sherd ratios for screened refuse from the 3 community clusters. Screened refuse collections were not made for all time periods for all community clusters, and comparisons are limited as a result. However, collections from those contexts sampled are surprisingly large (ranging from 1597 to 7699 sherds with a mean of 5116 sherds), and all ratios except that for Period 6 are expected to be stable. The Grass Mesa Village ratio is consistently lower than those for the other community clusters. The Middle Canyon area ratio is higher than that for Grass Mesa Village in Periods 3 and 4, and the Middle Canyon ratio is greater than that for collections from the McPhee Community Cluster for Period 5. Period 6 collections are only available from the McPhee area.

The observed variation in the cooking jar/bowl ratios for the individual community clusters conforms to the ranking predicted by the relative agricultural quality of the community catchments. However, differences are not as strongly expressed as those evident in the sherd/bone ratios. This weaker expression may reflect the relatively greater "noise" inherent in the use of this measure due to potential ritual gathering biases.

ECONOMIC AND SOCIAL ORGANIZATION

Changes in economic and social organization affect both the production and the use of containers. Organization of the production of ceramic vessels is affected by resource availability, differential skill levels among artisans, and the relationship between social hierarchies

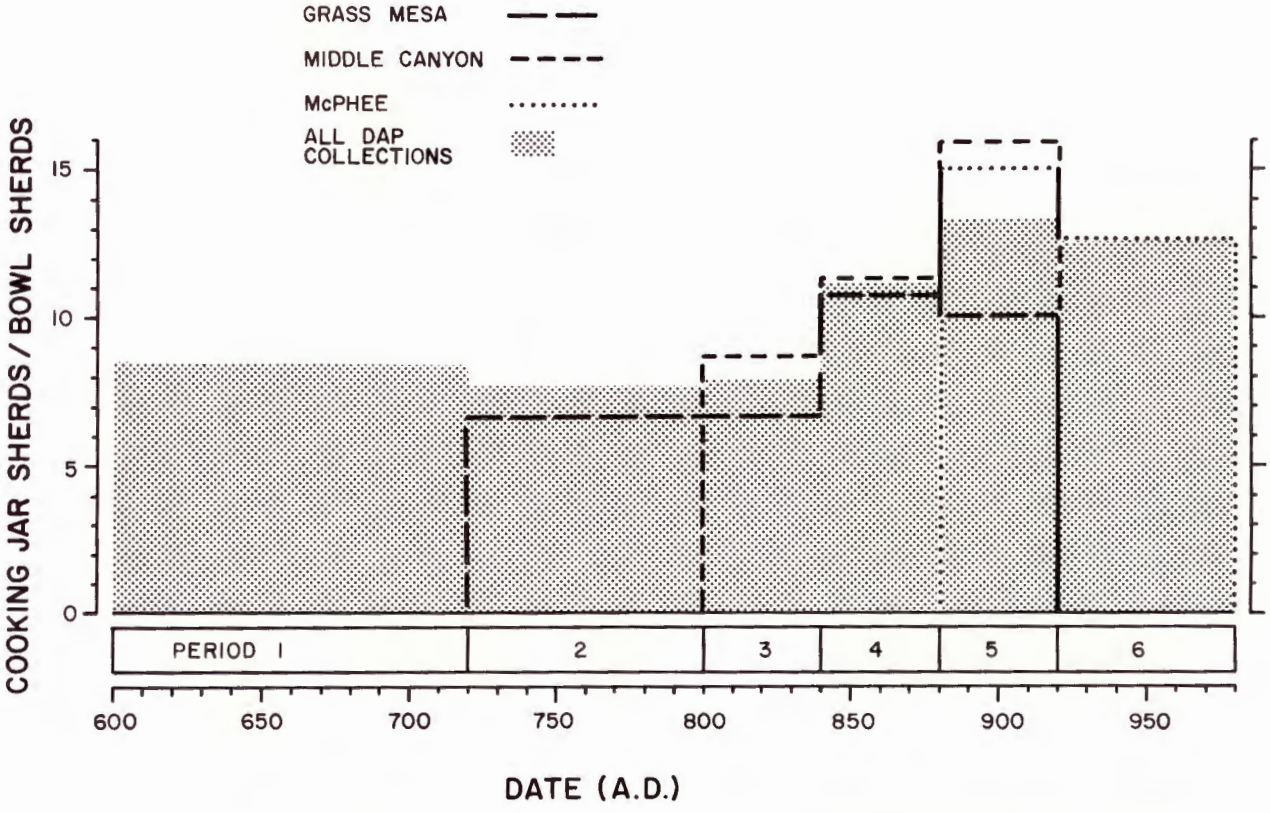

Figure 12.6 – Ratios of cooking jar sherds to bowl sherds in screened refuse collections from three of the community clusters or locations in the Dolores area. Appropriate collections are not available for all community clusters for all time periods. The shaded area represents the ratio for collections from the project area as a whole, and the coincidence with the McPhee Community Cluster collection for Period 6 is due to the lack of screened refuse collections from other portions of the Dolores area for that period.

and control of production and distribution. In turn, the organization of production affects some aspects of social interaction by establishing a need for commodity exchange and economic interdependence of social units. Use of containers is affected by the need to satisfy specific functional requirements within the tasks of food preparation and consumption. The strongest of the relationships linking use to social organization appears to be the size of the food consuming group.

Specialization in Ceramic Manufacture

Increasing economic differentiation is expected as a concommitant to increasing social complexity, and craft specialization is an aspect of economic differentiation. However, whereas specialization is expected within complex societies, specialization can also occur without significant political complexity. In terms of ceramic manufacture, specialization can occur as a regional emphasis on the manufacture of pottery or of certain pottery wares, as a part time specialization at the level of skilled individuals, as a full time occupation without other subsistence responsibilities, or as combinations of intermediate states of these conditions. These levels of specialization share the characteristic that ceramic production is unevenly distributed among the households of the population, but the levels of specialization vary in their implications for social complexity.

Changing levels of social complexity have been proposed for the Dolores area on the basis of site size hierarchies (chap. 10) and architectural complexity hierarchies (chap. 14). Simple decision making hierarchies are implied by a two-tiered, site size ranking as early as Period 2, with complex decision making hierarchies evidenced as part of the high population levels in Periods 4 and 5. The complex decision making hierarchies of Periods 4 and 5 coincide with intrasite architectural complexity in some members of the largest site-size tier. These increasing levels of complexity from Period 1 through Period 5 could simply be a response to the management and conflict mitigation needs of the increasing local population in the face of pressure on the access to agricultural land. Alternatively, the complexity in Periods 4 and 5 could reflect leadership development beyond the adaptive needs of the population (cf. Lightfoot 1984).

Specialization of ceramic manufacture could occur as one aspect of a broader economic differentiation (task specialization resulting in the economic interdependence of household groups) associated with the process of developing social complexity. This is not a requirement of either the minimalist expectations for social complexity under an economic model of behavior or the power or control expectations for social complexity under a leadership development model of behavior. However, the increased overhead costs of the leadership model are slightly more compatible with the development of specialized manufacture than is the efficiency concept associated with economic motivations for organized social control.

Measures of specialization of ceramic production in archaeological contexts are varied but often focus on the level of standardization in the execution of particular vessel forms (Rice 1981). Such measures are marginally appropriate for the northern Anasazi due to the predominance of hand-built, as opposed to mold-made or wheel-thrown pottery. Even under conditions where specialization (or at least mass production) is suspected in the context of hand built pottery, such standardization appears to be secondary to shared conceptions of style among regional populations of potters (Toll 1985). Other measures of specialization consist of the identification of evidence of ceramic production (workshops, tools, raw material concentrations), and the evaluation of the eveness of the distribution of such evidence. These measures can be implemented in the context of the northern Anasazi and have been used successfully to identify craft specialization at the level of skilled individuals (Ambler 1983).

Within this framework for the identification of specialization, positive occurrence of ceramic manufacturing must be weighed against the absence of such evidence. This requires the assessment of the interaction between sample size and the perception of negative evidence, and arguments become subjectively probabalistic. Within the Dolores area, the technology of ceramic production changes through time, resulting in a need for different criteria for the acceptance of negative evidence. These differences result in a greater difficulty in accepting negative evidence from contexts dating to Periods 1 and 2 (Blinman and Wilson 1985a) than from contexts dating to Periods 4 and 5 (Blinman and Wilson 1985b). Insufficient data are available to derive models of production evidence from Periods 3 and 6.

Although weakened by the need to depend on negative evidence, the distribution of ceramic production evidence suggests a low level of specialization in manufacture of gray ware vessels during Periods 1 and 2 (Blinman and Wilson 1985a). At least one large collection attributable to the activities of a single household lacks production evidence, and several moderate-size collections also lack such evidence. Circumstantial support for the inference of noninvolvement in ceramic production at these households is provided by the coincidence of higher frequencies of nonlocal gray ware sherds in the collections that lack associated evidence of ceramic manufacture (chap. 15). No positive evidence of white ware vessel manufacture occurs in any of the Period 1 or 2 collections, and although white ware production cannot be ruled out, it is likely to have been at least partially specialized, probably at the level of skilled individuals. Red ware vessels are first present in Period 2 collections, but their manufacture appears to have been regionally specialized outside of the Dolores area (Lucius and Wilson 1980; Lucius and Breternitz 1981). Thus, a low level of specialization in gray ware manufacture appears to characterize the early Anasazi occupation of the Dolores area, with a higher level of white ware production specialization, and regional specialization of red ware production.

In contrast to the apparent situation in Periods 1 and 2, no specialization in gray ware production can be argued for Periods 4 and 5. This conclusion is based on a detailed evaluation of collections from the McPhee Community Cluster (Blinman and Wilson 1985b), and a similar situation is assumed to apply to the other contemporary villages and communities within the Dolores area. No large collections associated with individual household or interhousehold groups lack evidence of ceramic production. Gray ware manufacture appears to be ubiquitous, but only some households can be positively associated with white ware manufacture. Production of red ware vessels continues to be regionally specialized. Thus, there appears to have been a decrease rather than an increase in household economic interdependence, as measured by the ubiquity of ceramic production, through the A.D. 600-920 period. This suggests a limited influence of social complexity on this aspect of economic organization.

Cooking Jar Volume Variation

Apart from the influences of dietary composition on ceramic vessel variation, changes in the organization aspects of food consumption may influence ceramic containers through the size of the group for which food is prepared. This has been argued by Turner and Lofgren (1966) who used variation in cooking jar volume as a proxy for variation in household size, but other factors appear to influence vessel size as well (Nelson 1981). These factors are both functional (the types of food prepared and the variety of preparation techniques) and organizational beyond simple family size. The organizational influences affect the size of the food consuming unit, augmenting household needs by needs imposed by or connected with the status and political

and social roles of the particular household. These factors limit the confident interpretation of variation in cooking jar size, but to the extent that confounding factors can be controlled, they effectively extend the range of lower confidence inferences that can be drawn about the organizational aspects of food consumption.

The basic assumption linking aspects of social organization to vessel size is that cooking jar volume is predetermined to suit the modal need or needs for the volume of food to be prepared at one time. This need is translated into vessel volume by the potter, and the closer the relationship between the potter and the need felt, the more sensitive vessel volume is likely to be to changes in the modal need. Although some specialization of gray ware (predominately cooking jar) manufacture is evident prior to A.D. 800, the level of specialization is low, with many sources of gray ware vessels. Under these circumstances, designed vessel volume is likely to approximate needed vessel volume with some possibilty of error. After A.D. 840, gray ware production is ubiquitous, and designed vessel volume is likely to correspond closely with modal needs. Exchange of gray ware vessels was relatively common for all time periods (chap. 15) and could decrease the association between household needs and household vessel characteristics insofar as needs were unevenly expressed across the geographic extent of the exchange and interaction system.

Potential influences on the felt need for particular cooking jar volumes in the Dolores area include changes in the types of materials being consumed, changes in preparation techniques, and changing sizes of the food consuming unit. Variation in the nonorganizational influences are unlikely to have major effects on individual vessel characteristics. No indications show that classes of food items were added to or deleted from the subsistence system through the A.D. 600-980 period. Observed or anticipated changes are restricted to changes in relative emphases on cultigens, primarily corn, and concurrent changes in the level of wild food procurement and consumption. No "new" functional vessel forms (such as the comal [Reina and Hill 1978]) are introduced into the container assemblage, suggesting relative stability in food preparation techniques, at least in terms of broad technique categories. However, this broadly defined technological stability does not preclude the possiblity of variety within broad preparation categories (e.g., soups, stews, and gruels as varieties of boiled foods).

Given the stability observed or inferred for types of foods and types of preparation techniques, much of the variation in cooking jar volume is likely to be in response to variation in the size of the food consuming group. This variation subsumes change in household size, changing patterns of regular hosting of gatherings that include individuals from outside of the household, and changes in economic behavior that would subdivide the household group on a regular basis. All 3 of these factors could have influenced cooking jar size in the Dolores area in the A.D. 600-980 period.

The population history of the Dolores area (chap. 8) includes instances of rapid population growth between Periods 1 and 2 and between Periods 3 and 4. The rate of increase is believed to be too extreme to reflect internal population increase, and the regional pattern of settlement location indicates that abandonment of adjacent areas at lower elevations coincided with the increases of population in the Dolores area. If the inference of immigration into the Dolores area is incorrect or only partially correct, then an extreme increase in household size would be necessary to explain the observed population growth in the Dolores area. This potential variation in household size should be reflected in cooking vessel size.

Concurrent with the increases in Dolores area population are increases in local population density or aggregation (Orcutt 1985b). In Period 1, the median site size suggests the presence of a single household, but enough multiple household sites are present to raise the mean size estimate to 2.1 households. Median site size remains at one household in Period 2, but more and larger multiple household sites are present, and the mean site size increases to 3.4 households. Aggregation continues in Period 3 with a median site size of 3 households and a mean of 4.9 households. The large population increase in Period 4 was concentrated in a limited number of large villages, such that the median size increased to 10.9 households. Smaller sites appear to have been abandoned more rapidly than the villages as part of the Period 5 population decline, raising the median site size to 7 households as the mean site size increased to 14.8 households. Futher population decline in Period 6 reduced the median site size to 4 households and the mean to 5.3 households. Some hosting of suprahousehold gatherings is expected for all time periods, but hosting activity is expected to intensify as aggregation increases. This hosting should be reflected in increased numbers of large volume cooking jars in vessel assemblages.

Changes in aggregation are also accompanied by changes in the spatial organization of economic (agricultural) activities. Settlements and their agricultural catchments are relatively compact at low population levels and low levels of aggregation. As aggregation increases, the sizes of agricultural catchments increase and the mean distance between the settlement and field locations increases (chap. 9). To the extent that fields require attention (planting, weeding, protection from

herbivors), seasonal field house strategies would become relatively cost effective alternatives to the high transportation costs associated with permanent village residence. Increased aggregation (as measured by both mean settlement size and the discrepancy between median and mean settlement size) suggests that field house strategies should be expected in Periods 4 and 5 (although most field houses [seasonal sites] are attributable to Periods 4 and 5, some date to Periods 3 and 6 as well). Adoption of such a strategy could be accompanied by (but would not necessarily require) occasional subdivision of the household into smaller units, with occasional needs for the preparation of small quantities of food.

Volumes of 145 reconstructible cooking jars from DAP structures have been measured as part of a study of vessel form and function (Blinman 1985). The size distribution (fig. 12.7) indicates a considerable range, from a miniature of less than 0.5 L to a vessel with a capacity exceeding 14.0 L. Following Turner and Lofgren (1966:125-127), it is assumed that some of these vessels were not intended for normal household use, and the volume distribution was divided into small, medium, and large categories. The division into small and medium categories is defensible on the observed characteristics of the histogram (fig. 12.7), which indicate bimodality within the smaller vessels. A low frequency of vessels of between 6.0 and 6.5 L capacity serves as the justification for the division between medium and large vessels, but this division is considerably less defensible on the basis of histogram shape alone. Again following Turner and Lofgren, some support for this division can be found in that cooking jars of 6.0 L or more could contain 8 servings (based on a mean serving size of about 0.7 L [Turner and Lofgren 1966:127]). Eight servings is unlikely to represent a modal household size except where large extended families are involved or under conditions of extreme population growth, and such a size cannot be supported by Dolores area architectural organization or room size arguments.

Mean vessel volumes for all cooking jars and for medium-sized cooking jars are presented in table 12.1 for Periods 2 through 5. Mean volumes increase in both jar categories between Periods 2 and 3 but remain relatively stable thereafter. The magnitude of the Period 3 increase is about 15 percent of the Period 2 volume for both jar categories and is slightly less than the single serving volume estimate used by Turner and Lofgren (1966). Both mean volume and temporal trends in volume are remarkably similar between the 2 categories, suggesting the arbitrary difinition of 2- to 6-L jars as household cooking vessels does not mask any significant variation.

Frequencies of the 3 size classes of cooking jars for each period (fig. 12.8) indicate more variation than is evi-

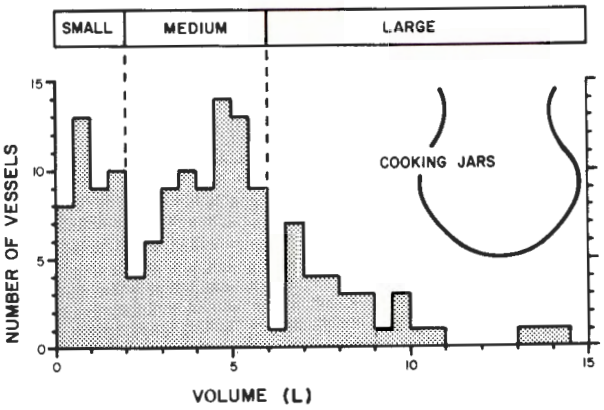

Figure 12.7 – Volumes of gray ware cooking jars from A.D. 720-920 structure surfaces. Arbitrary size classes of cooking jars are defined to reflect the discontinuities in the volume distribution at 2 and 6 L (adapted from Blinman 1985).

Table 12.1 – Mean cooking jar volumes for Periods 2 through 5

Vessel size class	Period 2	Period 3	Period 4	Period 5
Medium cooking jars	3658 mL	4287 mL	4319 mL	4471 mL
All cooking jars	3944 mL	4504 mL	4358 mL	4361 mL

dent in the mean volume data. The two Period 1 vessels fall into the large size class, but their volumes could not be precisely measured due to their fragmentary condition, and no mean volumes appear in table 12.1. Small samples for Periods 1, 2, and 3 cast some doubt on the representativeness of the proportions, and these samples of vessels cannot be interpreted as random samples of temporally defined populations. However, despite these weaknesses in the data, medium-sized jars dominate the collections from all but Period 1. Medium-sized jars are most abundant in Period 3 collections; their frequencies decline in Periods 4 and 5. Small jars are present during Periods 2 through 5, but appear to increase in frequency in Periods 4 and 5. Similarly, large jars are present in collections from all periods, but are more common in Period 4 collections. Relative ratios of small to large jars do not appear to change during Periods 2 through 5, and the change in mean volume of all cooking jars from Period 2 to 3 (table 12.1) is unlikely to reflect changes in the 2 extreme size classes.

The increase in cooking jar volume at A.D. 800 coincides with the first increase in median site size within the Dolores area, but the increase in mean site size in Period 3 is not significantly different from the magnitude of the previous increases. Although site size increases, Period 3 exhibits a stable rate of population

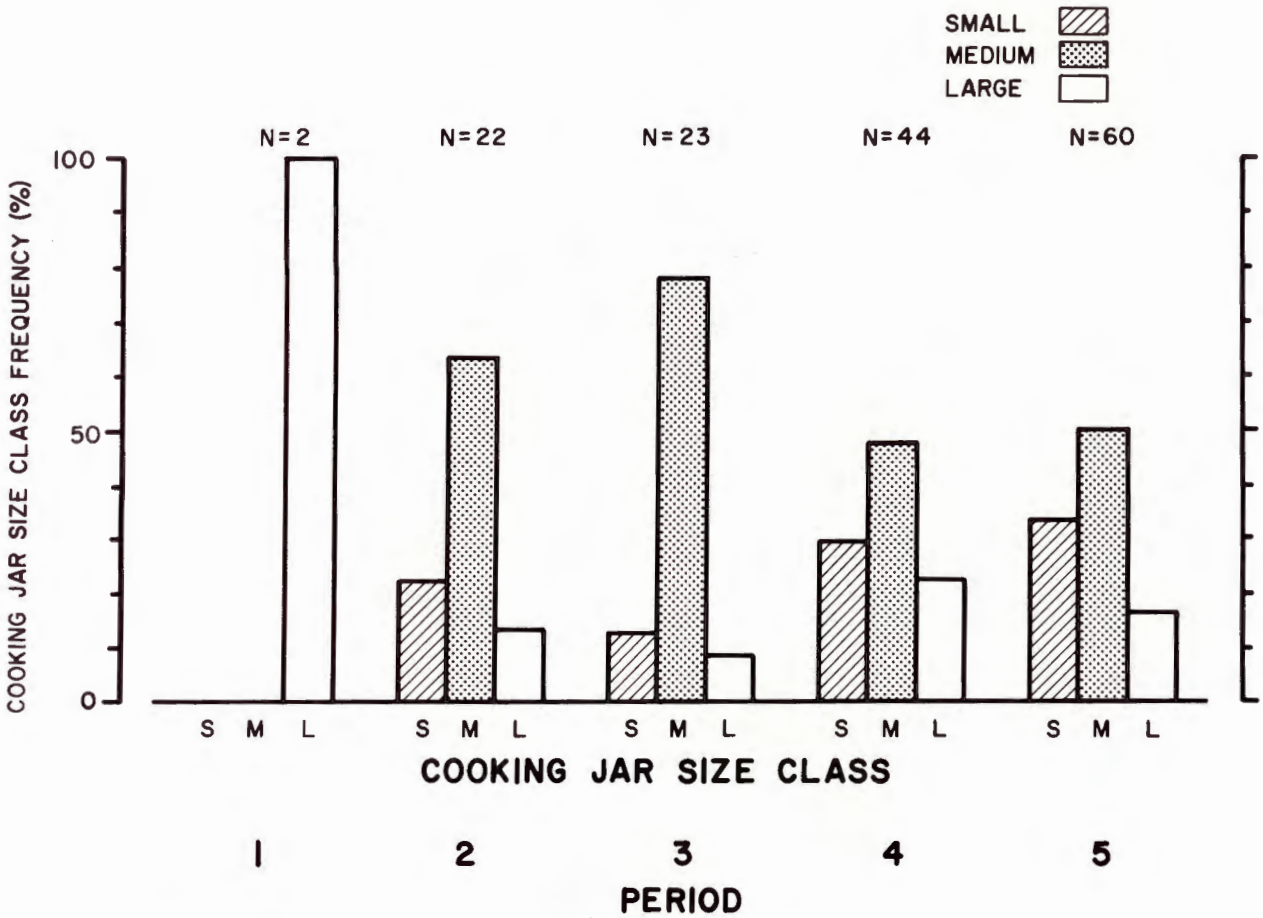

Figure 12.8 – Proportions of cooking jar size classes in dated structure surface collections. Numbers above the graphs represent the numbers of reconstructible vessels on which the proportions are based.

growth relative to Period 2, and the extremely large increase in Period 4 appears to be initiated after the start of Period 4 rather than beginning in Period 3. This implies the observed increase in cooking jar volume at A.D. 800 is either not related to or only weakly related to a change in the size of the household unit. Also, the lack of change in cooking jar volume coincident with the Period 4 population increase suggests the food consuming unit did not change in size during the growth period and that immigration is a better explanation for the increase than is internal population growth.

A possible confounding factor affecting the archaeological perception of change in cooking jar volume at A.D. 800 is a change in cooking jar shape. Prior to Period 3, cooking vessels are predominantly Chapin Gray jars with plain rims, short necks, and relatively little neck flare. In Period 3, Chapin Gray jars begin to be replaced by Moccasin Gray jars. These neckbanded jars have longer necks with relatively more neck flare and wider orifices. The changing neck and orifice characteristics of the Moccasin Gray jars increase measured volume without necessarily increasing the effective volume of the body of the vessel below the shoulder. It is unlikely this stylistic change within cooking jar shape can explain all of the observed differences between Period 2 and Period 3 volumes, but it does account for some of the difference.

The increased number of small and large cooking jars in Periods 4 and 5 correspond with increased population and the increased aggregation of that population. The aggregation correlates with settlement distribution and architectural measures of increased social complexity and integration both within settlements and within the Dolores area as a whole (chap. 10, 13, and 14). Opportunities for hosting gatherings are assumed to be enhanced by the proximity of population and the need for integrative rituals to mediate potential conflict, providing at least a partial, and perhaps a total, explanation for the increase in the large jar category. Large cooking jars are relatively evenly distributed across sites and structures in Periods 4 and 5 (16 structures contained 1 large jar, 3 structures contained 1

large jar, and 1 structure contained 3 large jars), suggesting that food preparation for large numbers of people was evenly distributed among the households within communities. This even distribution of large volume food preparation contrasts with the concentration of food consumption evidence at particular sites and roomblocks (chap. 15), and it appears that food preparation in support of ritual gatherings was broadly distributed rather than being concentrated as a responsibility of "leadership" positions.

The increase in numbers of small jars with the Period 4 and 5 aggregation is not equally expressed within different structures or site types. The structures contributing to the data in figure 12.8 are all from habitations and include both pitstructure and surface room collections. Within this data set, small cooking jars are more abundant in Period 4 and 5 surface room collections than in pitstructure collections (table 12.2), medium-sized cooking jars are more abundant in pitstructures, and large cooking jars comprise similar proportions in collections from the 2 structure types. During these periods, surface rooms are assumed to be loci of household activities while pitstructures are assumed to be domestic and ritual space shared by more than 1 household (Kane 1983; chap. 5). The weak association of small cooking jars with space assumed to be restricted to household use suggests the primary use of small jars within the context of food preparation for the household or its subsets.

No reconstructible cooking jars were recovered from the few field house excavations carried out by the DAP, but one field house collection did result in the recovery of 42 rim sherds attributable to cooking jars. The field house, Site 5MT2191 (Hewitt 1983), is assumed to have been used by residents of the McPhee Community Cluster on the basis of proximity, and the ceramic materials indicate that use of the field house occurred primarily within Period 4 and may have continued slightly into Period 5. Architecture at the site is substantial relative to other field houses, and the amount of material culture recovered in the excavations suggests repeated use of the site to an extent not apparent at other field houses (e.g., site 5MT2181 [Etzkorn 1983]).

Comparisons between rim radius data and cooking jar volume data are limited by several constraints. Although rim radius is positively correlated with vessel volume, volume estimates based on rim radius entail some error. Also, estimation of rim radii from sherds is subject to measurement error due to the small size of most sherds (Plog 1985). The former constraint is dealt with by compiling data on rim radii for the size classes of reconstructible cooking jars (fig. 12.9). Overlap is evident between the size classes, but the overlap (potential errors in classification) appears to be greater for the medium and large size classes than for the small and medium size classes.

Table 12.2 – Cooking jar size distributions by structure type, Periods 4 and 5

Structure type	Cooking jar size class					
	Small		Medium		Large	
	N	%	N	%	N	%
Surface rooms	11	35.5	13	41.9	7	22.6
Pitstructures	21	28.3	35	47.3	18	24.3

Percentages are calculated based on the total number of cooking jars associated with each structure type.

Potential measurement errors for the field house rim sheds were minimized (but not eliminated) by application of a consistent measurement technique. The rim arcs were compared with polar coordinate graph paper, and the "best match" radius was recorded for each sherd. Quantification consisted of the degrees of arc subsumed by each sherd. All measurements were made by a single analyst (minimizing the effects of observer inconsistency), and random errors in measurement probably do not exceed 1 cm in radius, or 5° in arc. The degrees of arc measurements were used as an approximation of vessel equivalents by accumulating measurements for each 0.5-cm radius interval. Thus, 5 small sherds that subsume a total of 75° of arc are interpreted as the same vessel representation as a single sherd that subsumes 75° of arc.

Although the accumulated degrees of arc of the radius intervals are assumed to be the best estimators of the relative frequencies of the vessel sizes broken at the field house (fig. 12.9), comparison with the habitation vessel radius data must be made with caution. The habitation data approximate "in use" vessel inventories, and the field house data approximate vessel inventories as modified by breakage rates (David 1972; DeBoer 1985). Thus, the habitation data are used to aid in transforming the field house rim radii measures into vessel size classes, and the field house data are interpreted as reflecting the relative intensities of use of the different vessel size classes at the field house.

The range of rim radii in the field house collection is great and sherds could have been derived from vessels of all size classes. However, relatively few sherds could have been derived from large jars, and sherds attributable to small jars are more abundant than those attributed to medium-sized jars. Food preparation at field houses appears to have served a small consuming group with fewer instances of food preparation for the full household or an extended consuming group. This

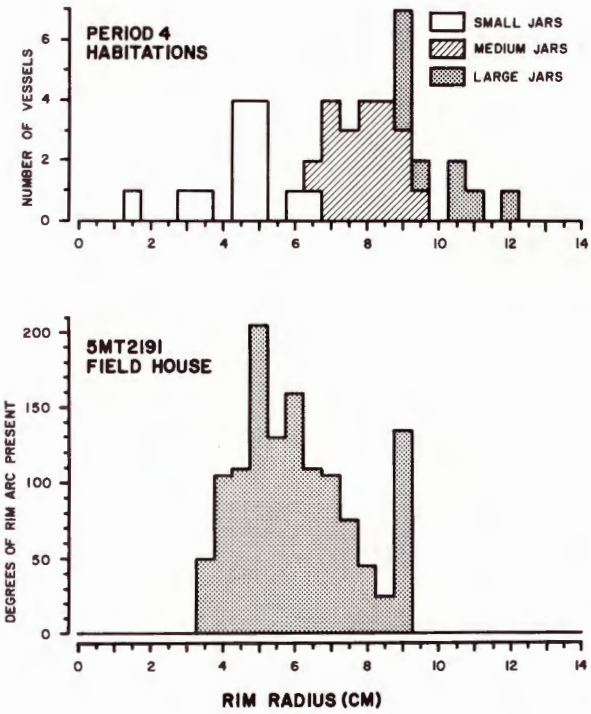

Figure 12.9 – Cooking jar rim radii for reconstructible vessels from habitation structures and for sherds from a field house (Site 5MT2191). Quantification of the sherd radii is expressed in the total degrees of rim arc represented by the sherds exhibiting a given radius.

conforms to the expectation that seasonal field house strategies would fragment the household unit for portions of the year, and provides a likely explanation for the increase in the number of small cooking jars after A.D. 840.

CONCLUSION

The observed changes in the ceramic container class of Dolores Anasazi material culture conform to general expectations based on changes in the subsistence economy and in aspects of social interaction. The former changes consist of varying levels of agricultural intensification as the relationship between population (resource demand) and resource supply changes through time. The latter changes are assumed to accompany changes in population aggregation. Both intensification and aggregation can be interpreted as consequences of economic decisions or as consequences of feedback within a leadership development cycle (Lightfoot 1984), but the timing of the changes in the Dolores area conforms more closely to the interpretation of economic motivational factors.

The close coincidence of changes in bone/sherd ratios with changes in Dolores area population supports the interpretation that agricultural intensification was an economic response to stress on resource supply. The single discrepancy between population predictions and the ratio (continued intensification in Period 5) coincides with increased climatic stress on the agricultural system, and the additional constraints on resource supply exceed the decrease in population-based resource demand. More confirmation of the sensitivity of intensification to economic factors is the close correspondence between bone/sherd ratios of individual communities and their agricultural catchment ranking. This observation has implications for differential needs for storage facilities between the communities and for social status interpretations from storage data (chap. 13).

Organizational changes that can be measured with changes in the ceramic data set are less clearly associated with either causal model of culture change. The changing level of specialization in gray ware manufacture is opposite that which could be expected to result from aggregation, regardless of the motivation for the aggregation. However, the change may be related less to aggregation than to the relative level of demand for cooking vessels. The increase in reliance on corn that is apparent as early as Period 2 (the change in storage containers) may have increased the demand for food preparation vessels to the point that household production was more efficient than intensifying the craft specialization in some households.

The container data set is not strong enough to evaluate the subtle changes in cooking jar volume expected to accompany the early stages of aggregation (Periods 2 and 3), but the more extreme changes in aggregation associated with village formation (Periods 4 and 5) are reflected in vessel assemblages. These include the abundance of large jars within the temporally defined vessel assemblages, the strong association of small jars with field houses, and the weaker association of small jars with surface rooms in villages. Large jars are widely and relatively evenly distributed, and although hosting of ritual gatherings appears to be concentrated at specific roomblocks within villages, there does not appear to be a corresponding concentration of large jars. This lack of association implies widely shared responsibility for provisioning ritual gatherings rather than an exclusive responsibility that could be associated with individual or leadership roles.

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Chapter 13

TECHNOLOGY: FACILITIES

G. Timothy Gross

STATEMENT OF QUESTION

Changes in the form, size, relative locations, and methods of construction of facilities during the Anasazi occupation of the Dolores Project area are well documented and are distinctive enough to serve as the basis for the definition of phases and subphases for the DAP (Kane 1984:25). The major focus of investigations under the facilities subdomain of the technology modeling domain has been an explanation of these changes in relation to other aspects of the cultural systems that operated in the area.

Changes in facilities are some of the most easily observed changes in the archaeological record and are often evident through the comparisons of survey records alone. A relationship between the forms of facilities and the behavior of individuals and families is often assumed, but its study has not received much attention (Trigger 1968:55). Housing is one of the more conservative aspects of human technology (Hoebel 1966:251), and yet in the span of about 350 years (ca. A.D. 600-950), rather large changes can be seen in housing in the Dolores Project area. The rapidity of the change and the size of the DAP data base bearing on that change make its study and explanation a prime target for research.

This chapter contains discussions of facilities change at Dolores and attempts to explain that change within the framework of the DAP model (Lipe 1983). Previous studies of the Dolores area facilities and new tests based on manipulations of a computerized data base are presented, but the discussion relies on previous facilities modeling work (Gross 1983) for its basic structure.

The convention of viewing economic and social variables as 2 separate sources of change in the archaeological system (chap. 6) arose relatively late in the history of DAP model construction and testing; neither time nor personnel was available to incorporate this view into the facilities studies. Some other chapters examine contrasting expectations derived from consideration of the economic and social variables as separate sources of change. The discussion in this chapter, however, employs a view of facilities change within a general model of culture change that incorporates both economic and social variables. Since this earlier conception of the model relied heavily on the variables that became part of the economic set in the later modeling, the following discussions have a strong economic cast. Social variables have been considered in the discussions, but as part of an integrated system and not as a separate source of change.

Although it was not possible to direct much research at testing implications of social versus economic sources of change as they relate to facilities, the DAP data base will certainly provide a basis for such studies in the future. In the meantime, Kane (chap. 14) presents a discussion of social organization, which uses facilities data to examine many aspects of social change and of social variables as independent sources of change.

SYSTEMIC RELATIONSHIPS

Figure 13.1 is adapted from Lipe's general model diagram (chap. 6:fig. 6.1); the simplified version presented here focuses on facilities technology. This, along with most of the definitions listed in the following section, is adapted from Lipe (1983). The general model, the definition of terms, and the relationships between variables have all been considered to some degree in preceding chapters and are presented only briefly here.

Definitions of Variables

Facilities

These have been defined in the archaeological literature as "objects which serve to prevent motion and/or energy transfers" (Binford 1968:272) and similarly as "devices which contain or restrain the motion of matter" (Hunter-Anderson 1977:295). Both of these definitions are based on Wagner (1960) and express essentially the same idea. Facilities intervene between their contents and the environment in some way. They may keep material together, protect material or people, or serve to

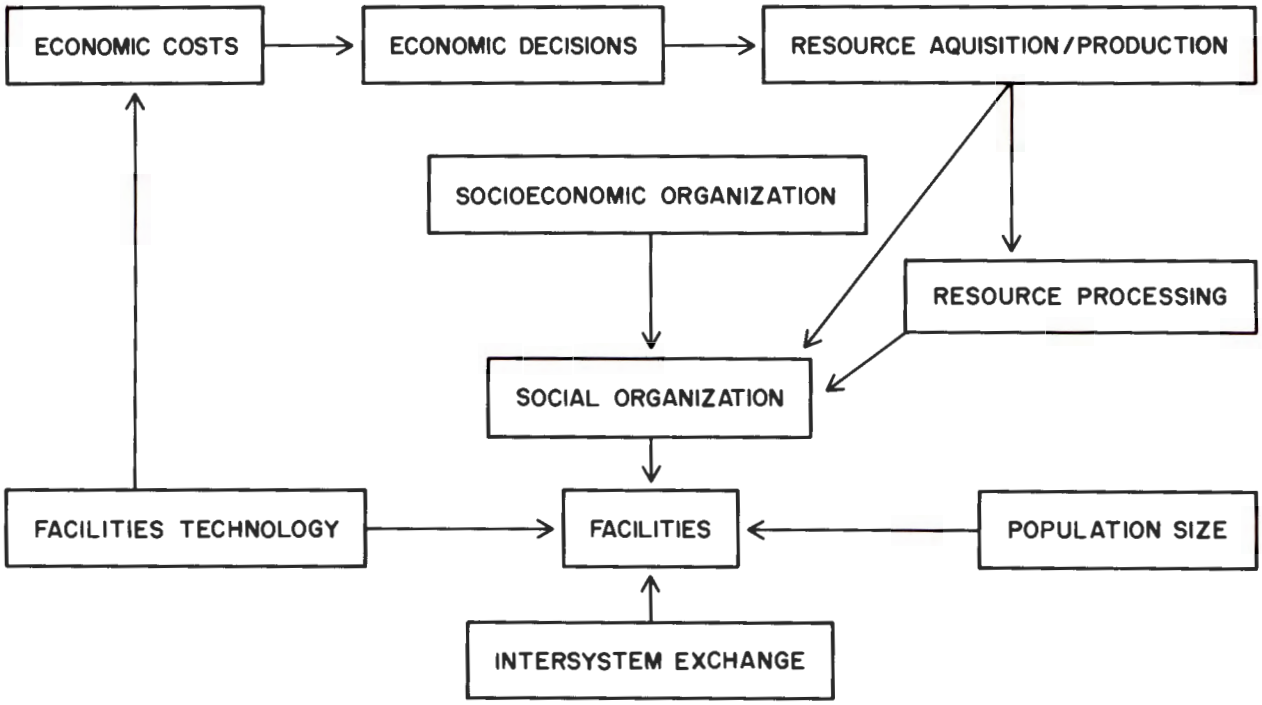

Figure 13.1 – Diagram of the facilities technology portion of the model.

restrict the motion of materials being processed. This chapter deals with 3 classes of facilities: houses, storage facilities, and integrative facilities.

Houses and integrative facilities contain people and shelter them from the environment. They also contain the activities performed by people. Storage facilities serve both to contain materials and to protect them from the environment. Storage does not always require specialized facilities, as materials may be stored in generalized containers within houses, but separate facilities may be constructed.

Facilities Technology

Facilities technology is defined as the body of knowledge, motor skills, and habits involved in the construction and use of facilities.

Economic Decisions

The process of determining which resources to obtain, the quantities to be sought, and the technology and organization to be employed in the procurement or production of those resources.

Resource Acquisition/Production

Acquisition/production is the result of all economic decisions. It is the total amount of materials obtained (whether collected or produced) and can be conceived of as either individual quantities or as the proportional mix of resources. An aspect of this variable with important implications for facilities is the degree of dependence on stored resources.

Population

Population is the number of people for a unit of area. Population can be viewed at a number of levels ranging from the individual structure to the population of a region or larger area. Household, community, and regional populations are particularly important in the following discussion.

Economic Costs

Economic costs are the amounts of energy and cultural material expended in the procurement and processing of a resource.

Intersystem Exchange

Intersystem exchange refers to the transfer of material, services, or information into or out of the system under study. The commodity transferred either originates or ends up in another cultural system.

Social Organization

Social organization is the way in which human interactions within a cultural system are structured. In this discussion, 3 aspects of social organization are considered. These are economic organization, social differentiation, and integration. Economic organization is defined as the ways in which people cooperate in the procurement and processing of resources. Differentiation refers to the number and degree of ranking of social roles. Integration is defined as the mechanisms employed to alleviate conflicts, to achieve collective action, and to maintain the interaction necessary for the system to function.

FACILITIES TECHNOLOGY AND FACILITIES AS DEPENDENT VARIABLES IN THE MODEL

Facilities serve to contain things and to shelter their contents. The form, size, location, and effort involved in construction should be determined by the following factors:

1. The form of the contents (Hunter-Anderson 1977:296-299; Schiffer et al. 1975).

2. The homogeneity/hetrogeneity of the contents, whether they are materials (Schiffer 1973:304-305) or people, and their associated roles (Hunter-Anderson 1977:303).

3. Frequency of use of the facility or of access to the contents of the facility.

4. The subsistence strategy, particularly economic decisions about the length of dependence on stored resources (cf. Gilman 1982, 1983:128-134) and the nature of cooperating economic groups.

5. The range of expected environmental conditions that the facilities shelter their contents from (Trigger 1968:56).

These factors vary in their importance to the 3 types of facilities under consideration, as will be seen in the following discussion of the effects of the model's variables on facilities.

Facilities Technology

Facilities technology includes both the knowledge of how to construct various kinds of facilities and the techniques for using those facilities. The technological aspect of facilities has an influence on economic costs and is influenced by economic decisions.

Technology contributes to economic costs in 2 ways. First, facilities have costs. These costs, as Earle (1980) points out, arise primarily from the construction of the facilities, but also include maintenance (McGuire and Schiffer 1983:278), and are averaged over the use of the facilities. Since facility costs are generally high initially, it is worthwhile to construct facilities with a fairly long uselife so the cost may be spread over a number of use episodes. One way to reduce long-term costs to the system would be to construct more permanent facilities so the cost could be averaged over a larger number of uses.

The second way technology affects economic costs is in limiting the number of alternatives. Only those strategies for which technology exists or is obtainable can be considered. It is not possible to consider a subsistence strategy that calls for the storage of items in the absence of a storage technology.

Changes in technology can have a great effect on the costs of various subsistence options (Earle 1980). Technological changes can allow for the more efficient procurement and storage of a resource that in turn changes the cost of that resource relative to others. For example, a change in the construction techniques of storage facilities that makes those facilities more secure from pests could increase the percentage of the stored resource available at the end of the storage period, thereby making the dependence on stored resource more efficient. Less of the resource would have to be produced or procured over the long run.

Economic decisions influence technology in that the particular decisions about economic alternatives will determine what available technological alternatives are to be used and to what extent. Economic decisions are limited by available technology, but the decisions determine how available technology is to be employed. The choice of particular strategies determines the set of facilities to be constructed and which techniques will be employed.

Facilities

The actual facilities, as contrasted to the technological aspects just discussed, have a direct influence on resource demand and in turn are influenced by population, resource acquisition/production, resource processing, social organization, and intersystem exchange.

Resource Demand

The demand for resources to construct facilities is dependent on the number of facilities required by the

population and the technology employed to construct those facilities. As the demand for facilities changes, a similar change should occur in the demand for the resources required. Changes in technology may serve to either increase or decrease the demand for resources depending on the nature of the change. Structural changes, for instance, may increase the use of building stone while decreasing the demand for timber. Changes in technology of construction may increase demands on all resources involved. Such a change might come about if a population were trying to build more pest-resistant storage facilities or more weatherproof houses.

Population

The level of the population sets the demand for the number of facilities. Changes in overall population in a given area should cause related changes in the number of facilities or at least in the total facilities volume within the region.

The size of the individual facilities should be a function of the number of people dependent upon those facilities. While other factors enter into the determination of facility size, the size of the group using the facility should be an important factor.

Resource Acquisition/Production

Resource acquisition/production should have the greatest effect on storage and processing facilities (resource processing is a separate variable under the model and is discussed later). The proportional mix of resources selected by a group has serious implications for storage facilities, since it includes those resources, if any, that must be stored. The diversity of stored resources should be related to both the size and the shape of the facilities employed. The greater the diversity of resources stored within a particular facility, the greater the likelihood the facility will be rectilinear rather than curvilinear (Hunter-Anderson 1977:297-298) and the greater the proportion of the total volume likely to be devoted to access volume (Schiffer 1973).

The long-term strategy should include decisions about the length of time people will be dependent on those resources in storage. The longer the period of dependence, the larger the amount of material that will have to be stored and the greater the volume required to store that material. Changes in the length of that period of dependence (e.g., increased sedentism) should be reflected in changes in storage volume.

The more dependent a population is on stored resources, the greater the need for protection of these resources. Gilman (1982), in a review of ethnographic literature for the Southwest, provides some interesting support for this assertion. She found that people with a relatively high dependence on agriculture (70 percent), and by implication a high dependence on stored resources, stored their produce in rooms adjoining their houses. People with lower levels of dependence stored in locations away from the houses (caves, pits, basketry granaries). Storing resources in facilities connected to houses does provide a degree of protection in that it allows monitoring of the condition of the stored material and provides some control of access to the facility. Protection also can be afforded by investing greater effort in construction (Gilman 1982).

The acquisition/production aspect of the model also may be reflected in house form and size. House form should be related to the number of biological functions and role-related activities performed within the house, the diversity and timing of those activities, and the bulk of implements, raw materials, and facilities associated with the activities and functions (Hunter-Anderson 1977:304-305). The greater the value of any or all of these variables, the more likely it is that the house will be rectangular rather than curvilinear. The nature, diversity, timing, and material associated with at least some of the role-related activities should be a function of the proportional mix of resources exploited.

Hunter-Anderson (1977:331) suggests

> that there is a regular relationship between the certainty of procurement of large amounts of resources and the amount of effort invested in facilities. Facilities are constructed when the availability of the contents that they will contain or house is to some degree predictable.

It would follow that an increase in a group's dependence on stored resources should be accompanied by an increase in the effort expended in construction of facilities, since the decision to increase dependence on stored resources implies a degree of predictability to the availability of those resources.

Resource Processing

The types of resource processing facilities required by a system will be a direct result of economic decisions about the proportional mix of resources. Not all processing requires facilities, as many processing tasks may be accomplished with implements alone. The facilities produced should respond to some of the same influences as other sorts of facilities. Size of facilities such as drying areas, cooking pits, or collecting bins should be related to the number of people relying on them and the frequency of the processing event (e.g., annual drying of produce versus daily grinding of meal).

Housing may reflect resource processing activities as well. Those activities performed inside the house should contribute both to the size and shape.

Social Organization

Social organization should be reflected in several aspects of facilities. House size and shape should reflect the number and diversity of roles. The location of facilities, particularly houses, should reflect aspects of social control (Birkedal 1982). The type and number of integrative mechanisms should be at least partially reflected by the type and elaborateness of integrative structures (cf. McGuire and Schiffer 1983:281).

Within social organization, vertical differentiation may be reflected in house size or by variations in storage volume. Atypically large houses, storage facilities, or both, may indicate the presence of high status individuals (Lightfoot and Feinman 1982; Lightfoot 1984; Kane and Wilshusen 1985).

Exchange

Involvement in exchange has the potential for affecting primarily storage facilities. To the extent that materials to be exchanged may be stored prior to exchange, increases in storage volume may be related strictly to exchange.

THE FACILITIES DATA BASE

Nature of the Data

The data base available for facility studies consists of various DAP forms (including those for features, structures, surfaces, and architectural inferences), narrative field notes, field maps, and photographs. This data base differs in some important ways from most of the data sets used to evaluate the DAP model. The resulting information does provide a useful and, in many cases, outstanding data base for the explanation of change in facilities, but the ways in which this data base differs from others, and some of the biases that may be present in it, must be considered.

While artifact and ecofact analysis systems were designed to answer specific questions, were implemented by analysts trained in their use, and were supervised by full-time specialists, the majority of the facilities data has been collected as routine observations in the course of site excavation. Standardized forms, in a computer compatible format, were prepared during the first year of program operations to describe both observations and inferences about various types of facilities (features, structures, and their associated surfaces) encountered during excavation. These forms were completed by the excavation supervisors at each site. In addition to the forms, a wealth of information also exists in the narrative notes, maps, and photographs, which can, and have been, consulted to fill out the picture presented in the computer-coded data base. Even though first-hand observers provided the bulk of the description, a great deal of variation occurred between individual observers. Forms were reviewed for consistency and feedback was provided to the observers, but the system of facilities data collection was never subject to the kinds of review and justification process that the analysis systems for the individual classes of material had to undergo. The major analytic groups (additive technologies, reductive technologies, environmental archaeology, and survey) all prepared midlevel research designs and formal or informal coding manuals (or in the case of survey, a field manual) that both justified procedures and the variables measured, and provided for standardization of recording. The forms comprising the core of the facilities recording at the DAP did not go through such formalized review but remained much as they were originally designed. Values for existing variables, and occasionally entirely new variables, were added when unexpected situations were encountered, and the forms did undergo modification during a project-wide review aimed at reducing redundancy in computer files.

As is always the case when trying to design forms for general description, the architecture forms were very broad in scope but were only minimally focused on specific problems. The lack of a specific facilities research design until after most of the data had been collected meant the forms and notes did not always meet the needs of the research (Wilshusen 1982:13). That is unavoidable and should not be construed as a general criticism of the conduct of the program.

The data that are available form an excellent base from which to both document and, in concert both with the model and the other DAP data bases, explain change in facilities at Dolores. The data are, however, spread out among several computer files and throughout the archives of field notes, maps, and photographs. To deal with this, individual researchers have had to create their own computer files that pull together information from the various separate date sets into a usable form.

STRUC20: The Facilities Data File

Description

The computerized data file used in later analyses in this chapter has been given the name STRUC20. The file was originally compiled as a general purpose file to be

used in program architecture studies. The file was assembled by laboratory personnel, using both paper records and excavation reports.

As it was originally compiled, the file contained floor area estimates for as many excavated or partially excavated structures as possible. Additional management variables included site and structure number, assessment of site type and structure type, and the source of the floor area estimate (planimeter measurement, site report, or other). To make the file more useful for the evaluation of the facilities portion of the model, temporal period assignments were added to each room so that data could be grouped by period. The temporal assignments used reflect the program temporal file as of early spring,1985. Also taken from that file were confidence and integrity assessments, so it was possible to select for analysis only structures assigned to particular time periods with a specified level of confidence.

It appears that no screening process was part of the compilation of the file; estimates appear to have been included whenever available in the reports or records, without regard to the potential accuracy of the estimate. Some rooms were included with only inferred wall lines as evidence of the floor area.

Evaluation

Most of the surface structure floor area estimates contained in the file were coded as originating in reports or other sources, and none of the estimates was coded as being a planimeter measurement. For these reasons, it seemed desirable to check the consistency of the data contained in the file. To examine the quality of the data, a sample of 20 surface structures was drawn using a table of random numbers. For each of the 20 structures selected, floor areas were measured using a compensating polar planimeter. The planimeter measurements were then compared with the values contained in the file. Differences between the file data and the planimeter measurements were assessed for statistical significance using a *t* test for paired samples (Snedecor and Cochran 1967:92-94).

Table 13.1 presents the comparison of the 2 estimates of floor area for each structure in the sample. The differences ranged from −2.13 to 1.83 m^2 with a mean of the difference of −0.04. While extreme differences of 2 m^2 between the file estimates and the planimeter measurements are disquieting, the small mean suggests that the differences will not have great effects on the analyses. The *t* test for paired samples comparing these 2 sets of observations (table 13.2) gave a value of 0.22, which is not significant at the 0.5 level.

The results of the *t* test suggest the variation between the file estimates and the planimeter measurements acts like a random variation in the data. The differences tend to even out when more than a few cases are considered together. Although this appears to be true for the whole sample, there were several extreme cases so the file was examined for some sort of systematic bias in the data. It appeared that many of the estimates in the sample were obtained by multiplying the length of a room by its width. It seemed likely that rooms that were curvilinear in plan rather than rectangular would yield distorted values when this method was employed. To test this possibility, the data from the sample were grouped by time, since earlier structures were often curvilinear in plan, and by structure type, because rooms classed as "other rooms" are often curvilinear. The *t* test results, presented in table 13.2, all suggest no significant difference between the 2 types of estimate.

One other check was performed to explore the effects of curvilinear rooms on the sample. All of the rooms at LeMoc Shelter (Site 5MT2151) are curvilinear, are classed as "other rooms," and are assigned to Period 2 (period definitions are provided in chapter 1). The records for the rooms were examined. One room, Room 13, was inferred without enough evidence to allow for a reasonable planimeter measurement, although an area estimate based on the length and width inferred for the room did appear in the file. Planimeter measurements of all the other rooms at LeMoc Shelter were compared to the estimates contained in the file. The *t* value obtained for this comparison was 2.26 ($0.050 > p < 0.025$, with 10 degrees of freedom). This is not a random sample, but it does demonstrate that for these curvilinear rooms the estimates in the file, apparently derived by multiplying measured or inferred lengths by widths, did not very closely approximate the actual floor areas as measured by planimeter.

The following analyses should be viewed with some caution, given the differences between the measurements of the floor areas and the estimates that appear in the computer file. Time did not allow the measurement of all of the rooms in the file, but the *t* test values suggest the results obtained using STRUC20 are useful, particularly if sample size is large. The problems noted with curvilinear rooms should not affect the comparisons and analyses reported in the following text to any great extent because these rooms appear to be early or to be classed as other rooms. Early rooms are only compared with one another, and few conclusions are drawn. The general patterns of change probably hold from period to period, but the magnitude may be less than that reported. In later periods, although other rooms are present in the sample, they do not enter into the analysis. Discussions in the following section briefly describe the studies that have been aimed at facilities, and

Table 13.1 – Comparison of floor area estimates in the structure data base (STRUC20) and planimeter measurements

Site number	Room number	Planimeter area (m^2)	STRUC20 area (m^2)	Difference (m^2)
5MT23	3	5.01	4.62	0.39
5MT23	4	5.73	4.83	0.90
5MT23	79	19.89	20.00	-0.11
5MT23	165	3.11	3.10	0.01
5MT2151	12	10.49	10.29	0.20
5MT2161	1	3.97	4.60	-0.63
5MT2336	8	3.81	3.82	-0.01
5MT4475	18	9.55	9.80	-0.25
5MT4479	7	13.78	14.04	-0.26
5MT4545	4	3.38	4.80	-1.42
5MT4613	1	4.00	4.06	-0.06
5MT4614	5	8.07	10.20	-2.13
5MT4654	2	8.93	7.10	1.83
5MT4671	2	7.45	7.00	0.45
5MT4671	33	5.05	4.80	0.25
5MT4671	39	1.31	1.30	0.01
5MT4725	1	1.41	1.20	0.21
5MT5107	13	11.24	11.25	-0.01
5MT5108	3	4.68	4.95	-0.27
5MT5108	4	5.43	5.40	0.03

Table 13.2 – Results of *t* tests evaluating the data used in analysis of structure floor area

Test	Sample size	Degrees of freedom	*t* value	Probability of a higher value
Whole sample	20	19	0.22	$p > 0.50$
Periods 1-3	6	5	-1.14	$0.40 > p < 0.20$
Periods 4-6	14	13	0.94	$0.40 > p < 0.20$
Front rooms	4	3	0.13	$p > 0.50$
Back rooms	10	9	0.31	$p > 0.50$
Other rooms	6	5	0.40	$p > 0.50$

comments are provided on the data sets assembled for these studies.

FACILITIES STUDIES

Because no full-time supervisor for facility studies was appointed, investigations were performed by various DAP staff members as the demands of their other (often unrelated) duties allowed, or were performed by individuals assigned to investigate a specific area on a more or less full-time basis. Two of the studies that figure heavily into the discussion of facilities change at Dolores were performed as thesis research. Although these studies relied on DAP data, they were independent of the program.

Despite the lack of a full-time facilities specialist, a number of productive studies have been carried out. One of the earliest DAP studies of facilities was a paper by Lipe and Breternitz (1980) focusing on the variability inherent in structures from the Dolores area. After summarizing the trends observed in structure change, they discuss 3 basic approaches for study of changes in Dolores Anasazi structures. The 3 approaches emphasize different sets of variables: adaptative, demographic, and social variables. This study was intended to point directions for fruitful research, and available DAP data was brought into the discussion where possible. The set of variables that the 3 approaches centered on have been incorporated into the model of facilities change, and many of the questions posed have been pursued.

In late 1980 and early 1981, research was conducted on the temporal variability observed in pitstructure construction at the DAP (Hewitt et al. 1983). A data base was compiled from existing records concerning both metric and presence/absence variables and the construction dates of structures. Since the data set was quite small, structures from other parts of the Mesa Verde Region were also included in the file. Despite the small data set, some significant trends were recognized. The main focus was on documenting architectural trends in hopes of developing a means of dating pitstructures in the absence of wood for tree-ring dating, and does not attempt to explain the changes observed.

In 1982, a study of evidence for ritual behavior at DAP sites was commissioned. Raffensperger (1982) considered not only artifacts but features and structures associated with ritual. Her models for identification were based both on general theory and on ethnographic accounts.

At about the same time as the ritual study was commissioned, a study on architecture was initiated using data gathered to that time. The study had as its goals the documentation of variation in the size of habitations, the examination of spatial organization of units at the household and interhousehold level, the development of a scale of technological input into the construction of structures, and a synthesis of data that would allow evaluation of change in Anasazi social organization at Dolores during the major occupation (Wilshusen 1982:3). The specific data set assembled for this study included information on numbers and sizes of the pitstructures, surface living rooms, and surface storage structures associated with 23 elements at 16 Dolores area sites. Evidence of structures and rubble scatters was also evaluated in the examination of habitation size variation. Although the study did not meet all of its goals, it provided an important baseline data set and served as the basis for a number of synthetic reports by Wilshusen on various aspects of Dolores Anasazi architecture and social organization.

Both Raffensperger's ritual study and Wilshusen's architecture studies were aimed at broad aspects of problems identified both in the initial DAP research design (Kane et al. 1983) and in the early program discussions of modeling (Lipe 1984). As outgrowths of later discussions, several studies were initiated. In late 1982, an informal study of the demand for storage facilities was undertaken (Gross 1982a). Based on figures provided by Wilshusen, it was estimated that the amount of storage space for each household was more than adequate to store the amount of corn needed by that household for several years, indicating that storage had the ability to buffer fluctuations in the availability of edible resources.

Two modeling-related studies were undertaken by Wolf. The first (Wolf 1985) tested differences between structures inferred to have been storage facilities and structures (pitstructures and surface rooms) inferred to have been dwellings. She found significant differences between inferred storage facilities and dwellings in both feature compliments and in artifact content. She went on to explore differences in other aspects of artifact content in the storage rooms. The second study (Wolf et al. 1985) looked at agricultural production and the ability to buffer fluctuations in that production through accumulation of surpluses. As part of this study, she examined spatial variation in storage facility floor area. For these studies, files were created that pulled together aspects of structure size and artifact content at selected, well-dated sites.

Finally, 2 studies conducted as part of master's thesis research contributed substantially to the understanding of change in Dolores area facilities. These projects consisted of the replication of an Anasazi pitstructure (Glennie 1983) and a surface roomsuite (Varien 1984). These structures were based on actual excavated examples from the Dolores Project area and on the results of theoretical reconstructions based on engineering formulae (Wilshusen 1985a). As part of both studies, extensive records on labor expenditure and on the use of materials were kept. Based on these efforts, comparing the construction costs of different types of structures observed in the archaeological record at Dolores is possible. Such comparison is critical to the evaluation of the DAP model and has allowed some interesting insights to be gained about the interrelationships of the types of structures that occur on Dolores Anasazi sites.

Dolores Archaeological Program facility studies have ranged from theoretical discussions of how such studies can be approached to detailed studies of observed variation in the archaeological record. The DAP modeling effort has led to 2 replication experiments as well. These studies form the basis for the discussion of change in Anasazi facilities that follows.

EXPLAINING CHANGE IN DOLORES ARCHAEOLOGICAL PROGRAM FACILITIES

The changes in the various kinds of facilities have been summarized in the general chapter on the prehistory of the Dolores Project area (Kane, chap. 5) and in other reports (Lipe and Breternitz 1980; Kane 1983, 1984; Wilshusen 1982, 1985a). The following discussion will examine shape, size, location relative to other types of structures, and construction input.

Although the model discussions (Gross 1982b, 1983) are phrased in terms of households, storage facilities, processing facilities, and integrative facilities, the archaeological record at Dolores has been described in terms of pitstructures and surface structures. The functions of the archaeologically observed structure types change through time such that it would be difficult to organize the discussion of changes around the types of facilities recognized by the model. Pitstructures and surface structures are the main organizing criteria for the discussion that follows. Surface structures will be further divided into isolated rooms, back rooms in roomblocks, and front rooms in roomblocks.

Pitstructures

Shape

The earliest DAP pitstructures are round and have antechambers that are also rounded. By A.D. 700, pitstructures become more square in plan, and by A.D. 760 the pitstructures are square with rounded corners. After A.D. 920, a few true kivas are recorded at Dolores. These late structures are again round.

Since all DAP facilities have features indicating activities performed in them, they fit Hunter-Anderson's (1977:303) definition of activity houses. Hunter-Anderson argues that the shape of an activity house is related to the number of biological functions and role-related activities performed in the structure, the diversity and degree of temporal overlap of the functions and activities, and the volume of raw materials, implements, and facilities associated with the functions and activities (1977:304-307). As the values of these variables become greater, the greater is the tendency for the activity house to be rectangular. Round houses are associated with low values of all these variables.

Evidence at Dolores indicates an increase in both the number and the diversity of activities being performed in pitstructures. Between A.D. 600 and 700, pitstructures were the main domiciles. A number of routine domestic activities were performed in pitstructures, including the processing of food and other resources. Also, evidence shows that some ritual activities were performed in these structures. By A.D. 725-760, elaboration is seen in ritual activity in the form of complex sipapus (Wilshusen 1985b:11). Sand-filled pits, which Wilshusen argues may have played a role in anchoring altars or partitions (1985b:27-35), occur on pitstructure floors by A.D. 750, and by A.D. 860-880 they are very common features in a number of pitstructures. Central vaults, another feature that appears to have been associated with ritual activities, occur in pitstructures at A.D. 860 and later (Wilshusen 1985b:37). By A.D. 860, the pitstructure had been replaced by surface living rooms as the main domicile, but domestic activities continue to be common in pitstructures. For example, metates are found in pitstructures dating to all periods prior to A.D. 860. The continuation of domestic activities in the pitstructures and the increasing elaboration of ritual in the structures, as evidenced in the types of features present and in the occurrence of artifacts that Raffensperger (1982) argues are associated with ritual, would lead to increasing the number of activities, the bulk of the materials and features associated with those activities, and the heterogeniety of the activities. Following Hunter-Anderson, this situation would lead to the construction of rectangular pitstructures. The adoption of round pitstructures again after A.D. 920 is probably related to a reduction in the number of roles. By this time the structures appear to be primarily integrative/ritual structures and domestic activities have been removed from them. With fewer, relatively similar activities to house, there is a greater tendency for the structures to be round.

Size

A great deal of variability occurs in size of pitstructures, as measured both by floor area and by depth. It was originally expected that a simple relationship would exist between the size of a structure and the population of that structure. Wilshusen's (1984) argument that there is a relationship between pitstructure size and the number and method of construction of the surface structures at a site questions the simple relationship with population. However, the greatest part of the variation in pitstructure volume related to surface structure construction appears to be accounted for by the increasing depth of structures. Variation noted in pitstructures dating between A.D. 600 and 720, a period where the pitstructure/surface structure relation does not hold, may be related to variation in household size.

Kane (1983, 1984) and Wilshusen (1985a) have noted a trend toward increasing pitstructure floor area through time. These increases may well go hand in hand with the increase in ritual activity noted. Certainly the presence of 2 size classes of pitstructures in the A.D. 800's suggests the presence of 2 levels of integration.

The presence of a class of large pitstructures in the A.D. 840-920 period fits model expectations rather well. These large pitstructures are associated with roomblocks that appear to have been the scene of unusual levels of food consumption as measured by the inflated levels of bowl sherds relative to cooking jar sherds. Blinman (chaps. 12 and 15) argues this is a result of these sites having been the locations of ritual gatherings. People from outside the roomblock unit would have brought their own serving bowls. Those broken at these

gatherings were discarded at the site, along with the bowls broken during the course of day-to-day activities. Based on the model, community level integration is expected at this time period to alleviate the stresses brought on by increased population levels in general and by the increase in population aggregation in particular (Lipe 1984:257).

Relative-Location

The location of pitstructures relative to other kinds of structures at Dolores area sites remains relatively stable through time. The distinctive pattern of site organization in which pitstructures are located generally south of the surface structure occurs throughout the Anasazi occupation.

Construction Input

The most obvious change in construction input is that pitstructures tend to become deeper through time. This change is quite understandable in light of Wilshusen's (1984) argument that pitstructure backdirt formed the basic construction material for surface rooms. This situation is reversed after A.D. 880, as Grass Mesa and Cline Subphase pitstructures tend to be shallower than pitstructures of the preceding Periman Subphase.

Another aspect of construction input that changes through time at Dolores is the use of wood in pitstructure construction. Although no well-preserved roof fall patterns for structures date to the period between A.D. 600 and 760, Wilshusen (1985a:50-57) was able to reconstruct general patterns of wood use and indicates that much less wood is required for roof construction in the A.D. 700-760 pitstructures than in the preceding period. Surface structure construction changed at the same time, however, to require much more wood. Timbers required for surface structures were generally shorter than those for pitstructures, and fewer large-diameter timbers were required. If, as has been suggested by Kohler et al. (1984), depletion of wood resources was a problem during the Anasazi occupation of the Dolores area, then this change might be a response to changes in the availability of long or large-diameter timbers.

An increase in the wood demands for pitstructures occurs between A.D. 760 and 800 with the addition of small-diameter leaners that appear to have served a trusslike function. After A.D. 800, the design of roofs changes to a flat roof that is rather efficient with wood (Wilshusen 1985a:56-70). Again, the trend toward efficiency in wood use suggests a concern for wood use and may indicate that wood, particularly long or large-diameter timber, was becoming more costly to obtain.

Surface Structures

Three types of surface structures are discussed here. These are isolated surface structures, back rooms in roomblocks, and front rooms in roomblocks.

Isolated Surface Structures

Isolated surface structures accompany pitstructures in the period between A.D. 600 and 760. From A.D. 600 to 700 these structures are round and appear to have had relatively light superstructures of brush and mud. After A.D. 700, the structures become square and have evidence of more substantial superstructures, including post-supported roofs.

Wolf (1985) has demonstrated that statistical differences do occur between these structures and pitstructure main chambers of the same period in the occurrence of both features and artifacts. The isolated surface structures contain fewer features and fewer artifact types and appear to have served primarily as storage facilities.

Shape. – The change from round to rectangular shape in storage structures is discussed by Hunter-Anderson (1977). She argues that round facilities more often hold contents that are homogeneous. When items are being withdrawn from storage, each item has an equal target value (Schiffer 1973) so it does not matter which items are withdrawn. As contents become more diversified so that it begins to matter what part of the contents of a storage facility are withdrawn at a given time, there is a tendency toward rectangular facilities. In the Dolores case, a change in the diversity of stored resources should be expected to coincide with the change in the shape of storage facilities at A.D. 700.

The increase in heterogeneity of resources stored could result from an increase in kinds of cultigens being stored (e.g., storage of different varieties of corn) or in the mix of cultivated and noncultivated plant material being stored. While some evidence indicates an increase in the use of all types of plants at the time in question (Neusius and Matthews 1985), no evidence suggests any resource but corn having been stored on a large enough scale to contribute to the noted shape change. There is certainly good evidence for the increased use of agricultural products at this time, but we have not recognized differences in corn varieties and cannot, therefore, suggest that differences in corn varieties are contributing to the change.

A relationship also exists between the form of the contents of a storage structure and the shape of the structure (Hunter-Anderson 1977). A change in the form of

the material being stored could account for the change in shape of storage facilities. Changing from storage of shelled corn to the storage of ear corn might be responsible for such a change. Storage of individual grains is quite efficient in round facilities (Hunter-Anderson 1977), but storage of ear corn is probably more efficient when it is stacked in rectangular containers. One bit of evidence is available to support this suggestion. Blinman (chap. 12) notes that vessel storage, which is practical only for shelled corn, appears only in the pre-A.D. 720 portion of the record at Dolores. Charred cob fragments in the concentrations of charred corn at Tres Bobos Hamlet (Brisbin and Varien 1981) and at Chindi Hamlet (Tucker 1983), sites which both date to the earliest period of occupation at Dolores, suggest some storage of ear corn occurred in this period preceding the change in structure form. Although no strong evidence supports any of the possible explanations for this change in shape, it is probably due to some sort of major shift in storage strategy.

Size. – The size of storage structures has been taken as a direct proxy measure for volume of stored resources and indirectly for degree of dependence on stored resources (LeBlanc 1982) and for size of population (Schiffer 1972). It was originally assumed that such relationships would hold at Dolores.

A storage demand study explored the relationship between the amount of material that could have been stored in DAP facilities (based on volume estimated from floor area) and the amount of material needed by a household. Since that study was reported only in an informal meeting paper (Gross 1982a), and since the volume estimates used in that paper were based on temporal groupings of structures that are now out of date, that study is briefly summarized and updated here.

The purpose of the storage volume study was to estimate the storage space required for a family and to investigate the degree to which that space requirement could have been met by Dolores area structures. It was relatively easy to determine the floor areas of structures, and by making assumptions about the depth to which the structures could have been filled, to estimate available storage volume. Estimating the amounts of material needed by a household was more difficult. Since it was assumed that corn was the principal stored crop and that corn was stored on the cob, it was necessary to estimate the volume of ear corn required to support a household. No figures on the caloric content per unit volume were readily available for ear corn, so it was necessary to estimate this quantity from available materials.

Fortunately, the Environmental Study Group's Botanical Studies Section had corn grown in the DAP experimental garden (Shuster and Bye 1984). This served as the basis for the estimation of the volume of ear corn in storage and for the weight of the corn per unit volume. Caloric content was taken from nutrition tables (Davidson et al. 1975:198) at 356 kcal/100 g, the value of whole grain meal. Corn ear volume was estimated as though the cob were a rectangular solid measuring 17 by 3 by 3 cm, based on measurements of an ear judged to be average from the experimental garden. This volume estimate assumes stored corn was stacked in storage facilities, but almost certainly overestimates the amount of space wasted by stacking. Since a maximum volume estimate was desired, overestimation was preferable to underestimation. The average yield of an ear of corn, based on 5 samples from the experimental garden, was 56.6 g of kernels. Taken in combination with the caloric content derived from the literature, estimates of 2.7 cm^3/g or 0.7 $cm^3/kcal$ for ear corn in storage were obtained. Similar figures (2.8 cm^3/g or 0.78 $cm^3/kcal$) are obtained using the formula described by Wallace and Bressman (1937:21) and a weight of 56 lbs/bu for corn.

The original study estimated storage volumes required for different size households, with corn contributing differing amounts to the total diet, and with varying proportions of yearly needs added to the total figure beyond the assumed consumption as a buffer against crop failure or storage losses. These figures were then compared to the amounts of storage volume estimated to have been available. Table 13.3 presents a simplified approach to these comparisons. In the table, the storage volume of the mean size storage structure (updated from the 1982 figures) from each period during the major occupation of the DAP is expressed in terms of person-years of corn (the amount of corn estimated to have been required to provide the total caloric requirement for 1 person for 1 year). Estimates in the table are based on storage of corn 1 m deep in the rooms. The average caloric requirement was estimated at 2200 kcal/day following Hassan (1974), who argues that this figure is reasonable for horticulturists.

Table 13.3 indicates that a single room during any period could have held enough corn to have supplied the total yearly caloric requirements of a household of 5 people. In all periods, however, more than one storage structure was associated with each household, so that the "two room" column provides a more reasonable estimate of available storage volume for most periods.

The Period 1 figures may be somewhat misleading. The storage volume estimates assume that structures are cubical. Period 1 structures, however, are rounded in plan and probably had conical superstructures (Wilshusen 1985a:52). Conical structures would not allow as great an amount of storage space per unit of floor area as

Table 13.3 – Corn storage potential of Dolores Archaeological Program facilities inferred to have been used for storage

Period	Mean floor area (m^2)	Person-years for single structure	Person-years for two structures
1	4.35	7.14	14.29
2.1–2.2	7.91	12.99	25.98
2.2–2.3	4.15	6.81	13.63
3	3.53	5.80	11.59
4.1	4.28	7.03	14.05
4.2	5.85	9.61	19.21
5	6.04	9.92	19.84
6	6.49	10.66	21.31

Person-year figures are the number of years 1 person could be supported by the amount of corn that could be stored in a facility if it were filled 1 m deep with corn. An average caloric requirement of 2200 kcal/day is assumed.

would cubical structures. The fact that several such structures were associated with each household in Period 1 indicates ample storage volume was available to households in this period.

From the table it appears adequate space was available in all periods for the storage of the corn required by a family of about 5 people, with corn supplying 100 percent of the calories required by a family. Such a diet would be boring and not particularly healthy (Wetterstrom 1976). More reasonable figures of between 50 and 75 percent of the diet for corn consumption would increase the differences between the amount of volume required and that actually available. Space beyond that required for storage of the anticipated yearly consumption could have been devoted to the storage of additional corn as a buffer, or for use as trade goods or gifts. Even with buffer materials in storage, though, it appears ample space is left to account for access volume (Schiffer 1973) and for unavoidable wasted space. Additional food and nonfood items could also have been stored in these structures. Since it appears more storage space was always available than would have been required to meet individual needs, it cannot be assumed that changes in storage volume necessarily reflect changes in the volume of food stored. Other factors must also be considered.

There is a change in observed size of isolated surface structures between Period 1 and Period 2. The mean size of isolated surface structures before A.D. 720, the end of the first period as coded in the structure file, was 5.40 m^2, with a standard deviation of 6.31 m^2. When the most extreme case was removed from the calculation of the mean, the figure dropped to 4.35 m^2, based on 24 cases. The 12 isolated rooms from Period 2 (A.D. 720 to 800) had a mean floor area of 6.45 m^2 with a standard deviation of 3.28 m^2. The 4 rooms that could be confidently dated to the period A.D. 720 to 760 had a mean floor area of 7.91 m^2 with standard deviation of 2.51 m^2. There is, then, an increase in the floor area of storage structures that accompanies the change in shape of the structures.

The change in storage volume, as reflected in floor area, is probably a function of both the greater reliance on plant materials, particularly agricultural products, and the change in storage methods suggested by the absence of large seed jars from the post-A.D. 720 assemblages. Although corn always appears to have been stored on the cob, this change in storage method for other materials (or for some part of the corn stores), could have added to access volume requirements for the storage facility, or could have contributed to wasted space, or both.

Relative location. – This aspect of isolated surface structures does not change. Isolated surface structures tend to be arranged in a loose group to the west, northwest, and north of the pitstructures. Gilman (1982), in a review of ethnographic literature from Southwest groups, notes that peoples with between 30- and 50-percent dependence on agriculture stored items in various kinds of situations including the basketry granary. The isolated surface rooms appear to be most analogous to such granaries.

Construction input. – When surface rooms became more rectangular in plan, they also became more substantial constructions. Wilshusen (1985a:54) notes that some of these structures had roofs supported by 4 posts and that the structures probably were akin to the jacal structure experimentally replicated by Varien (1984). The fact that no portions of superstructures of any of

these structures is preserved in the excavated sample makes it difficult to reconstruct the exact nature of the structures.

An increase in construction input is expected under conditions of agricultural intensification or in any situation where a dependence on stored resources is occurring, especially if that increased input results in a better storage environment within the structure (Gross and Wolf 1984). Thicker walls, for instance, would increase the insulation for the structure and would probably have made them more pest-proof; both factors would potentially lower storage loss. Reduction in storage loss makes more of the harvest available over the long run and therefore increases the consumable yield.

Back Rooms

Back rooms are the northern row of rooms in contiguous, double-row roomblocks (they are the farthest rooms from the pitstructure). These rooms are also found on the northwest and northeast sides of the roomblock (for a discussion of general site layout, refer to Kane and Robinson [1984]). Wolf's (1985) study of structures indicated back rooms generally fit her expectations for storage rooms.

Shape. – Back rooms continue the trend established in storage structures after A.D. 720, in that they are rectangular. The general arc of the roomblock makes these back rooms deviate slightly in form, from rectangular to truncated wedges. The greater the curvature of the roomblock, the greater the deviation from a true rectangle.

Size. – Mean floor areas for back rooms are presented in table 13.4. The 95 percent confidence levels for these means are plotted in figure 13.2. Figure 13.2 indicates a change in mean floor areas. Two contrasting groups of rooms can be identified: structures dating prior to A.D. 860 (prior to Period 4.2) and those dating to A.D. 860 or later. Within these 2 groups, it is hard to rule out sampling error as the cause of the variation, although the change between Periods 2.2-2.3, and Period 3 may be due to an actual change in mean floor area. It would be expected that both the major change at A.D. 860 and the smaller change at A.D. 800 would be the result of changes in storage methods. No evidence for changes in storage methods at either of these times was found. The slight decrease in storage volume at A.D. 800 does coincide with a dip in the ubiquity of all kinds of plants (cultigens, pioneers, and wild plants) recovered from fire-related features by the DAP (Neusius and Matthews 1985). These ubiquity indices are seen as reflecting relative reliance on plants, so that the decrease in this index does support the explanation of the decrease in floor area. Interestingly enough, the decline in the use of cultigens appears to be proportionally greater than the decline in either wild plant or pioneer plant use.

Table 13.4 – Mean floor areas of back rooms

Period	No. of rooms	Mean	Standard deviation
2.2–2.3	14	4.15	1.48
3	23	3.53	1.81
4.1	6	4.28	0.68
4.2	38	5.85	1.63
5	31	6.04	1.41
6	13	6.49	2.67

A rise in the use of plants in general between Periods 3 and 4 also occurs, as measured by the ubiquity indices. The botanical information is only presented by period, and it is not possible to determine where in Period 4 the change comes. The large change in floor area comes in Subperiod 2 of Period 4 (Period 4.2), or A.D. 860-880. The indices for Period 5 suggest proportional rises in the use of both cultigens and pioneers, but a decrease in the use of wild plants. A very small rise is seen in the floor area of back rooms, but it is not possible to eliminate sampling error as the cause of the apparent rise. A decrease in the ubiquity of all plant remains in Period 6 is not reflected in the floor area means, but the sample for Period 6 (the second smallest – 13 rooms) and the mean and the standard deviation are the largest for all periods (mean = 6.49; standard deviation = 2.67 m^2).

Another possible factor involved in the change in floor areas of storage rooms is mean number of people dependent on the storage facility. Because of the spatial association of living rooms with storage rooms, it is inferred that the household was the basic unit using the storage facilities associated with each living room. Blinman (chap. 12) has employed Turner and Lofgren's (1966) method to examine household size using ceramic jar and bowl volume variation through time. His analysis indicates that household size remained stable throughout the Anasazi occupation of the Dolores Project area. For that reason, change in household size will not be considered further as a possible cause for change in facilities size.

Kane and Wilshusen (1985), following Lightfoot (1984), suggest that within-period variation in storage volume can be taken as a measure of the degree of social differentiation and that sites with larger-than-average storage volumes were the headquarters of leaders. They then point out that differences in storage volume at the different villages investigated at the DAP correlate with expected differences in the complexity of the social structure at the sites. It is specifically suggested that

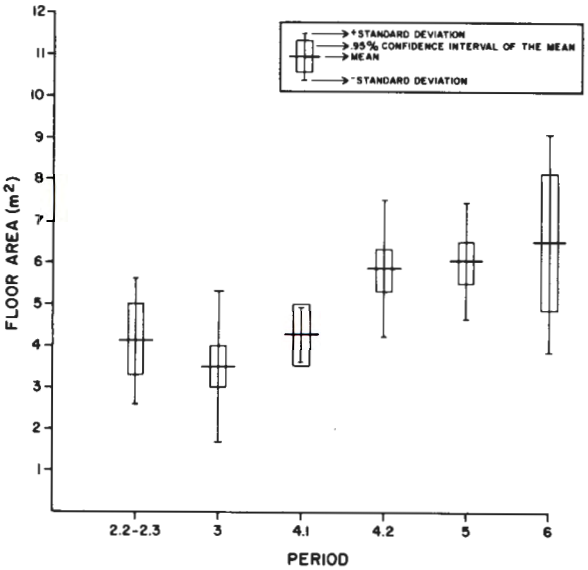

Figure 13.2 – Mean floor area of back rooms.

McPhee Community was a higher status community than others in the Dolores Project area.

Where Kane and Wilshusen (1985) suggest the development of community-level status differentiation as an explanation for the differences in storage volume between communities, an alternative view would suggest that storage volume would be more strongly associated with the degree of dependence on stored resources, especially cultigens. Differences in potential agricultural production have been suggested for communities in the Dolores Project area, and Orcutt (1985) has compiled indices that measure the relative agricultural quality of site catchments (in this case, Thiessen polygons drawn around the major village of the community). Since the agricultural quality of a village's catchment should be related to degree of dependence on agriculture, it is expected that a relationship between catchment agricultural quality and degree of dependence on stored (agricultural) resources will exist.

Table 13.5 presents both the agricultural quality indexes and mean back room floor areas for the 5 community clusters for which excavation data are available. Number of cases from which means were calculated is also reported. In several cases, the comparisons are hampered by small sample sizes, and several of the community clusters lack back rooms confidently dated to either the A.D. 800-840 period or the A.D. 880-920 period.

A Spearman rank correlation coefficient was calculated to test the correlation between the ranking based on agricultural quality of the catchment and the ranking of the back room size. Only the A.D. 840-880 period could be tested since that was the only period in which values for each of the five communities were available. The results indicated no correlation (r_s = 0.02). The same test was run on the ranking of total roomblock length in the community (A.D. 860-880), seen by Kane and Wilshusen as a proxy measure for community status, and the ranking of back room size. Again, no correlation was demonstrated (r_s = −0.1).

The lack of correlation in either test may be a result of sampling error due to small sample size for several of the communities, and it may be exacerbated by the dating problems for House Creek Community Cluster (having to lump material dated to A.D. 820-860 with material dated to A.D. 860-900). It is also possible that the agricultural quality index is not a very good predictor of degree of dependence on agriculture and hence stored food.

Blinman (chap. 12) has developed 2 measures that seek to reflect changes in the degree of dependence on agriculture. The ratio of nonhuman bone to cooking jars is seen as reflecting the contribution of animals to the diet in relation to cultigens, while the ratio of cooking jars to bowls is seen as reflecting the proportions of cultigens represented in the total amount of food consumed. Both of these measures are calculated for materials from screened refuse in an attempt to control for cluster effect caused by reconstructible vessels in nonrefuse contexts and to aid in comparability of the samples. The 2 ratios have been calculated for McPhee, Grass Mesa, Rio Vista, and House Creek Community Clusters, but the data from the neighboring Rio Vista and House Creek have been combined under the term Middle Canyon communities.

Grass Mesa Community Cluster has the largest amount of bone relative to cooking vessel sherds of any contemporary sites. Of the sites for which the bone/sherd ratios were calculated, Grass Mesa Community sites also have the lowest mean floor area for back rooms. Only May Canyon Community Cluster, for which the sherd-based measures were unavailable, ever has a smaller mean back room floor area, and this is based on a sample of only 6 rooms.

Bone/sherd ratios are not available for the McPhee Community or the Middle Canyon communities during the A.D. 840-880 period, but from A.D. 800-920, Middle Canyon sites appear to have had a slightly greater dependence on agriculture than McPhee Community sites. McPhee Community Cluster has more mean storage space in this period than does Grass Mesa, but figures for only one of the Middle Canyon communities are available for comparison. At House Creek Community Cluster, 6 rooms dating to this period have a smaller mean area than McPhee back rooms. In the

Table 13.5 – Agricultural quality indices and mean back room floor areas for community clusters

Community cluster	A.D. 800-840			A.D. 840-880			A.D. 880-920		
	Quality index	Area (N)	Area (m^2)	Quality index	Area (N)	Area (m^2)	Quality index	Area (N)	Area (m^2)
McPhee	37.2	—	—	43.0	68	5.9	3.8	24	6.1
May Canyon	32.9	—	—	39.8	5	4.2	28.0	—	—
Rio Vista	5.0	20	3.5	29.7	6	6.5	18.9	—	—
House Creek	5.0	6	*5.9	-5.8	12	†4.9	-6.8	6	§3.8
Grass Mesa	-84.4	1	2.4	-73.2	30	4.8	-81.2	9	5.2

* Rooms actually assigned to the period A.D. 820-860.
† Rooms actually assigned to the period A.D. 820-860, or the period A.D. 860-900.
§ Rooms actually assigned to the period A.D. 860-900.
Agricultural quality from Orcutt (1985:58-59).

A.D. 840-880 period, where bone/sherd ratios are unavailable, Rio Vista Community Cluster of the Middle Canyon group does have a larger mean back rooms size than McPhee Community Cluster, but only 6 rooms are in the Rio Vista sample. If the data for Rio Vista and House Creek Community Clusters are averaged together, the resulting mean is 5.4 m^2, based on 18 cases and is smaller than the McPhee mean.

Bowl/jar ratios for Grass Mesa are lower than other communities for all time periods, reinforcing the impression given by the bone/jar ratio. For the A.D. 800-840 and A.D. 840-880 periods, Middle Canyon communities have higher bowl/jar ratios than Grass Mesa, and both of the communities in the Middle Canyon group have higher mean back room floor areas. As with the bone/jar ratio, Middle Canyon is also higher than McPhee in the A.D. 880-900 period.

The 2 sherd-based measures agree with the back room floor area rankings where data are available for comparison. If these ratios are indeed measuring the relative contribution of agriculture to the diet, it appears storage volume is varying with the degree of dependence on agriculture.

To return for a moment to the question of storage area reflecting the locations of leaders in some sort of administrative hierarchy (Lightfoot 1984), it seems that mean storage area may not be the most appropriate measure. Mean storage area per roomblock should measure trends in storage for all households in the roomblock. If, as Lightfoot (1984) suggests, storage volumes should be larger for the households of leaders than other households, little difference in the mean values should occur unless a significant proportion of the households at a roomblock include leaders. An increase in storage room size across the board might be expected in roomblocks where the disbursement of the leader's "fund of power" was to those who lived nearby. Even in such a circumstance, the leader would still require storage space larger than those of other households not involved in the accumulation of a fund of power. Such extra large storage facilities should inflate the standard deviation of the floor area measures, as well as the mean, assuming any possible households of leaders are included in our excavated sample.

Between A.D. 760 and 920, standard deviations of back room floor area range from a low of 0.68 m^2 to a high of 1.81 m^2. In the A.D. 920-980 period (Period 6), the standard deviation jumps to 2.67 m^2. When the room size from McPhee Pueblo is examined through time (table 13.6) the largest standard deviations also fall within the A.D. 920-940 period (Period 6.1) and the 940-980 period (Period 6.2). There may be evidence, then, for variation in storage volume due to the development of leadership hierarchies in this late period, essentially the Cline Subphase.

Relative location. – As their name indicates, back rooms are located on the back, or north, side of the roomblock. From A.D. 720 on, they maintain this relative position. The important change, then, is the change from storage in isolated rooms to rooms in the northern row of a double-row roomblock.

Changes in the location of storage structures are expected as a result of increases in dependence on agriculture, with its implied increase in dependence on stored foods, and with increases in aggregation of population. Gilman's (1982) survey of the Southwestern ethnographic literature indicated that groups whose dependence on agriculture was 70 percent or greater stored food in facilities connected to their dwellings. Incorporation of storage rooms into the dwelling unit allows for easier monitoring of the conditions of the

Table 13.6 – Mean floor areas of back rooms at McPhee Pueblo, by temporal period

Period	No. of rooms	Mean	Standard deviation
4.2	17	6.2	1.9
6	2	5.0	0.8
6.1	14	6.4	2.6
6.2	6	6.2	2.2

contents of the facilities. Monitoring of material in storage is recognized as being important in maintaining the overall condition of that material and allows for early detection of problems such as insect infestation or rodent damage (Bailey 1974:355; Shove 1970:72). The placement of the storage rooms to the north of the living rooms means the front rooms provide insulation for the storage rooms – important in maintaining reasonable storage environments within the back rooms (Gilman 1983:125; Gross and Wolf 1984).

By bringing more people together at the same location, population aggregation also provides an impetus for the incorporation of the storage facilities into dwelling units. Placement of storage facilities in such a way as to limit access to the facility serves both to minimize unauthorized withdrawal from the facility (Gross and Wolf 1984) and to limit the knowledge of the level of the contents of the facilities to those immediately associated with the households (Gilman 1983). Although doors are rarely preserved in DAP structures (Wilshusen 1985a:65-67), it appears that location of the storage room immediately to the north of the dwelling and as part of the same architectural unit would effectively limit access to the facility. Quite possibly, the only access to the back rooms was through the front rooms.

Gross and Wolf (1984) have argued that the change in relative location of storage rooms coincides with an increase in dependence on agriculture, although no very strong lines of evidence support this contention. The botanical data presented by Neusius and Matthews (1985) is arranged by period, and show a major increase in dependence on plants of all sorts (but especially cultigens) in the A.D. 720-850 period over the A.D. 600-720 period. Population aggregation also increases during the A.D. 720-840 period (Orcutt 1985:table 1). Back rooms begin to appear in the Dolores archaeological record at A.D. 760.

Construction input. – Back rooms undergo substantial changes in construction input through time. The major change from isolated rooms to contiguous rooms is that the later structures shared walls, which meant that less material and less effort went into any individual structure. In the A.D. 760-800 period, sporadic use of upright sandstone slabs in the lower walls of structures occurs; after A.D. 800, masonry is common in lower wall construction. Between A.D. 860 and 900 there is an increase in the use of masonry, and Wilshusen (1985a:64) estimates that at least half, and perhaps all, of the walls of surface structures of this period were of horizontal coursed masonry. In the A.D. 920-980 period, surface rooms are all masonry.

It is expected that these observed changes in back room construction will be related to costs of construction and to the degree of dependence on stored resources. Changes in construction costs should lead to compensatory changes in techniques. As dependence on stored resources increases, there will be a greater reward for constructing facilities that provide better storage environments (Gross and Wolf 1984).

The relationship between surface structure construction and pitstructure depth has already been noted. As the number of surface structures grew relative to pitstructures, techniques that incorporated more rock and less mud for each structure were adopted (Wilshusen 1985a:80-81). Changes in wood requirements are also summarized by Wilshusen (1985a), but the significance of these changes will be left to those studying wood resource depletion (Kohler et al. 1984; Kohler and Matthews 1984).

The measures of reliance on agriculture do indicate increases at appropriate times, but some contradictions exist. From Neusius and Matthews' (1985) ubiquity indices, a rise in ubiquity reflecting a rise in degree of dependence on cultigens can be seen between Period 1 (A.D. 600-720) and Period 2 (A.D. 720-800). A small decline occurs between Period 2 and Period 3 (A.D. 800-840), followed by a rise in Period 4 (A.D. 840-880) to a level higher than any previous level. The ubiquity of cultigens reaches an all time high in Period 5 (A.D. 880-920) and then sharply declines in Period 6 (A.D. 920-980).

With the exception of the decrease in dependence on agriculture in Period 6 and the decrease between Period 2 and Period 3, the general increasing trend is as expected from the changes in construction input invested into back rooms and suggests that provision of adequate storage environment was an important construction consideration. It is suggested that the decrease in ubiquity of cultigens between Period 2 and Period 3 was small enough so as not to have an effect on back room construction. The increase in the use of masonry after A.D. 920, at a time when dependence on agriculture seems to be decreasing, is probably due to construction efficiency and may not be related to improvement of storage environment.

Front rooms

Front rooms enter the archaeological record at Dolores after A.D. 760. They form the front, or southern, row of rooms in the two-row roomblock. These rooms usually have hearths and other features, as well as artifact assemblages that indicate they were dwellings. Within the same roomblock, the construction of front rooms is usually less substantial than that of the back rooms.

Shape. – Front rooms are generally rectangular in shape. The shape does not change through time and is related to the fact that they are part of contiguous roomblocks. Rectangular rooms are the most efficient form for joining in multiple units (Hunter-Anderson 1977). This also continues a trend for surface architecture established in the period prior to the introduction of contiguous roomblocks (A.D. 720-800).

Size. – The trends in the size of front rooms are summarized in table 13.7 and in figure 13.3. Front room size starts off large in the A.D. 760-800 and declines over the next 40 years to reach its all time low at the A.D. 840-860 period (Period 4.1). There is a sharp increase to the maximum size attained in the period between A.D. 860 and 880 (Period 4.2), followed by a slight decline, and then a small rise between A.D. 920-980 (Period 6). The variation is large in each of the periods. When the standard deviation is expressed as a proportion of the mean, standard deviations for front rooms are proportionally larger than those for back rooms. The 95 percent confidence limits for the means also show a great deal of variation, with one exceptionally large value for the A.D. 840-860 period (fig. 13.3).

Given the extreme variation in the samples, the large standard deviation, and the relatively small sample sizes, determining whether the observed trends are culturally meaningful is difficult. In addition to the problem already discussed, an additional problem is caused by the nature of the architectural unit. Since most surface rooms occur in suites of 2 or, more commonly, 3 rooms and since these are arranged with 1 front room paired with 2 back rooms, it is difficult to attribute change in front room size to factors independent of change in back room size. To explore for correlation in the areas of front rooms and the areas of back rooms, mean front room area was regressed against mean back room area. The correlation coefficient ($r = 0.564$) suggests a weak positive correlation between mean front room floor area in each period and mean back room floor area.

The test looked only at the floor area means for each room type by period. Since the front rooms investigated and measured at any given site may not have belonged to the same roomsuites as the measured back rooms, the correlation is probably stronger than indicated. This suggests that factors affecting storage volume may ultimately affect the size of all the surface rooms at a site.

Table 13.7 – Mean floor areas of front rooms

Period	No. of rooms	Mean	Standard deviation
2.2-2.3	6	13.29	6.05
3	8	11.67	4.82
4.1	3	9.51	4.42
4.2	17	14.44	5.95
5	22	12.26	4.68
6	8	13.84	4.37

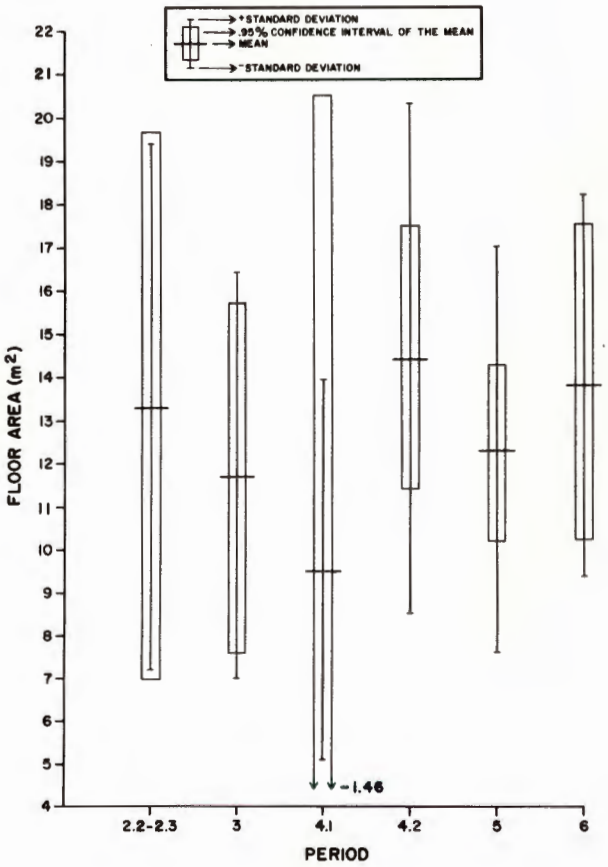

Figure 13.3 – Mean floor area of front rooms.

Before the correlation between back room and front room area was recognized, it was expected that front room size would respond to changes in household size. Ceramic evidence suggests household size does not change noticeably through time at Dolores.

Relative location. – The location of the living rooms, attached to storage rooms on the south side, marks a

major change in the location of dwellings. This change has much to do with providing improved storage environments, in monitoring conditions of stored materials, and in controlling access to stored goods. An increase in dependence on agriculture accompanied the change to the contiguous roomblock, in agreement with expectations derived from the model. The location of front rooms is critical to the quality of storage environment provided by contiguous roomblocks because the front rooms provide insulation on the critical south face of the storage rooms and help maintain temperature control. In addition, the joining of roomsuites together into roomblocks enhances the insulation by providing additional mass (Gilman 1983).

In addition to the benefits that accrue to storage facilities by the incorporation of the roomsuites into roomblocks, it is expected that there are social benefits as well. As Wilshusen (1985c) points out, economic cooperation is easiest among households that reside close to one another. Then, as population grows, and as it becomes more aggregated, a shift from isolated habitations (pitstructures) to contiguous dwellings is expected.

Population does increase at the time (A.D. 760) when surface living rooms first appear (Schlanger 1985). Population aggregation also increases in the period A.D. 720-800 (Orcutt 1985:table 1). The use of the specific measures of population and of population aggregation are based on roomblock characteristics, so the problem of tautology must be addressed. The measures of roomblock size contribute to population estimation, while number of households per roomblock are used to measure aggregation. The change in the location of the primary domicile is a change in spatial pattern and not a change necessarily linked to size.

Two variables appear to interact in a mutually reinforcing way to bring about the change from residence in pithouses to residence in surface rooms in the front tier of a double row of rooms. The need for economic cooperation in agricultural intensification provided one push toward residence in contiguous rooms, while the need to provide better storage environments, a minor form of agricultural intensification in itself, provided a push for contiguous surface rooms located south of the storage rooms. Locating living rooms in front of storage rooms increased the household's control over access to the materials stored in those rooms, providing further positive feedback.

Construction input. – The differential in construction input between back rooms and front rooms has already been noted. Front rooms are often of much lighter construction and are consequently hard to define in comparison to the back rooms of the same roomsuite. The trends in conservation of earth as pitstructures become less common relative to surface rooms hold for front rooms as well as back rooms.

SUMMARY AND CONCLUSION

Several major changes in facilities occurred during the Anasazi occupation of the Dolores area. The function of pitstructures changed. They began as being primarily domiciles, then became shared domestic and ritual structures, and ultimately became solely ritual structures or kivas. Surface structures, which at the outset of the Anasazi occupation are scattered, free-standing structures, develop into complex arrangements of rows of contiguous storage rooms fronted by rows of contiguous dwellings. These changes are addressed in the preceding pages and are examined in light of other DAP data for fit with expectations derived from both the general model (Lipe 1983) and the facilities portion of the model (Gross 1983). Population growth and aggregation, economic decisions, and social organization, and especially agricultural intensification play important parts in the generation of facilities expectations and therefore, in the proffered explanations of change. Costs of facilities have been addressed where possible, but exchange as a source of change has not been discussed.

Viewing the facility changes finally as an interrelated set of processes, after having discussed the various particular aspects of the changes, allows for a synthesis of causes of facility change in the Dolores case. It appears that population growth, including immigration into the Dolores area, began to stress the settlement/subsistence system. Adjustments in this system led to general subsistence intensification, one major aspect of which was increases in agricultural production. These increases led to greater dependence on stored resources. As stored resources became more important, it became necessary to provide better storage environments to minimize loss of stored foods. This led to one of the first changes discussed, the change in the shape of and construction input invested into isolated surface rooms.

As the need to intensify food production grew, it probably became necessary to organize labor beyond the household level. As more people began cooperating in economic and other matters, there arose a need for increased communications and increased integration of the population. These led to the increase in ritual features and the shape change in pitstructures, and to the move into surface living rooms that adjoined one another. As these trends continued, the need for integration led to the formation of roomblocks with extra ritual functions such as hosting rituals, and perhaps even to the development of a rudimentary leadership

structure. The change to surface living rooms also had the beneficial effect of improving the storage environments of the storage rooms.

The provision of better storage environments may have been the impetus for the formation of the classic Pueblo I pueblos. The construction of storage rooms is usually more substantial than the accompanying living rooms. The location of the front rooms to protect the storage rooms from solar radiation also suggests that it is the storage function of the rooms being accommodated by the pattern of construction. Further, the initial change in surface structures is the construction of more substantial storage rooms. A few of these rooms have hearths and show other signs of having been lived in, but they remain primarily storage structures. To form a pueblo all that is required is that these surface rooms be brought together and that some living rooms be built to the south of them to protect the south-facing wall of the storage rooms. The fact that these contiguous living rooms foster communication adds to the utility of the arrangement.

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Chapter 14

SOCIAL ORGANIZATION AND CULTURAL PROCESS IN DOLORES ANASAZI COMMUNITIES, A.D. 600-980

Allen E. Kane

Social organization is recognized as a factor in explaining the timing and direction of culture change evident in the archaeological record at Dolores. As such, social variables are afforded roles in the general model (chap. 6). The general model has been developed as a central framework for analytical studies that attempt to explain the demographic and organizational cycles evident for local Anasazi communities during the period A.D. 600-980.

Social organization consists of several subareas, each of which is individually important within the framework of the general model. These subareas are as follows: (1) economic organization, or how community groups are organized for subsistence production; (2) horizontal differentiation, or the array of functionally specialized roles within the community without regard to class (including craft specialists and ceremonial or religious specialists); (3) vertical differentiation, or the array of status roles within and between communities; and (4) integration, or the mechanisms and institutions developed to facilitate intergroup communication, to lessen friction between groups, and to further a sense of identity within a community.

Within the framework of the general model, social organization is linked with other variables that can be classified as economic and demographic variables. Economic variables are those variables affecting agricultural productivity and availability of economic resources including climate, soil fertility, and human disturbances affecting the prehistoric ecosystems. Demographic variables include population density, settlement size, and spacing among settlements.

A primary source of change within the general model are economic variables. These include changes in climate, population density, access to agricultural land, and other factors that affect total subsistence productivity or productivity per capita. The effects of economic variables are modeled as relative costs and these affect other variables according to least cost principles. For example, a drought year may drive up the cost of agricultural products and make them more expensive when compared to other potential sources of subsistence goods, such as plant gathering or hunting. Based on these differences in costs, a least-cost decision would focus more effort on alternate, cheaper sources of food, and this might necessitate changes in settlement strategies and in the organization of economic production groups.

Economic variables are then seen as operating within a satisficing, or minimization framework (e.g., the best option in terms of rising costs may be to intensify agricultural production and related settlement and social organization, especially if increased population density and production demands are a factor [Orcutt 1985a:2-9; Christenson 1980:36]). It may be comparatively cheaper to cope with increasing population and rising costs of subsistence by investing more labor in agricultural production (such as improving field locations, increased weeding, or planting more crops in a unit area) than by attempting to increase the yields of wild plant and animal foods.

Intensification might also be manifested as change in settlement and social strategies. For example, aggregation can be viewed as an intensification response to rising economic costs in that it might aid efficient mobilization of agricultural work groups. A shift from the simple nuclear family household to the extended family as the unit of economic production might be regarded as a similar accommodation. Selection of the cheapest option would tend to dampen the overhead costs of settlement and social strategies. For example, it may be necessary to implement a simple managerial structure at the community level to integrate aggregated groups that checks the ambitions of the managerial groups to keep overall system costs low.

Risks inherent in production strategies are also an important consideration. To offset risks, groups may decide to invest in buffering mechanisms, such as planting

increased acreage, diversifying field locations, or building additional and more substantial storage facilities. Implementation of these buffering strategies would appear to increase subsistence costs, but in the eyes of prehistoric agricultural groups, it would be the cheapest option in terms of survival.

Social organization can be viewed as an alternate or perhaps complementary source of change within the DAP general model. Even simple forms of social organization may be accompanied by relatively high overhead costs that may conflict with least cost goals. Conflict between social and economic goals may be exacerbated if the need for organizational and integrative mechanisms is increased by population aggregation. Rappaport (1971:28) notes that systems that manage ritual activities are very expensive. If personages or groups with leadership or management responsibilities are present, then they will normally act to maintain their positions and increase their wealth and power relative to other groups.

The appearance of either latent or sanctioned management groups may have several effects on other systems variables. For example, the presence of a centralized authority, either covert or visibly sanctioned by society, may have an effect on local and regional populations. The labor requirements associated with construction and maintenance of public buildings may have encouraged active recruitment of new settlers and possible participation in ritual ceremonies may have also encouraged immigration. If the groups residing at the center are perceived as successful in terms of standard of living and subsistence security, additional immigrants may be attracted to the settlement. Covert management groups might pursue wealth and status without primary regard to economic costs, even if acquired wealth must be accumulated in an inconspicuous form. Thus, such groups might encourage maximization of agricultural production above least cost requirements so as to acquire manipulable surpluses. Such surpluses could be used to fund redistributive ceremonies that would increase the status of the hosting groups or could be invested in status items, chiefly traded goods. The social model of change was primarily developed from the study of simple political systems in the prehistoric Southwest undertaken by Lightfoot (1984).

Explanations of prehistoric cultural process in the Dolores area are focused primarily on the economic and social subsystems as the major sources of change. Demographic variables, especially population growth and decline, are often employed by archaeologists as important factors in influencing cultural change. While it is recognized that demographic changes have profound effects on other cultural subsystems, shifts in population characteristics are viewed as part of the general economic cost structure or as being responses to social requisites rather than being independent developments (chap. 6).

GENERAL IMPLICATIONS OF THE SOCIAL AND ECONOMIC MODELS

Each model of change contains distinct implications for the timing of major changes within the cultural system and the directions of those changes. Essentially, the social model predicts change during the "good times" when production of an agricultural surplus is possible and can be manipulated to the advantage of leadership or management groups. The economic model predicts change during the "bad times" when economic costs are rising due to a combination of unfavorable or uncertain climate, high population density, and a decrease in the availability of agricultural land or other subsistence resources.

Implications for the Timing of Social Change

"Good times" or "bad times" at Dolores can be approximated by using climate and population estimates and agricultural production simulations (Petersen 1985; Schlanger, chap. 8; Wolf 1985). For example, Wolf's (1985) agricultural production and storage behavior simulations indicate the potential for generating agricultural surpluses was relatively high for the first 6½ decades of the ninth century (A.D. 800-864) given the virtually uniform favorable climate during this period.[1] Wolf's figures are based on Burn's (1983) tree-ring calibrated drought sequence for southwestern Colorado and Petersen's (1985) reconstruction of cold years when untimely frosts probably affected agricultural production. According to Wolf's figures (1985:figs. 16-20, 30-33), **per capita** excess production amounts (the amounts above annual consumption needs) are greatest in the A.D. 800's, 810's, 830's, and 850's; however, **gross** potential excess production figures are greatest for the A.D. 850's. Surplus production was possible for the earlier decades of the ninth century, but significant total surplus amounts were probably not produced until the middle ninth century given the estimated low indigenous population levels during the early portion of the A.D. 800-860 period. The "good times," or the conditions necessary for generating change according to the social model, are assigned to the window period A.D. 820 to 860 (population levels during the first 2 decades of the ninth century were probably not high enough to produce a significant useful surplus).

[1]According to Wolf's reconstruction, a short drought with mild predicted production shortfalls is present between A.D. 847-852.

"Bad times" are indicated by a combination of high population and climatic unfavorability. According to Schlanger (chap. 8), population at Dolores peaked in Period 4 (A.D. 840-880). It is thought that population levels were actually highest during the later decades (A.D. 860's and 870's); virtually all households constructed during the A.D. 840's and 850's continued to be in use during the last half of Period 4, and in addition, new residential units were constructed in the A.D. 860's and 870's (for example, the Weasel Pueblo and Aldea Alfareros roomblock units at McPhee Village [Kane 1985]). According to Wolf's (1985) simulation, agricultural production shortfalls might have been first encountered by Dolores groups in the late A.D. 840's and probably became a serious problem after A.D. 865. Climatic uncertainty was probably also a contributing factor, especially after A.D. 860 when a series of drought years alternated with good years (chap. 4, section 6). During the first 6 decades of the ninth century, crop failures due to freezes were probably not a problem; however, during the A.D. 860 to 910 period, 11 years with potentially crop-damaging freezes were recorded, including 4 consecutive years from A.D. 899 to 902. "Good years" in the late part of the 9th century and the early 10th century (A.D. 860-920) were not as favorable as those in the early 9th century in terms of production. Even though "surpluses" above annual needs could have been produced, both gross and per capita excess production amounts are less than during the earlier period. The "bad times" or the conditions sufficient to produce major change according to the economic model, are assigned the window A.D. 860-920.

Implications for the Direction of Sociocultural Change

The direction of the predicted changes is complex and may differ for specific cultural variables; essentially both models predict change in the direction of "intensification" in the economic subsystem (more emphasis on higher yielding crops or resources, more yield/unit of land, more total labor investment), in the demographic and organizational variables associated with production, and in the management of large aggregated groups. When considering social organization with reference to the economic model, overhead costs associated with social institutions should be minimized. Given production intensification, an expected necessity is the appearance and maintenance of managerial groups to coordinate complex production tasks, access to agricultural land, and aggregated populations. Political systems should be well integrated and characterized by cooperation; competition and status would be minimized because of the attendant high overhead costs. Basic shifts in production organization might be expected in response to rising costs and related changes in subsistence strategies and resource mix.

Somewhat different predictions for the direction of social organization are possible given the tenets of the social model. Simple political groups and social hierarchies based on these groups should be reflected in the archaeological record. Coincident with the rise of decision-making groups would be associated settlement and social phenomena such as the appearance of competing settlement systems, each with its own large, centrally located administrative center, networks of smaller satellite settlements and spheres of influence, and the use of status positions within each community.

Production of an economic surplus is a necessary condition for the social model; thus, the inherent economic organization of the groups on the threshold of a simple political society must have the capacity to produce a significant agricultural surplus. Once established, the managerial class should act conservatively to preserve the economic order that originally was and continued to be their source of power.

If the Dolores system was evolving in the direction of a tier power system (Stuart and Gauthier 1981), then the fledging leaders or managerial class would have gathered the trappings of power, including individual wealth. Such trappings might be in the form of personal material items, large or elaborate residences, or separate managerial facilities for the exercising of power.

In the following 2 sections, the economic and social models of change are assessed through an examination of the applicable archaeological data from Dolores. The examination is focused on 2 social subareas that appear particularly relevant to evaluating the models — vertical differentiation and economic organization. The timing of the appearance of managerial organizations and the extent to which the leaders or leadership class are able to attract power and wealth are critical areas in judging the applicability of the models. The timing and direction of changes in economic organization are also critical determinations in this assessment.

IDENTIFYING POLITICO-MANAGERIAL GROUPS IN THE ARCHAEOLOGICAL RECORD AND ESTIMATING THEIR INFLUENCE

Some of the general implications of the economic and social models are evaluated here by examining the relevant archaeological data from Dolores. The evaluation process consists of a search for the presence of possible managerial groups and sociopolitical hierarchies in the archaeological record, documentation of the timing of the appearance of these groups, and an assessment of the social power and wealth of these groups and social differences between the managerial class and the groups with less political power.

Identification of Possible Managerial Groups and Sociopolitical Hierarchies

The presence of managerial groups in the prehistoric record at Dolores might be signaled by the appearance of settlement hierarchies (large residential centers surrounded by a network of smaller settlements) and through the simultaneous presence of aggregated residence units and nondomestic architectural facilities (where managerial activities were enacted) at the primary residential centers.

According to the implications developed from the social model, settlement hierarchies and managerial architecture would be expected to appear in the archaeological record in the window A.D. 820 to 860, or during late Period 3 or early Period 4; according to the economic model, the predicted appearance would be somewhat later and should closely parallel the population growth curve for the area (A.D. 860 to 920). The critical difference is that in the social model, the appearance of managerial groups and the attendant settlement and architectural configurations should precede peak population periods, if economic production and organization were sufficient to generate a manipulable surplus and that enough initial population was present to support an administrative elite. In the economic model, the appearance of managerial groups should be a response to the necessities of efficiently administering large aggregated populations to produce subsistence goods at the least possible cost. Social model managerial groups **attract** population into aggregated settlements if they are successful; economic managerial groups are a **response** to the economic demands and administrative necessities of population growth and aggregation.

Orcutt (chap. 10) has analyzed the relevant settlement patterns at Dolores by period and suggests three-tiered (3 distinctive size rankings) settlement hierarchies were present in Periods 4 and 5; simpler two-tiered patterns were present during Periods 1, 2, and 3. Therefore, the search for the appearance of managerial groups and other related settlement and architectural correlates was focused on Period 4 (A.D. 840-880) and the immediately preceding time span (Period 3, A.D. 800-840). Inspection of the survey and excavation data from the project area led to the identification of 7 relatively large settlements-McPhee Village, Windy Ruin, Cline Crest Ruin, Grass Mesa Village, May Canyon Ruin, Rio Vista Village, and House Creek Village (table 14.1; fig. 14.1) – which were assumed to be the residential locations of managerial and status groups (the upper tier in a social hierarchy). These settlements are characterized by clustered aggregations of roomblock units (less than 75 m between contemporaneous roomblocks within the aggregated settlement). Based on excavation data from 4 of the 7 villages, aggregated settlements may contain as few as 7 roomblocks with less than 200 m of total roomblock length (House Creek Village) to more than 20 roomblocks with roomblock length totals exceeding 1000 m (McPhee Village). Oversized pitstructures, thought to be locations of intergroup ritual activities, are present at each of these settlements. These larger settlements, defined as the upper tier, are clearly differentiated from smaller settlements of the same time frame, which consists of 1 to 3 roomblocks with less than 100 m of total roomblock length. A quantitative test of this proposed dicotomy utilizing a rank-size distribution of settlements in the project area dating to the A.D. 840-880 period was not attempted; however, settlement analysis of individual community catchments (cf. Kane 1985) seem to support the proposed dicotomy. Thus a two-tier settlement hierarchy for Periods 4 and 5 rather than the three-tier construct proposal by Orcutt is adopted here.

The "oversized" pitstructures, thought to possibly represent the locations of managerial activities, are comparatively large (mean floor area = 46.6 m^2 versus 25.5 m^2 for all Period 4 pitstructures) with feature assemblages more indicative of ritual or ceremony than domestic functions. Traditionally, it has been assumed that great kivas might fulfill this role; however, at Dolores only one Period 4 great kiva was identified (at Singing Shelter [Nelson and Kane 1985]), and it is not within the limits of a large settlement. Rather, it is adjacent to the smallest upper-tier settlement, and is fairly close to 3 other uppertier locations as well. This socially neutral position suggests the structure may have functioned as an intercommunity integrative facility.

A size-rank distribution analysis of all Period 4 pitstructures (fig. 14.2) suggests 2 distinct size populations: first, those pitstructures with less than 32 m^2 of floor area and second, those with more than 34 m^2. This division is assumed to represent functional classes.

An examination of the feature assemblages of the large pitstructures suggests a correlation between large size and the presence of ritual features — rectangular central pit (or rectangular central vaults), lateral vaults, paho marks, and cylindrical sand-filled pits interpreted to be possible altar anchors (Wilshusen 1985). Structures with combinations of these particular features are assumed to be locations of regularly performed rituals or ceremonies and of managerial functions performed by groups who used the ceremonies as a medium for exerting their authority (Wilshusen 1985:49-50); he proposes (1985:45-48) a three-tiered hierarchy of ritual activity based on the complexity of ritual-associated features.

Wilshusen (1985:45-46) also suggests that red ware pottery exchange and deliberate ritual burning at abandonment were activities associated with pitstructures

Table 14.1 – Assumed upper tier settlements in the Dolores Project area

Site name/ site number	Location	Total roomblocks (N)	U-shaped roomblocks (N)	Total room-block length (M)	Oversized pitstructures		Pitstructures containing central vaults	
					Documented (N)	Estimated total (N)	Documented (N)	Estimated total (N)
McPhee Village*	On first terrace above flood plain west of river, within confines of canyon	20	2	855	5	7	5	12
Windy Ruin/ 5MT4353	On mesa top west of river canyon	13	1	484	0	7	0	9
Cline Crest Ruin/5MT2663	On mesa top west of river canyon	10	1	468	3	8	0	10
Grass Mesa Village/5MT23	On low mesa headland within confines of canyon east of river	9(?)	0	390	5	5	9(?)	14
May Canyon Ruin/5MT6794	On mesa top east of river canyon	15	0	370	0	3	0	12
Rio Vista Village/5MT2182	On talus of main canyon east of river	7	0	230	1	1	2	6
House Creek Village/5MT2320	Low, flat area north of House Creek and east of river	7	0	168	0	1	0	5

* For a list of sites associated with McPhee Village, refer to chapter 1.

containing rectangular central vaults. The correspondence between oversized pitstructures (>34 m²) and rectangular central vaults is especially striking; all oversized pitstructures contain these features according to the excavation data. A number of smaller but still relatively large pitstructures also contain rectangular central vaults. Here, Wilshusen's basic model is adopted: pitstructures containing features in the uppermost tier are thought to be the most likely location of managerial functions; pitstructure size is also concluded to be an important criterion.

Eleven Period 4 pitstructures with floor areas greater than 34 m² have been positively identified in the project area (table 14.2) and all are located within the proposed upper-tier settlements. Of the 4 upper-tier locations investigated through excavation programs (Grass Mesa Village, McPhee Village, House Creek Village, and Rio Vista Village), 3 had at least 1 oversized pitstructure. The possible exception, House Creek Village (Robinson and Brisbin 1984:26-35), was not as extensively investigated as the other locations. Magnetometer survey results suggest the possible presence of more large pitstructures in areas not examined by the excavation crews. Magnetometer survey also suggests the possible presence of 3 oversized pitstructures at Cline Crest Ruin (Huggins 1983:181-194); this inference was based on an estimated diameter of over 10 m for 1 structure (Pitstructure 15) and on a correlation between the relatively high magnetometer readings (indicating strong burning) and the relatively large size of the magnetic anomalies for 2 other pitstructures (Pitstructures 2 and 11).

Four oversized pitstructures positively or possibly dating to Period 3 are also present in the Dolores data. Two of these are at smaller, single roomblock (lower tier) sites: Pitstructure 2 at Windy Wheat Hamlet, Site 5MT4644 (Brisbin 1984b), was completely excavated but did not contain a central vault, and hence is not included in the sample; Pitstructure 2 at Squawbush Hamlet, Site 5MT2322 (Harriman 1984), was incompletely excavated and the presence or absence of a central vault could not be ascertained. Pitstructure 68 at Grass Mesa Village (Varien 1985) may be a Period 3 oversized structure, but the temporal placement of the structure is not firm and an estimate of feature assemblages was not obtained. One other case for a Period 3 oversized pitstructure is at Site 5MT4692, just south of McPhee Village. Although the site was not excavated, surface investigations and magnetometer survey indicated the presence of 2 or 3 roomblock units with 8 or more pitstructures, including 1 with an estimated 45 m² in floor area. Ceramic type frequency dating of

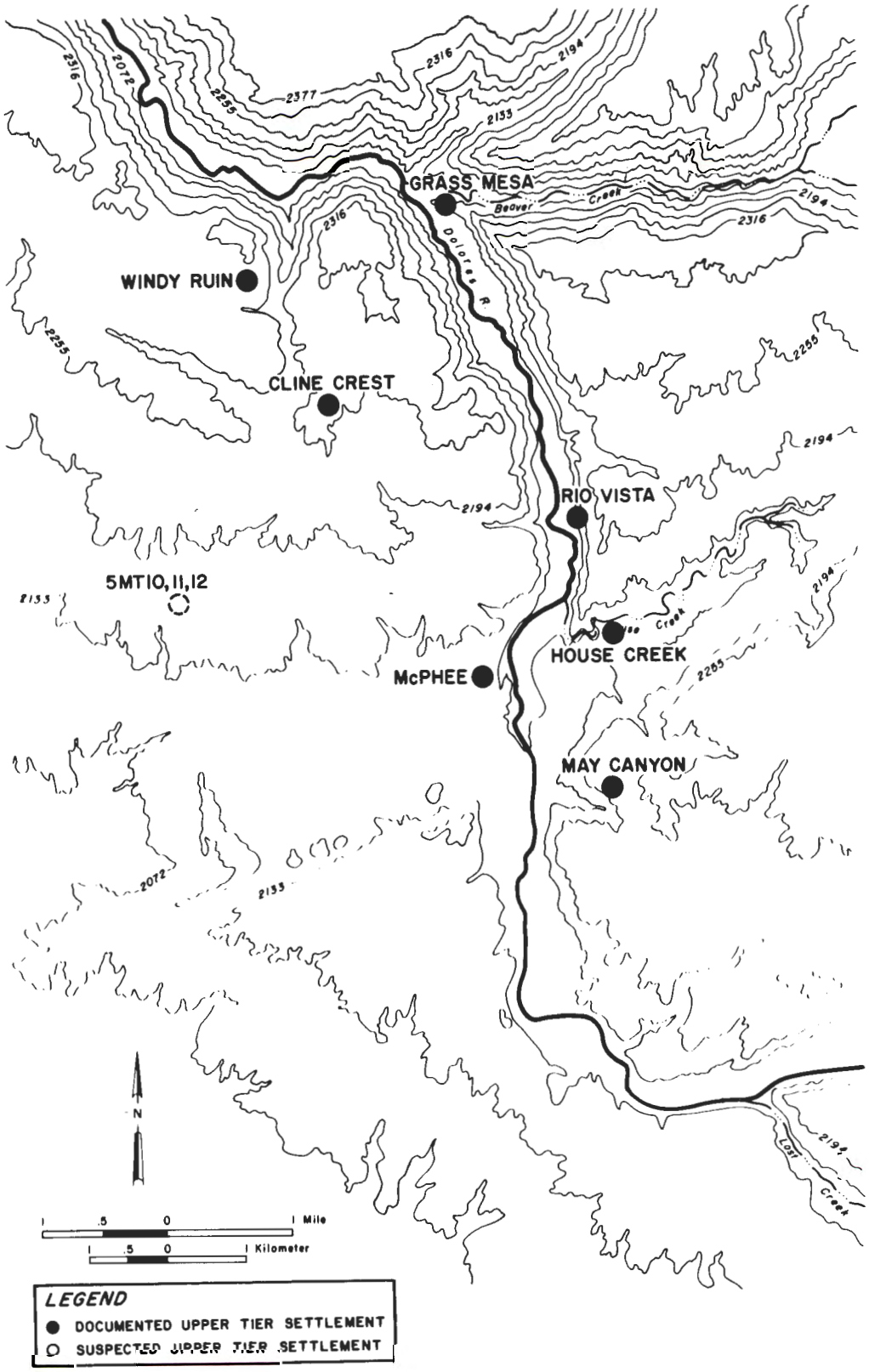

Figure 14.1 – Locations of Period 4 upper-tier settlements in the Dolores area.

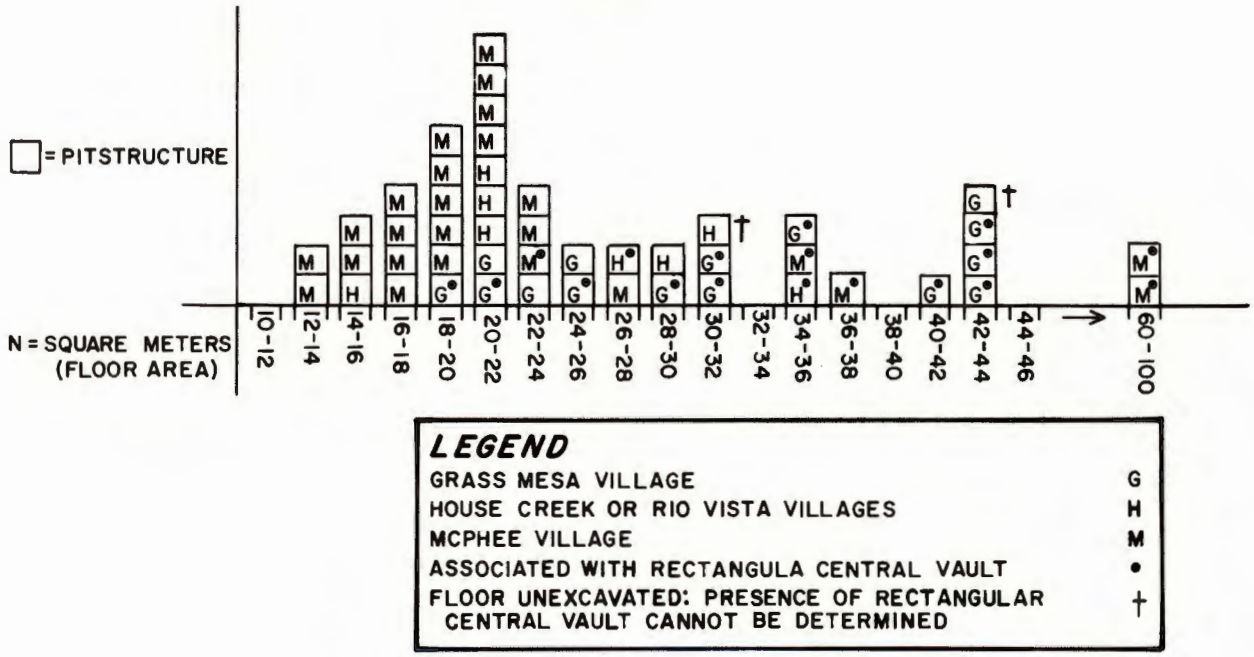

Figure 14.2 – Size-rank distribution of all Dolores Archaeological Program Period 4 pitstructures.

the surface materials suggests most of the site was occupied in Period 3 (A.D. 800-840).

In summary, the settlement evidence from Dolores consists of the presence of a residential site hierarchy with multiple (at least 7) roomblock units comprising the upper tier and up to 3 roomblock units in the lower tier. Architectural facilities that indicate possible managerial locations are present at the upper-tier settlements. These are "oversized" pitstructures (floor area greater than 34 m^2) with particular assemblages of ritual features. In the ritual hierarchy developed by Wilshusen (1985), these pitstructures constitute the uppermost tier. These pertinent settlement and architectural configurations are generally manifested in the ninth century and their presence is a general implication of either model. A more thorough analysis is necessary to narrow the temporal placement of their first appearance, as timing is a critical test for both models.

Dating the Appearance of Managerial Groups

Dating the appearance of the relevant settlement and architectural configurations is an important test in evaluating the "fit" of the social or the economic model. The social model would predict appearance of managerial groups relatively early in the A.D. 820-860 window, while the economic model would predict appearance relatively late (A.D. 850-920). Relevant here are first, the architectural development of the village settlements in the upper tier of the hierarchy including the appearance of multiple interhousehold roomblocks and aggregations of these and smaller roomblocks; second, the development of settlement hierarchies with the upper-tier settlements serving as managerial centers; and third, the appearance of oversized pitstructures with ritual feature assemblages.

Tree-ring dates (appendix A) and ceramic type dating suggest relatively lengthy spans of occupations for the 7 upper-tier settlements, with initial occupation in the early A.D. 800's or even late A.D. 700's and abandonment in the last 2 decades of the 9th century or perhaps as late as the first decade of the 10th century. This apparently long occupation history of the critical settlements has resulted in a difficult problem for DAP staff archaeologists. The critical period for evaluation of the models is the early and middle A.D. 800's; however, the archaeological manifestations examined by the field crews and laboratory staff are generally the abandonment configurations (A.D. 880-910). The critical evidence has in many cases been obscured by remodeling or by prior abandonment and superposition of newer architecture. Thus, in many cases, only indirect evidence can be brought to bear on the problem. Relevant excavation evidence is available from the 4 assumed upper-tier settlements partially excavated by the Dolores field crews and from several uncontaminated Period 3 settlements.

At Grass Mesa Village, stratigraphic interpretation and ceramic type dating suggest the site area was first occupied in the eighth century, possibly around A.D. 750

Table 14.2 – Village-associated Period 4 oversized pitstructures identified in the Dolores area

	Contemporaneous associations	Size (m^2)	Ritual feature content	Reference
Grass Mesa Village Pitstructure 3	Associated with Roomblock Unit 39, the largest recorded roomblock in the project area. The roomblock unit contains over 73 surface rooms and 12 or more pitstructures, including 1 other (Pitstructure 33) classified as oversized	40.7	Roofed rectangular central vault, cylindrical sandfilled pits (altar anchors), paho marks	Breternitz and Morris (1985:5.60-5.115)
Grass Mesa Village Pitstructure 26	Associated with Roomblock Unit 19. The roomblock unit contains approximately 25 to 30 surface rooms and 5 pitstructures, including 1 classified as oversized (Pitstructure 29).	42.9	Unknown (floor not excavated)	Morris (1985a:8.102-8.103)
Grass Mesa Village Pitstructure 29	Associated with Roomblock Unit 19 (contained in the same roomblock unit as Pitstructure 26)	43.6	Unknown (floor not excavated)	Morris (1985a:8.108-8.110)
Grass Mesa Village Pitstructure 33	Associated with Roomblock Unit 39 (contained in the same roomblock unit as Pitstructure 3)	43.5	Roofed rectangular central vault, cylindrical sandfilled pits (altar anchors); may have other ritual features (floor incompletely excavated)	Varien (1985:4.405-4.417)
Grass Mesa Village Pitstructure 82	Associated with Roomblock Unit 23. The roomblock contains 10 to 15 surface rooms	43.0	Roofed rectangular central vault, cylindrical sandfilled pits, paho marks	Morris et al. (1985:6.210-6.222)
Rio Vista Village Pitstructure 201	Associated with Roomblock Unit 3. The roomblock unit contains 20 to 25 surface rooms and 1 other pitstructure	34.6	Roofed rectangular central vault, cylindrical sandfilled pits	Wilshusen, comp. (1985:463-490)
McPhee Village Pitstructure 3 at McPhee Pueblo	Associated with a large horseshoe-shaped roomblock unit with 35 to 45 surface rooms and 5 other pitstructures	67.5	Roofed rectangular central vault, lateral vaults, cylindrical sandfilled pits, paho marks	Brisbin et al. (1985:271-338)
McPhee Village Pitstructure 2 at Mesa Negra Pueblo	Associated with a large roomblock complex north of McPhee Pueblo. The roomblock unit contains 40 to 50 surface rooms and 4 other pitstructures, including 1 classified as oversized (Pitstructure 6)	37.7	Roofed rectangular central vault, lateral vaults, cylindrical sandfilled pits, paho marks	Kuckelman (1984:56-120)
McPhee Village Pitstructure 6 at Mesa Negra Pueblo	Associated with a large roomblock unit north of McPhee Pueblo (contained in the same roomblock unit as Pitstructure 2)	45.5	Unknown (floor not excavated)	Kuckelman (1984:140-142)
McPhee Village Pitstructure 4 at Tres Chapulines Pueblo	Associated with a large roomblock unit east of McPhee Pueblo; the roomblock unit contains approximately 50 surface rooms and 5 other pitstructures	38.5	Large circular pit, smaller rectangular slab-lined pit, probably has other features (floor incompletely excavated)	Chenault (1983:46-51)
McPhee Village Pitstructure 9 at Pueblo de las Golondrinas	Associated with a large, horseshoe-shaped roomblock unit northeast of McPhee Pueblo; the roomblock unit contains approximately 50 surface rooms and 3 other pitstructures	63.7	Roofed rectangular central vault, lateral vaults, cylindrical sandfilled pits, paho marks	Brisbin (1984a:99-113)

(Lipe et al. 1985:18.63), with perhaps as many as 40 households residing at the village by A.D. 800. Lipe et al. (1985:18.66-18.67) and Kohler (1985) believe population levels during the early ninth century were lower, perhaps averaging about 20 households. This inference is based on the scarcity of structures dating to this period, as evidenced by tree-ring samples and ceramic collections; an alternate interpretation would suggest higher populations, but increased structure longevity. That is, if pitstructures and surface rooms built relatively early were continually occupied and merely refurbished (including replacement of roofing timbers) rather than abandoned and replaced with new structure, then the ceramics and tree-ring samples recovered from the continually occupied structures would only reflect the last use with little evidence for the early use. Such behavior might be anticipated in comparatively sedentary groups and is hinted at in some of the Grass Mesa data: based on the location of early pitstructures, the basic configuration of roomblock units was established early in the history of the site, a pattern that may have not survived if the site was virtually abandoned in the early A.D. 800's, and the frequent reuse of early timbers in late structures suggests refurbishment rather than abandonment and new construction. The important points here are that the site had a substantial pre-A.D. 840 population and the primary roomblock configurations of the site were established at a fairly early time during the occupation of the settlement.

At McPhee Village, early occupations have been documented at the Pueblo de las Golondrinas (Brisbin 1984a) and McPhee Pueblo roomblock units (Brisbin et al. 1985). At Pueblo de las Golondrinas, Pitstructure 2 is inferred to have been originally constructed in A.D. 829 or 830 (Brisbin 1984a:64) and this structure is superimposed on an earlier pitstructure; there are also substantial pre-A.D. 850 deposits in the midden (Brisbin 1984a:206, table 40). Brisbin (1984a:216-227) suggests the roomblock unit was a substantial residential complex (4 pitstructures and 35 to 40 rooms) during Element 2 (A.D. 780-825) and developed into its archaeological configuration (4 pitstructures, including 1 oversized example, and about 50 surfaces rooms) during the early part of Element 3 (A.D. 830-880). Thus, this roomblock unit is thought to have conformed to the pattern indicative of the presence of managerial groups at a relatively early (pre-A.D. 840) time. At McPhee Pueblo, the architectural configuration investigated by the field crews may have been superimposed on an earlier, pre-A.D. 850 roomblock (Brisbin et al. 1985:23, fig. 8); the midden also contains a substantial lower deposit of pre-A.D. 850 materials, based on ceramic type frequency dating of the excavated strata (Brisbin et al. 1985:26).

At Rio Vista Village, pitstructures thought to have been constructed in the AD. 780's and 790's were present in the northern 2 roomblock units (Wilshusen, comp. 1985:235, 309); other construction of this settlement appears to date to the post-A.D. 850 period.

Finally, at House Creek Village, Robinson and Brisbin (1984:179-195) suggest the occupation of this settlement may have been initiated before A.D. 800 and the use of Pitstructure 4 in particular was probably during Period 3 (A.D. 800-840). Thus, it can be established that the large settlement locations were in use long before the inferred period of maximum population at Dolores in the A.D. 860's and 870's. However, the continuous use of the settlements through the early A.D. 800's and the initiation of the role of these primary population centers as locations of managerial functions is more difficult to document.

Relevant settlement data from other occupations dating to earlier periods is not abundant. Whether this scarcity represents an accurate facet of the archaeological record, sampling error because of later superposition, or administrative limits on DAP field investigations is difficult to assess. Periman Hamlet (Site 5MT4671 [Wilshusen 1983; Yarnell 1983]) exhibits a possible early trend in aggregation of roomblock units. At this site, 3 small single pitstructure roomblocks are adjacent to one another; temporal interpretations based on ceramic type frequency and archaeomagnetic dating suggests all these may have at least been partially contemporaneous during the early part of Period 3 (A.D. 800-820). Periman Hamlet thus can be interpreted as a possible example of early settlement aggregation in the area before the massive population build up in the middle ninth century. However, at this site none of the roomblocks is associated with multiple or oversized pitstructures.

A second example that perhaps is more telling is Site 5MT4692; however, interpretations based on the data from this site are tentative as the site was not excavated but was subjected to a surface artifact collection and to a magnetometer survey in search of pitstructures (Huggins and Weymouth 1981). The available evidence suggests the presence of 2 to 3 aggregated roomblock units with a total of 8 to 9 pitstructures. The central roomblock unit probably contains 5 pitstructures, based on the magnetometer evidence, with 1 (Pitstructure 6) probably being an oversized facility. Ceramic dating of the surface collection suggests the main occupation of the site was in the A.D. 800-840 period. Thus, Site 5MT4692 may be a Period 3 settlement with multiple roomblocks, one of which is associated with more than 2 pitstructures and an oversized facility. In terms of the patterning of architectural units, Site 5MT4692 bears a very close resemblance to the A.D. 830's and 840's architectural configuration at Pueblo de las Golondrinas (Brisbin 1984a:fig. 68), i.e., a long

cresent-shaped roomblock with 4 to 5 pitstructures. Such configurations may indicate the early presence of local groups with a managerial structure.

Here, it is assumed that the initiation of possible administrative or managerial functions at upper-tier settlements is coincident with the initial construction of the associated oversized pitstructures. Tree-ring cutting dates of A.D. 852, A.D. 866, A.D. 871, and A.D. 874 were recovered respectively from roofing materials associated with oversized pitstructures at Grass Mesa Village (Pitstructure 3), Rio Vista Village (Pitstructure 201), and the Masa Negra Pueblo (Pitstructure 2) and McPhee Pueblo (Pitstructure 3) roomblock units at McPhee Village (appendix A). With the exception of the Grass Mesa and the Rio Vista pitstructures, these dates probably do not represent construction dates, but appear to represent the last time the pitstructure underwent major refurbishment, including replacement of the roof. Most oversized pitstructures underwent at least one major refurbishing based on the presence of capped vertical support postholes or superimposed floor surfaces. Wilshusen (1985) suggests the ritual features in these structures probably were regularly commissioned and decommissioned, perhaps in response to the necessities of regularly scheduled ceremonial events; hence, the case for major refurbishment must be based on main post support modification or superimposed floor surfaces. The dating assignment interpretations for the 11 oversized pitstructures identified in the DAP area are presented in table 14.3. The table suggests 2 of the pitstructures may have been constructed as early as the A.D. 830's or 840's and 2 as late as the A.D. 860's, but that most were probably constructed in the A.D. 850's. Thus, construction seems to coincide with the period of maximum rates of population growth but is earlier than the probable time of maximum total population levels.

In summary, some evidence indicates that the settlement and architectural configurations thought to be indicative of managerial groups, i.e., aggregated roomblock unit settlements and oversized pitstructures, preceded or was coincident with the period of maximum population growth and preceded the period of maximum population density in the project area. The evidence, unfortunately, is not as conclusive as it might have been if more directed excavated strategies had been implemented and if much of the evidence examined during excavation was not obscured by later occupations. However, when considered in total, the available evidence seems to support the relatively early appearance of managerial groups. Critical questions addressed in the following 2 sections are concerned with the influence of these groups within the social framework of Dolores communities and the role of these groups in intercommunity relationships.

Testing the Models: the Settlement Data

In this section, the implications of the economic and social models of prehistoric change will be tested using DAP settlement data. The tests are mostly based on the locations of the upper-tier villages in the settlement hierarchy and the network of lower-tier smaller hamlets surrounding each village (the network of smaller settlements plus the central village is the area occupied by the community). A brief discussion of aggregation is included.

One implication of the economic model is that settlement size should correlate with the potential economic production of the catchment associated with the individual upper-tier settlements; conversely, according to the social model, settlement size should correlate with the effectiveness and influence of the managerial class at the particular settlement.

Potential economic production figures for the catchments of the 7 upper-tier settlements were calculated using environmental data derived from Orcutt (1985a:tables 9 through 15). Predicted settlement size rankings were then derived from the production figures, and compared with the actual settlement sizes. In figure 14.3, the solid bars are the predicted settlement size from largest to smallest, while the clear bars are the actual sizes. The numbers reflect the actual population ranks of the settlements. A Spearman rank correlation coefficient was calculated for the actual versus the expected values; the rho value is 0.357, indicating a weak positive correlation. This correlation is not statistically significant ($P = 0.216$). Most of the actual sizes are smaller than predicted, while 2 (Grass Mesa and McPhee Villages) are much larger. This analysis suggests factors other than simple economic efficiency were responsible for the "success" (in terms of total population) of individual communities; social factors including managerial efficiency or the perception of successful leadership may have been partially responsible. Assuming all 7 upper-tier settlements were initially settled at virtually the same time, the actual estimated population levels illustrate a large range (the largest settlement, McPhee Village, is more than 5 times as large as the smallest, House Creek Village). This suggests differential growth rates among the upper-tier settlements, a phenomenon that supports the social model (Lightfoot 1984:66-67).

A second set of test implications derived from the models concerns central place tendencies. The appearance of competing managerial groups as predicted by the social model implies certain spacing particular to different tiers in the related settlement system hierarchies. For example, in a two-tier hierarchy, the small

Table 14.3 – Dating summary for village-associated Period 4 oversized pitstructures identified in the Dolores area

	Sources of dating inference*	Summary of dating assignment argument
Grass Mesa Village Pitstructure 3	Ceramic dating of associated fills suggests last use of upper floor (Surface 1) between A.D. 875 and 910. Pitstructure is beneath 2 Grass Mesa Subphase structures dating to A.D. 880-910. Archaeomagnetic date of A.D. 855-975 obtained from hearth in lower floor, date of A.D. 860-890 obtained for hearth in upper floor. Tree-ring cutting date of A.D. 852r obtained from post in ventilator fill	The A.D. 852 timber is interpreted to represent original construction; a later refurbishing of the main chamber roof did not include the ventilator. Suggested use is between A.D. 852 and 885.
Grass Mesa Village Pitstructure 26	Ceramic dating of postabandonment fills suggest they were deposited after A.D. 860. Spatial patterning suggests this structure is contemporaneous with Pitstructure 29	A precise dating interpretation is not possible given the available evidence. It is suggested that Pitstructure 26 is contemporaneous with Pitstructure 29 (A.D. 850's to 880's)
Grass Mesa Village Pitstructure 29	Ceramic dating of postabandonment fills suggest they were deposited after A.D. 860. Pitstructure 28, dating to A.D. 880-910, is superimposed on Pitstructure 29	The dating evidence for this pitstructure does not allow a precise interpretation. It is suggested that it is contemporaneous with the other Grass Mesa oversized structures (A.D. 850's to 880's)
Grass Mesa Village Pitstructure 33	Ceramic dating of associated fills suggests upper floor dates no earlier than A.D. 860. Pitstructure 34, dating to A.D. 880-910, is superimposed on Pitstructure 33; archaeomagnetic date of A.D. 845-865 obtained from hearth in lower floor	The available evidence suggests the upper floor was used in the A.D. 860's and 870's; thus the lower floor was probably used in the A.D. 850's; this interpretation is consistent with the archaeomagnetic date. Suggested use is between A.D. 850 and 880.
Grass Mesa Village Pitstructure 82	Pitstructures 80 and 81, dating to A.D. 880-910 are superimposed in Pitstructure 82. Archaeomagnetic date of A.D. 865-945 obtained from hearth in upper floor. Tree-ring date of A.D. 861vv obtained from post in roofing materials	The A.D. 861 date is interpreted to represent remodeling, suggesting the last roof was constructed in the A.D. 860's. The lower floor was probably used in the A.D. 850's. Suggested use is between A.D. 850-885, which is consistent with the archaeomagnetic date
Rio Vista Village Pitstructure 201	Tree-ring cutting date of A.D. 866rG from post in roof fall stratum. Archaeomagnetic date of A.D. 855-910 obtained from floor-associated hearth	The A.D. 866 date is interpreted to represent construction. Suggested use is between A.D. 866 and 885, which is consistent with the archaeomagnetic date
McPhee Village Pitstructure 3 at McPhee Pueblo	Tree-ring cutting date of A.D. 874r from post in roof fall stratum. Archaeomagnetic dates of A.D. 870-890 and A.D. 880-890 obtained from hearth in upper floor; archaeomagnetic date of A.D. 890-910 obtained from north wall. Ceramics associated with lower floor date to A.D. 825-910	The A.D. 874 date is thought to represent remodeling; original construction was probably 15 to 20 years earlier. Suggested use is between A.D. 860 and 895, which is consistent with the archaeomagnetic dates
McPhee Village Pitstructure 2 at Masa Negra Pueblo	Ceramic dating of use-associated and postabandonment fills is A.D. 900-930. Archaeomagnetic date of A.D. 860-950 obtained from hearth in upper floor. Tree-ring cutting date of A.D. 871r obtained from post in roof fall materials	The A.D. 871 date is thought to represent remodeling. Suggested use is between A.D. 855 and 890; this interpretation contradicts the ceramic dates; however, the upper floor assemblage may have been contaminated by subsequent refuse deposition
McPhee Village Pitstructure 6 at Masa Negra Pueblo	Spatial patterning suggests Pitstructure 6 is contemporaneous with Pitstructures 1, 2, 3, and 4	A precise interpretation is not possible; it is suggested that the use of Pitstructure 6 parallels that of Pitstructure 2 (A.D. 855-890)
McPhee Village Pitstructure 4 at Tres Chapulines Pueblo	Spatial patterning suggests Pitstructure 4 is at least in part contemporaneous with the other Tres Chapulines pitstructures	A precise interpretation is not possible; Pitstructure 4 is probably contemporaneous with the general use of the site (A.D. 845-880)
McPhee Village Pitstructure 9 at Pueblos de las Golondrinas	Archaeomagnetic date of either A.D. 850-870 or A.D. 885-925; spatial patterning suggests Pitstructure 9 is contemporaneous with Pitstructures 1, 2, and 10	A precise interpretation is not possible; Pitstructure 9 is probably contemporaneous with the use of the main architectural configuration of the roomblock (A.D. 830-880)

* Appropriate site report references are reported in table 14.2.
r – Less than full section is present, but the outermost ring is continuous around available circumference.
vv – There is no way of estimating how far the last ring is from the true outside.
G – Beetle galleries are present on the surface of the specimen.

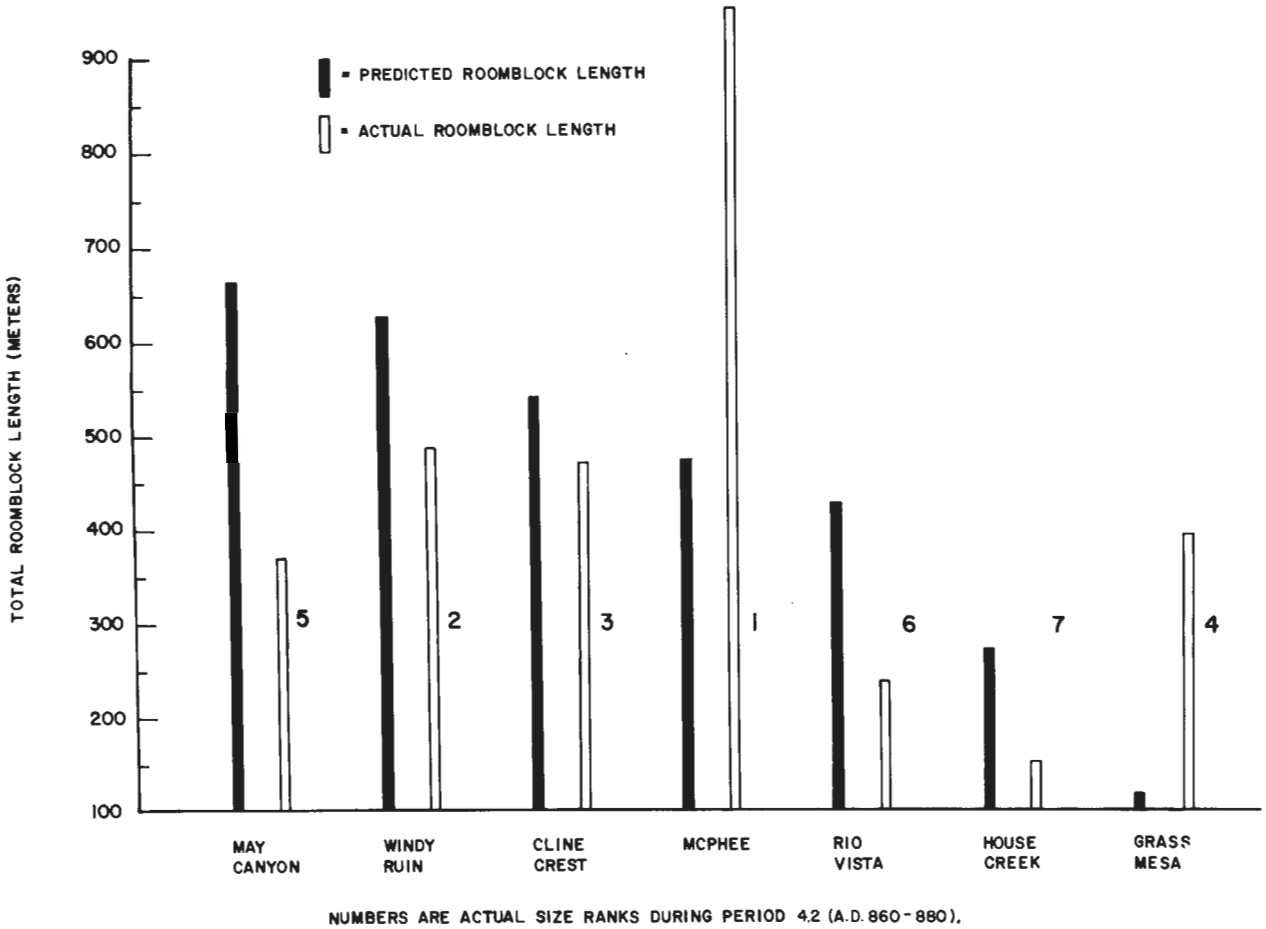

Figure 14.3 – Comparison of predicted settlement size and actual settlement size. Predicted settlement size is derived from calculation of potential economic production of settlement catchments (from Orcutt 1985a:fig. 4 and tables 9 through 15).

settlements in the lower tier would be expected to cluster around the upper-tier large central villages, while the villages considered as a group should exhibit a tendency toward even spacing, indicative of intercommunity competition. Competition among villages would be very minor or nonexistent given the tenets of the least cost model, because of overhead costs. Rank-size distributions are also indicative of social hierarchies and the nature of intercommunity relationships. "Primate", or concave, distributions (with only 1 settlement in the highest size ranking) may be indicative of a system where one settlement functions as an administrative center for a number of smaller ones. Convex distributions may indicate several competing political centers, and log-normal distributions may be suggestive of well-integrated political systems (arguments derived from Lightfoot's [1984] treatment of political dynamics in the prehistoric Southwest).

A nearest neighbor analysis (Hodder and Orton 1976:40-41) of the upper-tier settlement locations (fig. 14.1) suggests a more random than even distribution (*RE/RA* = 1.3, where 1.0 is random spacing and 2.15 is exactly even distribution). If an eighth possible upper tier settlement located just outside the project area to the west (Sites 5MT10, 11, and 12 [fig. 14.1]) is added to the case set, the nearest neighbor statistic jumps to 1.5. The actual location of the eighth possible upper-tier settlement is unknown, and this will affect the nearest neighbor statistic since an arbitrary point was used in the calculation. These values are interpreted as not reflecting a significant trend toward even spacing.

A different way of looking at Dolores area settlement during Period 4 is to consider it as 2 competing systems separated by the river. Settlements on the west side of the river would not compete strongly for land or local resources on the east side and vice-versa. The river would be a formidable obstacle to travel and communication during the runoff season, which would coincide with spring planting. Considered as 2 separate east and west groupings, the relevant statistics are much higher (*RE/RA* = 2.01 for the upper-tier settlements on the east side of the river and 1.78 for those on the west

side if the eighth possible settlement on the west periphery of the project area is included [fig. 14.1]). These values are much more indicative of even spacing and tend to support the hypothesis of intercommunity competition. Admittedly, sampling error is a potential problem in this analysis as only 4 settlements are included in each group. Edge effects, however, are probably not a factor as the large settlements on the east side mark the east limit of the two-tiered Period 4 settlement system and archaeological survey on the west side suggests all potential nearest neighbors have been identified.

Orcutt (chap. 10) has analyzed other pertinent portions of the settlement data and reports the following results:

1. Small settlements and medium settlements exhibit clustered distributions during Periods 2 and 3, implying the absence of social hierarchies.

2. Small settlements are clustered around large settlements in Periods 4 and 5, conforming to the predictions for settlement patterns if managerial groups are present.

3. Large settlements are randomly distributed during Period 4 and grouped medium and large settlements (including Sites 5MT10, 5MT11, and 5MT12 [fig. 14.1]) exhibit a weak trend toward even spacing in Period 5. This finding is essentially similar to the nearest neighbor discussed earlier in this report. Orcutt (chap. 10) used site rubble area rather than roomblock length to generate the rank-size distributions and did not consider the possible effects of the Dolores River on settlement.

4. Rank-size distribution for all settlements conforms to the log-normal pattern indicative of well-integrated settlement social systems. Period 5 rank sizes exhibit a log normal distribution.

Aggregation is another aspect of settlement that has bearing on the applicability of either model. In the economic model, aggregation is viewed as a solution to the increased costs of higher population density and the increased emphasis on agricultural production (agricultural intensification). According to Orcutt (1985b:38-39) increases in population density or resource mix intensification would produce an increase in the measures of aggregation. Aggregation is viewed as the cheapest solution to population packing and crowding, and to meet the labor requirements of an economy dependent to a large degree on agricultural production. In the project area, where agricultural land and water are both relatively abundant, aggregation would occur reluctantly and only in association with substantial increases in population, agricultural intensification, and economic costs and risks (Lipe, chap. 6). In contrast, in the social model, aggregation is viewed as an aspect of the successful development of leadership and the recruitment of followers (Lipe, chap. 6). It may also reflect competition among centers in the social hierarchy; that is, it may indicate warfare or feuding between neighboring centers. Dispersed populations may be attracted to large settlements because of their relative safety under such conditions. In the social model, aggregation may precede or at least be uncorrelated with the rate of population increase and the degree of agricultural intensification.

Orcutt (1985b) adopted 2 primary approaches in her treatment of prehistoric settlement aggregation. In the first approach, household aggregation was measured as mean number of households for each individual rubble area (roughly equivalent to a roomblock unit), the percent of rubble areas with each designated household size, and the proportion of total households that occur in rubble areas of each household size. In the second approach, spatial aggregation was measured as the average distance between rubble areas, the average distance to the nearest rubble area, the average distance to the nearest 2 rubble areas, the average number of households 100 to 1500 m from a rubble area, and the total number of households/quarter section (Orcutt 1985b:6). While levels of household aggregation correlate fairly well with levels of population – population density and aggregation are both highest in Periods 5 and 7.2 (fig. 14.4) – household aggregation and population increase at the same time during the critical time span (A.D. 600-980, Modeling Periods 1-6). In figure 14.4, the greatest rate of increase in household aggregation is shown to be between Periods 2 and 3 (A.D. 760-820), and the greatest rate of increase for population density is between Periods 3 and 4 (A.D. 820-860). This phenomenon is also apparent in Orcutt's other graphic displays; for example, during Period 2, 56 percent of the population resided in roomblock units with 5 or less households, while during Period 3 this figure shrank to 40 percent (Orcutt 1985b:fig. 3). She also compared aggregation with 6 different variables and variable combinations, each of which could be interpreted as a proxy for resource mix intensification.

This author interprets the lack of significant positive correlation between aggregation and resource mix intensification (proxied as climatic stress) as indicating that household aggregation levels increase before resource mix intensification until the latter "catch up" during Period 5. The correlation between spatial aggregation and population seems stronger when considering periods of increase. However, indications are that spatial aggregation increased earlier than expected. For example, when the average number of households within 100 m of each other was evaluated, they more than doubled between Periods 2 and 3 while population

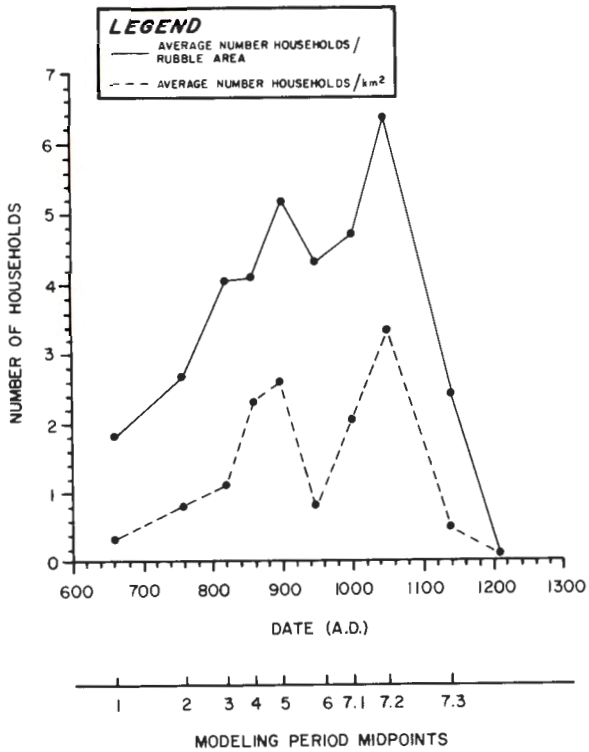

Figure 14.4 – Comparison of household aggregation and levels of population density in the Dolores area by time period. From Orcutt (1985b:fig. 16).

density increased only slightly. Again, no significant positive correlation is shown between the predicted rank orders of spatial aggregation and actual spatial aggregation; in fact, there is a slight negative correlation. The actual rankings for Periods 3 and 4 are higher than expected and are lower than expected during Period 5, suggesting spatial aggregation increased before resource mix intensification. While significant positive correlations occur between expected rank orders based on the proxy measurements and the actual orderings (Orcutt 1985b), spatial aggregation is interpreted by this author to have been consistently greater than anticipated during Periods 3 and 4, indicating that aggregation increased before population and resource mix intensification.

Thus, although both types of aggregation appear to be positively correlated with increase in population density, the aggregation data is interpreted as supportive of the social model. Aggregation in the project area increased before population density and before resource mix intensification.

Considered as a whole, the settlement data contains certain characteristics that can be used to support either model. The following points support the social model:

1. The poor positive correlation between upper-tier settlement size and catchment productivity.

2. Differential growth rates among the upper-tier settlements.

3. The even spacing among upper-tier settlements (indicating competition), if the comprehensive settlement pattern is considered as 2 separate east and west systems.

4. The clustering of small settlements around large settlements in Periods 4 and 5.

5. The increase in household and spatial aggregation before increases in population density and climatic stress.

6. The noncorrelation or negative correlation between aggregation and resource mix intensification (proxied as climatic stress).

Points in the settlement data that support the economic model include the following:

1. The nearly random spacing of the upper-tier settlements if they are considered as one group.

2. The clustered distribution of settlements during Period 3.

3. The log-normal rank-size distribution of settlements during Periods 4 and 5 (indicating a well-integrated system).

4. The significant positive correlations between household and spatial aggregation and population density.

Characteristics appear to support the social model in the settlement data; the disparities among catchment productivity and upper-tier settlement size, and the early appearance of aggregation are particularly pertinent points.

Testing the Models: the Architectural Data

To further test the implications derived from the alternate social and economic models of cultural change, architectural data are used to estimate the relative power and wealth of managerial groups versus the commoner class. Generally, according to the predictions of the social model, it is expected that managerial groups or communities with more effective management would be more "visible' in the archaeological record than such groups would be in an economic model scenario. Early in this chapter, it was assumed oversized

pitstructures containing assemblages of ritual features were the actual locations of managerial functions. Leadership can be manifested directly through formal institutions (executive authorities) and enforcement groups (judicial authorities and police) or through the more subtle and indirect means of ritual and ceremony. Rappaport (1969:182; 1968:224-242) stresses the social advantages of management by ritual and ceremony. In the absence of sanctioned political statuses or offices, formalized ritual may serve as a mechanism for distributing land and economic resources, and for regulating warfare; it also may serve to resolve conflicts in economic production scheduling and seasonality. Ritual is thought to have played an important regulatory role in societies where the arbitrariness of social conventions was increasing, but where the authority of managerial groups, if they existed, was limited. The assumption made here is that, in general, managerial groups are present in societies regulated through ritual, but leveling mechanisms are present that inhibit their emergence as visible status groups. The presence of managerial groups with direct control and their separation as a social class are regarded as necessary prerequisites in initiating a true sociodemographic "power cycle" as described by Stuart and Gauthier (1981).

Wilshusen (1985:49-50), in his study of ritual facilities at Dolores, suggests the local Anasazi communities were ritually regulated and managerial groups probably had no direct authority. Here, the search for direct power and wealth is carried further, based on an examination of size variability in storage, habitations, and pitstructure facilities and a more qualitative evaluation of the intrasettlement placements of storage facilities and living quarters.

Variability in Sizes of Architectural Facilities

The sizes of architectural facilities are examined according to 2 possible vertical differentiation, or status, systems. First, the possible presence of intercommunity status divisions is investigated. It is assumed that groups residing at the largest communities (those centered at McPhee Village, Cline Crest Ruin, and Windy Ruin) would have more status or might be better situated in an economic sense than those residing in communities centered on smaller upper-tier settlements. For this analysis, 3 architectural data case sets were established on the basis of the combined axial lengths of the roomblocks in the village: (1) communities centered around large upper-tier settlements (total roomblock length greater than 450 m [the available excavation data is from McPhee Village]); (2) communities centered around medium-sized upper-tier settlements (total roomblock length of 300-450 m [the available excavation data is from Grass Mesa Village]); and (3) communities centered around small-sized upper-tier settlements (total roomblock length of less than 300 m [available excavation data is from Rio Vista and House Creek Villages]).

The second system of vertical differentiation investigated related to possible intracommunity status or wealth categories. The basic assumption is that varying degrees of access to oversized pitstructures within the community were reflections of status or power positions. Four hypothetical status categories have been designated based on the following criterion:

I – Residence at a roomblock outside the limits of an upper tier central settlement.

II – Residence at a roomblock within the limits of an upper-tier settlement, with no oversized pitstructure in the roomblock.

III – Residence at a roomblock within the limits of an upper-tier settlement, with one or more oversized pitstructures present in roomblock.

IV – Residence at a "horseshoe-shaped" roomblock within the limits of an upper-tier settlement. Horseshoe-shaped roomblocks are associated with the largest pitstructures (floor area greater than 60 m^2); access to the oversized pitstructure is assumed to have been restricted, especially at McPhee Pueblo, where a slab wall connects the arms of the horseshoe configuration horseshoe and thus completely encloses the plaza.

Figure 14.5 illustrates the relationships among these possible intracommunity status categories.

The possible intercommunity and intracommunity status categories were evaluated by examining the size distributions for several different functional classes of architectural facilities; the architectural data set used for these analyses was limited to structures assigned to Periods 4.1, 4.2, and 5.1 (A.D. 840-900), or the time period when status groupings were most likely to occur. Sizes of storage facilities (equivalent to back rooms within the ninth century Dolores area roomblock units [fig. 14.6]) for the categories were compared. The expectation of the social model is that larger storage facilities would be spatially correlated with high-status intercommunity and intracommunity locations. Greater storage capacities would be needed at managerial locations to accommodate foodstuffs and other goods used in periodic ceremonial redistributions, and to accommodate the surplus needed to fund the managerial groups and their relatively successful families (Lightfoot 1984:46). The economic model predicts relationships more indicative of egalitarian groups. Sizes of habitation (living-sleeping) rooms (front rooms at

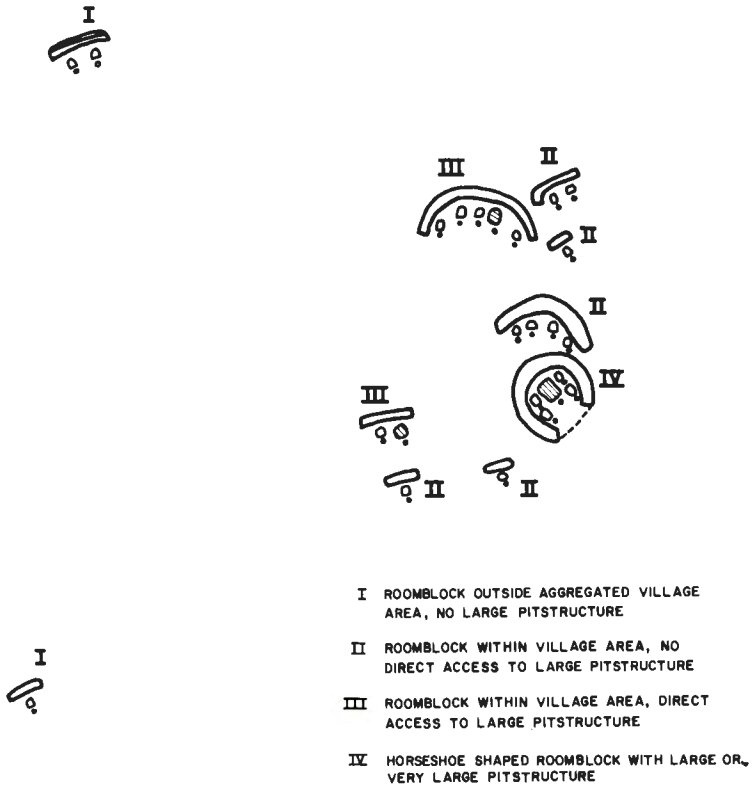

Figure 14.5 – Theoretical intracommunity status of architectural categories.

DAP ninth century settlements) were compared. The assumption was that more successful families and groups with a higher standard of living would reside at the presumed higher status intercommunity and intracommunity groupings; high status would be correlated with larger living facilities. Given the implications of the economic model, variation in living room sizes should be unpatterned and reflective of an egalitarian society. Sizes of pitstructures (assumed to be locations of ritual or overt managerial activities were also compared. Given the general implications of the social model, managerial activities should be centered at locations of status and power, and pitstructures should be larger at these locations. Also, more variation in pitstructure sizes should occur at relatively successful communities, reflecting the greater status of managerial groups at such locations and greater social distance between the managers and the commoners, especially if the upper-tier settlement acted as an attractant for relatively poor foreign households.

In addition, temporal implications for the size of architectural facilities are based on the social and economic models. For example, given the implications of the social model, increases in the mean size of storage facilities should occur relatively early and at the same time as the appearance of managerial groups. Given the implication of the economic model, increases in sizes of storage facilities should be relatively late, reflecting the role of storage as a buffer against crop yield variability and as an aspect of agricultural intensification.

The results of the analysis of the architectural data for the possible presence of status groupings are presented as a series of tables and figures (tables 14.4, 14.5, and 14.6; figs. 14.7, 14.8, and 14.9). Table 14.4 and figure 14.7 summarize the temporal trends in sizes for the 3 measured types of facilities (storage rooms, domestic rooms, and pitstructures). The size trends are generally consistent for all 3 facility categories; the sizes of these types of facilities increase through time for the periods in question. During the critical period for evaluating the models of change (A.D. 820-920), storage room mean size increased by nearly 40 percent. Wolf et al. (1985) report similar findings in their study of prehistoric storage behavior at Dolores: at McPhee Village household storage capacity increased from 176 bushels in A.D. 800-840 to 260 bushels between A.D. 841-860; storage capacity per household also increased at Grass Mesa, albeit at a much slower rate. Much of the increase is interpreted by this author to have occurred before the late 9th and early 10th century period (A.D. 864-920), when stress on the economic system from climate and population would be highest.

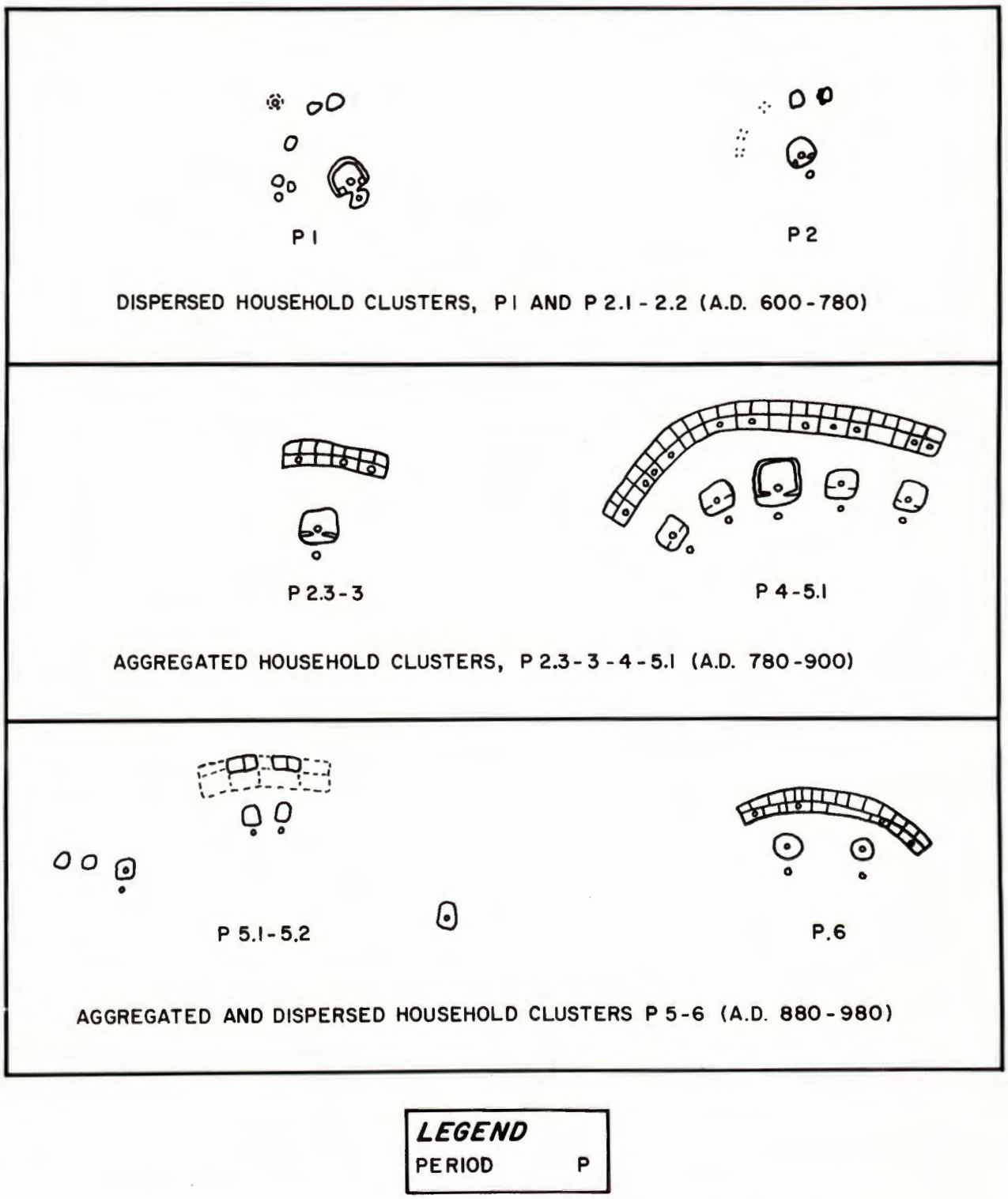

Figure 14.6 – Schematic of "normal" spatial configurations of Dolores area storage, habitation, and pitstructure facilities.

Table 14.4 – Mean floor areas and standard deviations of architectural facilities, by period

	Time period (A.D.)													
	600-720 (P 1.1-1.3)		720-780 (P 2.1-2.2)		780-820 (P 2.3-3.1)		820-860 (P 3.2-4.1)		860-890 (P 4.2-5.1, except Grass Mesa Subphase)		880-900 (P 5.1, Grass Mesa Subphase)		920-980 (P 6.1-6.2)	
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
Back (storage) rooms	3.21	0.21	4.17	0.33	3.98	0.23	4.38	0.22	5.55	0.11	†	†	6.03	0.48
Large living (habitation) rooms	*	*	*	*	12.2	1.42	13.22	1.50	15.42	0.53	†	†	13.91	1.53
Small living rooms	*	*	*	*			6.75	0.25	8.30	0.44	†	†		
Pitstructures	23.43	3.29	17.85	1.15	22.87	1.96	25.65	1.73	26.60	1.83			20.43	4.68

* These architectural units are not present during Periods 1, 2.1, and 2.2.
† Grass Mesa Subphase architectural data are extremely variable; storage and habitation rooms are not a consistent feature of household clusters; hence means and standard deviations were not calculated for the applicable categories.
$\overline{X}$ – Mean size (m²).
SD – Standard deviation.
P – Period.

Table 14.5 – Mean floor areas and standard deviations of architectural facilities for Dolores communities, A.D. 840-900

	Storage rooms		Large habitation rooms*		Small habitation rooms†		Pitstructures	
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
House Creek and Rio Vista Communities	4.67	0.28	14.62	0.93	7.73	0.99	23.65	2.28
Grass Mesa Community	4.76	0.21	15.99	1.17	7.41	0.58	26.93	1.60
McPhee Community	5.95	0.14	16.97	0.89	9.29	0.69	25.43	2.95

* Associated with 2 rear storage rooms.
† Associated with 1 rear storage room.
$\overline{X}$ – Mean area (m²).
SD – Standard deviation.

Table 14.6 – Intracommunity comparisons of sizes of architectural facilities

	Storage rooms		Large habitation rooms		Small habitation rooms		Pitstructures	
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
Group I	4.53	0.19	13.58	0.74	7.20	0.87	24.00	2.13
Group II	6.17	0.17	16.14	0.85	8.16	0.44	19.56	1.44
Group III	5.28	0.15	15.30	0.80	8.72	0.61	24.06	1.03
Group IV	5.95	0.21	18.30	1.44	10.80	1.09	34.02	8.17

$\overline{X}$ – Mean floor size (m²).
SD – Standard deviation.

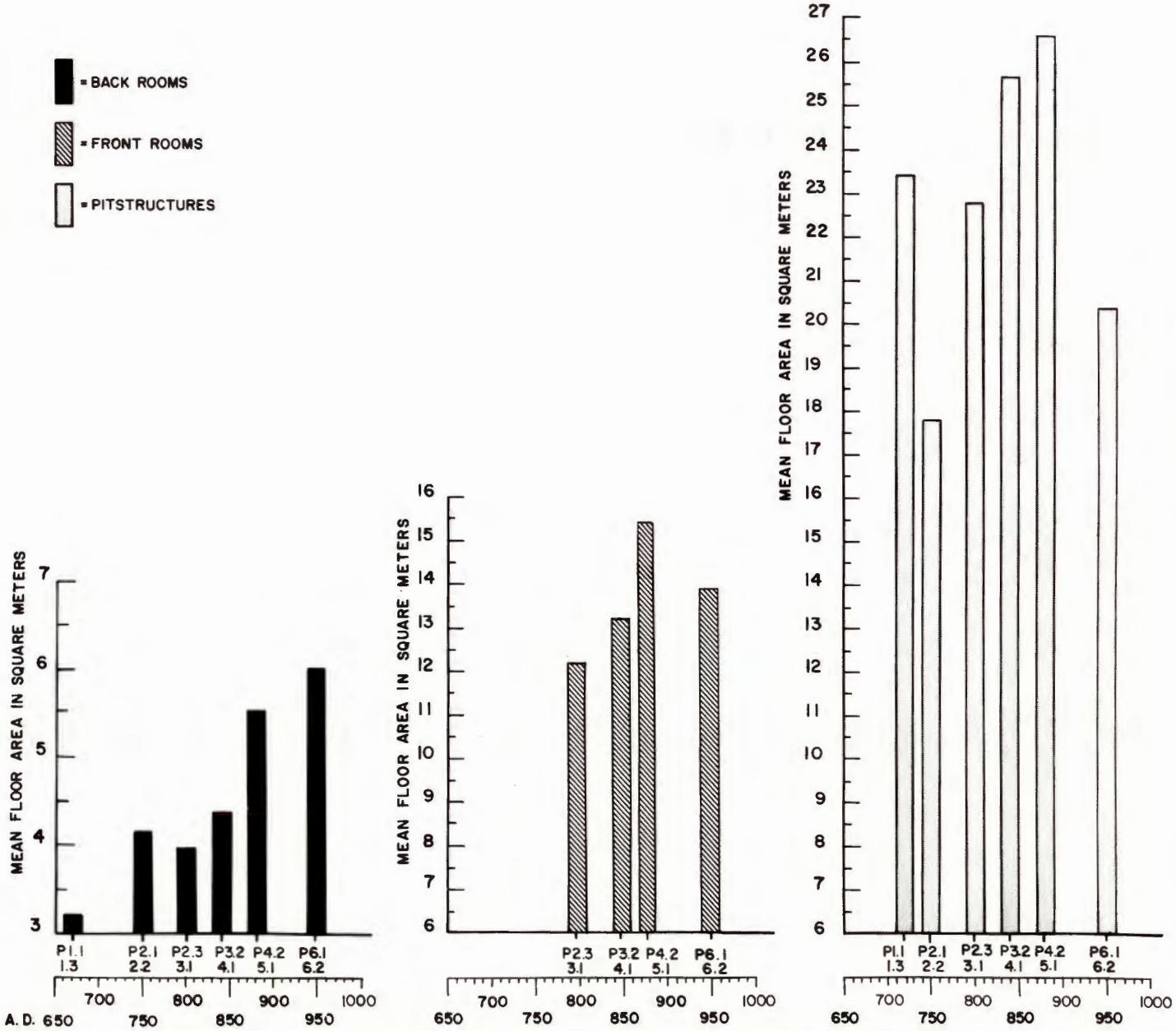

Figure 14.7 – Bar graph illustrating variability in sizes of architectural facilities, by period.

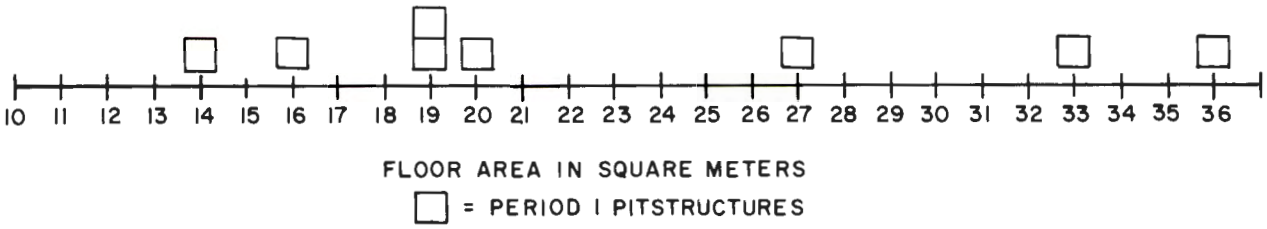

Figure 14.8 – Bar graph illustrating variability in facility sizes between communities.

Standard deviations of storage room size show a consistent decrease through time, indicating a greater standardization in sizes of rooms in the later periods. Living (habitation) rooms also consistently increase in mean size, although the increase in size is not as substantial as for the storage rooms, estimated to be approximately 25 percent between A.D. 800 and 860. To assess whether the apparent increase in storage room size was strictly a function of increased demand for storage space or whether the increase was related to a trend to larger habitation facilities in general, ratios of storage space to living space were calculated for the A.D. 780-820, A.D. 820-860, and A.D. 860-900 periods, omitting structures assigned to the Grass Mesa Subphase (table 14.7). The increased ratio during the A.D. 860-900 period suggests that storage capacity may have been a more important consideration during this period.

Pitstructures also exhibit a general trend toward increasing size with the exceptions of Period 1 and the Grass Mesa Subphase. These exceptions are believed to be related to function and to the number of groups using the structure. For example, the rank-size distribution of all pitstructures dating to Period 1 (fig. 14.10) may be indicative of a bimodal distribution, although the case set is too small to make a certain determination. Other evidence indicates large Period 1 pitstructures were domiciles for 2 nuclear families while the smaller ones housed only 1 domestic unit. During the succeeding period (Period 2), only one-family pitstructures were identified. The Grass Mesa Subphase pitstructures are thought to represent 1 family residences with relatively low investments in material and labor; they provide an extreme contrast with the functionally and architecturally complex pitstructures assigned to the partially contemporaneous Periman Subphase (Periods 4.1, 4.2, and 5.1 [A.D. 850-900]).

The temporal variation in the mean sizes of different function architectural facilities can be used to support either model. The general trend toward increasing size can be interpreted as an "intensification" or increased investment in architectural facilities. The increase does not appear to be correlated with either the A.D. 820-860 "window" implied by the social model or the later A.D. 860-900 window implied by the economic model. The specific higher rate of increase for size of storage structures in Periods 4.2 and 5.1 is support for the economic model. Climatic uncertainty documented for this time span (A.D. 860-900) and possible production shortfalls (Wolf 1985) may have necessitated increased reliance on long-term storage as a buffering mechanism.

The results of the intercommunity structure comparisons are shown in table 14.5 and figure 14.9. The results are interpreted as generally consistent with the predictions derived from the social model. Storage and habitation structures are expected to be largest at the largest communities, reflecting the relatively greater economic and biological success of these household groups.

Less patterned variation would be expected according to the implications of the economic model. The mean sizes of pitstructures for small, medium, and large communities vary somewhat from the predictions for the social model. As anticipated, the small communities contained the smallest pitstructures and the least variability in sizes of pitstructures. However, Grass Mesa Community pitstructures are larger and have less variability in size than McPhee Community pitstructures, contrary to the social model expectations.

This discrepancy is difficult to interpret. Pitstructure size is not a sure indication of the relative success of household groups, as A.D. 780-900 Dolores pitstructures are generally interpreted as shared facilities (Kane 1983:22-25) with both domestic and ritual functions. The greater variation in pitstructure size at McPhee versus Grass Mesa, perhaps indicative of greater divergence in function, is also a consideration. The largest 2 oversized pitstructures dating to Period 4 are located at McPhee Village; however, the McPhee Village architectural data set also contains some very small pitstructures, such as Pitstructure 1 at Willow Flat Pueblo (floor area is approximately 13 m^2 [Nelson 1985]). One possible interpretation is that access to larger pitstructures and their inherent ritual and ceremonial activities were more restricted at McPhee than at Grass Mesa. This speculation is supported by Wilshusen's (1985) distributional analysis of ritual features common to Period 4 and 5 pitstructures.

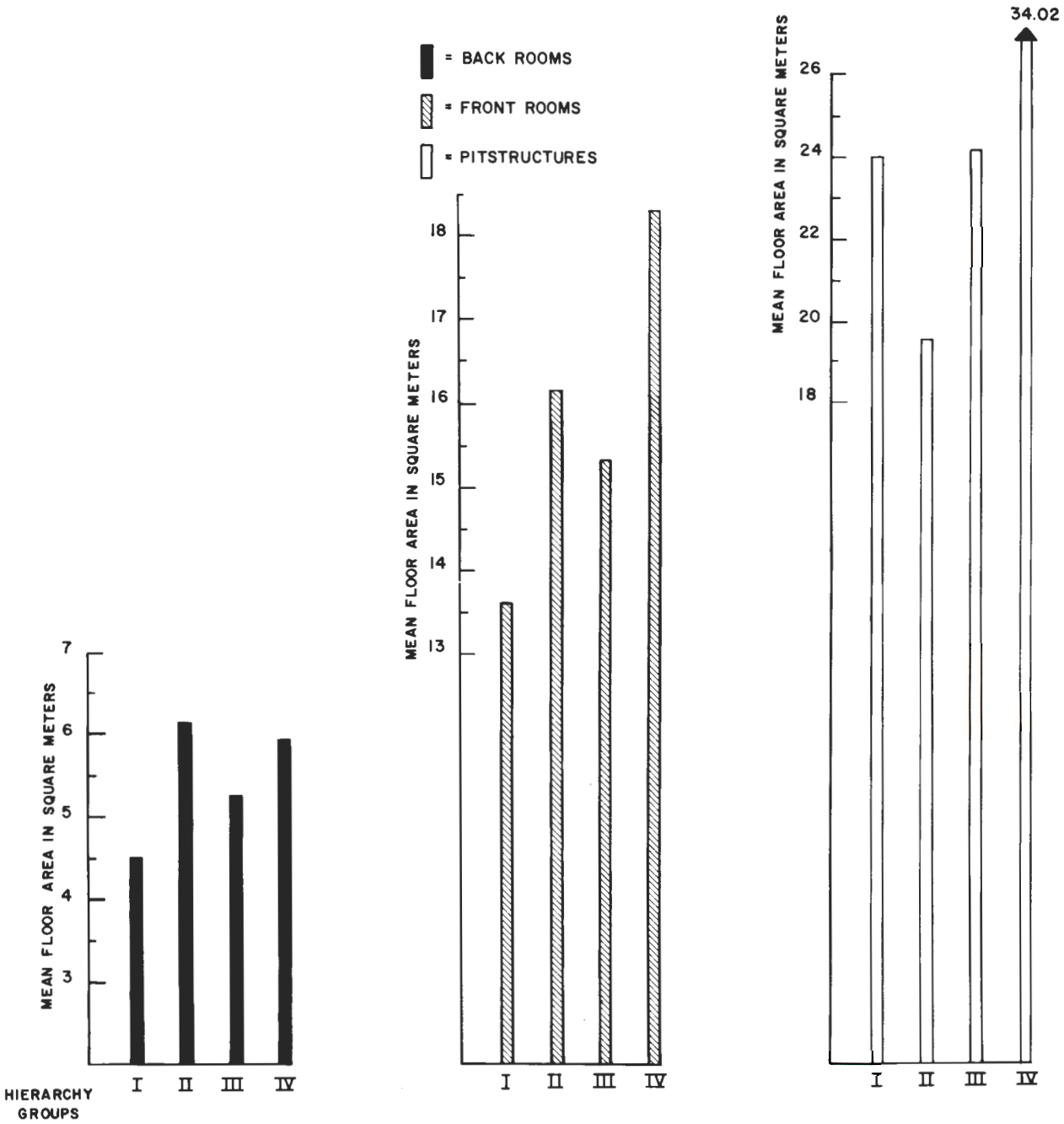

Figure 14.9 – Bar graph illustrating variability in facilities among intracommunity roomblock groups.

Table 14.7 – Ratios of storage space to living (habitation) space during the A.D. 780-900 time span

	Time Period (A.D.)		
	780-820 (P 2.3-3.1)	820-860 (P 3.2-4.1)	860-900 (P 4.2-5.1)
Ratio of storage space to living space	0.65	0.66	0.72

P – Period.

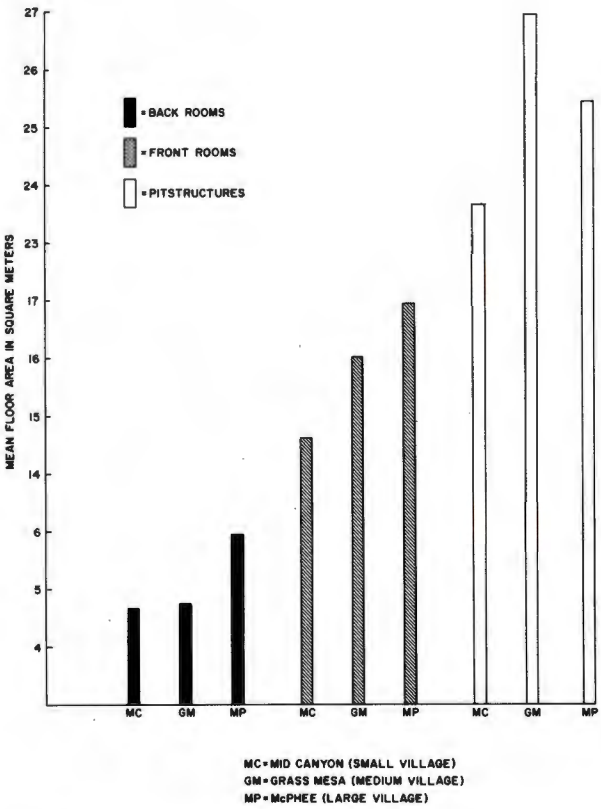

Figure 14.10 – Rank-size distribution of Period 1 pitstructures.

Apparently, more pitstructures with rectangular central vault features for each household are found at Grass Mesa than at McPhee (4 to 5 households/vault-containing pitstructure at Grass Mesa versus 10 to 12 households/vault-containing pitstructure at McPhee, if it is assumed there are 2 vault-containing pitstructures at Mesa Negra Pueblo [Wilshusen 1985]). Thus, the 2 largest pitstructures at McPhee Village (Pitstructure 3 at McPhee Pueblo and Pitstructure 9 at Pueblo de las Golondrinas) may have subsumed the ritual or managerial functions of several (4 to 5) vault-containing pitstructures at Grass Mesa. Both Pitstructures 3 and 9 are situated in the plazas of horseshoe-shaped roomblocks, which may indicate access to these special ritual facilities was limited.

In summary, the intercommunity comparisons of storage, habitation, and pitstructure facilities appear generally to conform to the expectations of the social model of change. Storage and habitation rooms are largest at the largest excavated community (McPhee Village). Pitstructure size might be interpreted as an exception to the social model expectations; however, the variability in pitstructure size in the Grass Mesa and McPhee data sets can be interpreted as possibly reflecting greater social differentiation at McPhee Village, consistent with the social model. The greater range in pitstructure size as McPhee and the fewer number of vault-containing pitstructures/household at this community may indicate greater control of large pitstructures and their inherent ritual activities by local managerial groups.

The results of the intracommunity comparisons of storage and habitation rooms and pitstructures are presented in table 14.6 and figure 14.8. While the trends are not as consistent as the intercommunity comparisons, a general tendency to larger facility sizes at the higher social-ranked architectural categories is evident. Group I storage and habitation facilities are smaller than those within the limits of the upper-tier settlements proper, and facilities within the horseshoe-shaped roomblocks are largest for all 3 functional architecture categories. The unexpected comparatively large mean size of pitstructures at lower tier settlements (Group I) may reflect a more integrated functional role for pitstructures at outlying settlements. Here, pitstructures may have been locations for relatively diversified interhousehold functions including domestic-economic tasks, integrative rituals, and managerial activities, while pitstructures were probably more function-specific at the upper-tier villages (small pitstructures function primarily as loci for interhousehold routine activities and integration, and oversized pitstructures function primarily for higher level integration and management).

Under the social model, the physical manifestations of leaders or managers might be more notable or pronounced than those expected by the economic model. For example, extrahousehold storage facilities (i.e., storage facilities owned by managerial groups and used for housing of manipulable crop surpluses, and not spatially associated with habitation rooms) would be expected if managerial groups were able to amass overt power and wealth. Also, given the implications of the social model, the residences of powerful leaders may have been significantly larger in size and different in

content than those of the "commoner" populace. The residences of community leaders should be spatially associated with locations of managerial power (roomblocks with oversized pitstructures).

A search of the architectural data base for evidence of nonhousehold, or extrahousehold, storage proved almost entirely negative. The 2 most likely locations for storage facilities owned by leaders or managerial groups used for nondomestic purposes were anticipated to be the 2 investigated horseshoe-shaped roomblocks (McPhee Pueblo and Pueblo de las Golondrinas) at McPhee Village. At McPhee Pueblo all storage facilities could reasonably be associated with household or interhousehold architectural groupings. At Pueblo de las Golondrinas 2 storage rooms not spatially associated with household configurations were identified on either end of the roomblock (Brisbin 1984a:fig. 4). Unfortunately, these rooms were not excavated and their contents were not ascertained; they may represent interhousehold storage rather than storage space for managerial groups. Neither roomblock contained storage space associated with the oversized pitstructures or with possible high status household architecture configurations.

The architectural data base was also searched for habitation architecture that might be indicative of high status. The search included identification of unusual household cluster configurations, locations, or habitation rooms on the large end of the size distribution. The configuration and location search yielded 1 case (a household cluster at Willow Flat Pueblo in McPhee Village) that might be indicative of high status. The size search yielded 7 habitation rooms with floor areas greater than 20 m^2. Six of the rooms are located within the limits of McPhee Village (McPhee Pueblo, Rooms 59, 79, and 116; Aldea Alfareros, Room 8; Rabbitbrush Pueblo, Room 8; and Willow Flat Pueblo, Room 1), and the other large room is located at Grass Mesa Village (Room 79).

The largest habitation room in the data set (Room 1 at Willow Flat Pueblo [Site 5MT5104]) is part of a small, single pitstructure roomblock complex spatially distant from the assumed locations of power (the horseshoe-shaped roomblocks at McPhee Pueblo and Pueblo de las Golondrinas). The habitation room is associated with the largest 2 storage rooms recorded by the DAP and also has a small mealing room attached to the front (Nelson 1985). This elaborate household cluster configuration with large-sized rooms may be indicative of a high-status residence. A turquoise ornament fragment was recovered from the floor of the room and fragments from a gray ware ceramic effigy vessel was recovered from the postabandonment fill above the floor.

The second largest habitation room recorded by the DAP is Room 8 at Rabbitbrush Pueblo (Site 5MT4480). The room is located in a small, unusual perpendicular appendage to the main cresent roomblock. This large room is part of a normal three-room apartment configuration. The artifact assemblage recovered from the floor of the room was unusual in that a large quantity of burnt corn (unusual in habitation rooms), relatively large numbers of ground stone tools, 2 miniature vessels, and an effigy vessel (possibly a canine or ursine representation) were present (Kuckelman and Harriman 1984:117-129). Whether these unusual characteristics are indicative of high status could not be determined.

Three of the large habitation rooms (Rooms 59, 79, and 116) are incorporated into the McPhee Pueblo (Site 5MT4475) horsehose-shaped room-block unit or its eastern cresent-shaped appendage; all 3 large habitation rooms are incorporated in normally arranged three-room household cluster apartments. Only Rooms 59 and 79 were excavated; Room 116 was merely outlined. The artifact assemblages recovered from the floor surface and feature fills of the excavated rooms consist of household refuse (Brisbin et al. 1985:44-55, 113-128) with few unusual items. A small fragment of azurite pigment was recovered from the floor of Room 79.

Room 8 at Aldea Alfereros (Site 5MT4479 [Kleidon 1984]) also does not appear to be in an intravillage location reflective of possible status or power. The room is situated in a small double-pitstructure roomblock complex about 200 m east of the McPhee Pueblo horseshoe and 100 m south of the Pueblo de las Golondrinas roomblock. The room is part of a normal three-room household cluster apartment; the artifact assemblage from the floor of the room did not contain any items indicative of high status (Kleidon 1984:86-94).

The single large habitation room identified outside of the McPhee Village area, Room 79 at Grass Mesa Village, is also part of a small single-pitstructure roomblock complex. The roomblock is located on the west extremity of the residential area of Grass Mesa and does not have an associated oversized pitstructure. The artifact and feature content of the room suggest it functioned as a normal household habitation facility. No items indicative of high status are present in the associated material collections (Morris 1985b:39-49).

In summary, the architectural data from the DAP can be used to support either the social or economic model of change. Temporal trends in room and pitstructure

sizes suggest increasing investment in architectural facilities in the A.D. 800's, consistent with the general Dolores area "intensification" of subsistence practices and demography documented during this period. Household storage capacity increased significantly between A.D. 800-860, which is a point in favor of the social model; however, the increase in the ratio of household storage space to living space after A.D. 860 supports the economic model.

The results of the intercommunity and intracommunity spatial comparisons of room and pitstructure sizes were generally consistent with some of the implications derived from the social model. The largest storage and habitation rooms are present at the largest community (McPhee Village), suggesting greater biological success and a higher standard of living for groups residing at the largest communities. Pitstructures are largest at the medium-sized community (Grass Mesa Village), but standard deviations were largest at McPhee, perhaps suggesting greater development of functional differentiation and social control of ritual at the latter community. For the intracommunity assumed power rankings of roomblock units, the actual sizes were generally consistent with the predictions. Storage and habitation room sizes were larger at the expected higher status or power roomblocks. Pitstructures were unexpectedly large at Group I roomblocks; however, standard deviations were largest at Group IV roomblocks, consistent with the expectations of the social model.

A data base search for nonhousehold storage facilities or storage space associated with locations of power proved negative. No separate storage rooms or compartments were associated with oversized pitstructures. Nonhousehold associated storage rooms are possibly present on both ends of the Pueblo de las Golondrinas roomblock, but incomplete excavation renders a confident interpretation impossible; nonhousehold associated storage rooms were absent at McPhee Pueblo.

The locations of large habitation rooms did not appear to be correlated with assumed locations of power and the feature and artifact content of these possible high status residences did not seem to vary significantly from "normal" residences. The 2 best cases for high status residences, where large size is correlated with either large storage rooms or possible intraroomblock prominent position, and possible high status items in the associated material culture (Room 1 at Willow Flat Pueblo and Room 8 at Rabbitbrush Pueblo), are situated in Group II roomblocks. The evaluations of particular storage and habitation room contexts did not identify any particular associations that would support the social model, and thus must be considered a strong point in favor of the economic model.

SUMMARY AND CONCLUSION

In this chapter, aspects of prehistoric Anasazi social organization in the Dolores area have been examined according to alternate models of socio-cultural change. The models were developed as part of the DAP's comprehensive effort to explain local change at Dolores in the ninth century. Opposing implications for the archaeological record were developed based on whether social or economic factors were primarily responsible for the observed changes. Specifically, the social model predicts change in response to the rise of managerial structures, which may be manifested as the emergence of a leadership class and competition among settlements, while the economic model predicts change in response to subsistence and demographic stress. These stresses can be collectively estimated as "costs"; as costs for existing economic or demographic strategies increase, less costly options are substituted.

Different implications for the timing and for the direction of change are implicit in the models. Essentially, the social model predicts the greatest rate of change during the "good times" or when settlement expansion and production of a crop surplus are most viable; at Dolores, the "good times" probably correspond to the period A.D. 820-860. Change, given the implications of the economic model, probably corresponds to the "bad times" when stresses on the system were highest, here assigned the time window A.D. 860-920. Implications for the direction of change are more complex; basically, both models predict change in the direction of cultural intensification, but specific intensifications may differ. For example, in the economic model, as the basic governing principle is to keep costs at a low level, overhead costs associated with necessary managerial institutions would be minimized. The managerial structure might be manifested through indirect means, such as ritual and ceremony rather than overt power. Political systems would be well integrated and characterized by cooperation among communities; conflict within and between settlements would be minimized because of the added costs of these phenomena. In the social model, the basic principle is the maintenance of managerial institutions and groups and the accumulation of power and status by these groups once they appear. Settlement and architectural hierarchies reflective of the position of managerial groups should thus be present in the archaeological record. Once established, the managerial class should act conservatively to maintain the economic and social conventions that were the source of their power.

Using the models and some derived implications as an organizational framework, the relevant social attributes of the local Anasazi system were estimated from settlement and architecture data and used to evaluate the

relative applicability of both models. The primary focuses of this chapter were 2 particular aspects of social organization – vertical differentiation, or the presence or absence of status groups within a society, and the influence and the success of these groups in amassing individual wealth – and economic organization, or how the society is organized for economic production.

The discussion of vertical differentiation was based on a search for possible managerial groups and social hierarchies in the archaeological record at Dolores, documentation of the timing of the appearance of these groups, and an assessment of their relative power and wealth based on the settlement and architectural data. Based on the documented presence of tiered settlement hierarchies in the archaeological record in the late ninth century, the search for patterns reflecting social hierarchies was focused in Periods 3, 4, and 5 (A.D. 800-920). A size-rank analysis of settlement sizes during Period 4 (A.D. 840-880) suggests 2 separate populations: small, lower tier settlements consisting of 1 to 3 roomblock residential complexes and large, upper-tier settlements consisting of 7 or more roomblock complexes. All upper-tier settlements contained a large (oversized) pitstructure with features and associated artifacts assumed to be indicative of ritual and ceremonial activities. These pitstructures were assumed to be the locations of managerial functions necessary to coordinate the community. The coexistence of tiered settlement hierarchies and possible managerial facilities in the record during the middle A.D. 800's was interpreted as verification of the presence of management groups during this period.

A more detailed study was then conducted to ascertain the occupational history of the upper-tier settlements and the first occurrence of associated oversized pitstructures. All 4 upper-tier settlements subjected to field excavations appear to have been settled for periods approaching 100 years. Grass Mesa Village apparently was first occupied in the mid-eighth century. The establishment of large cresent roomblocks with multiple pitstructures apparently dates to Period 3 (A.D. 800-840) based on the superposition of surface rooms and pitstructures evident at some of the large roomblocks. While construction of most of the oversized pitstructures apparently dates to the A.D. 850's, there is some evidence that some may have constructed somewhat earlier, perhaps in the A.D. 830's.

In conclusion, this study of temporal placement tends to support the social model. The settlement and architectural configurations thought to reflect management institutions were developed and in place before the period of maximum demographic and economic stress.

The larger question of the role of management groups in shaping ninth century Anasazi society was then addressed using other pertinent aspects of the settlement and architectural data; even though the probable presence of management institutions at early ninth century Dolores communities is fairly well established, their influence on the direction of change and their relative power within the communities are also important determinations in terms of the model.

The settlement data contains different characteristics that can be used to support either model. The economic model implies that settlement sizes should be positively correlated with the agricultural productivity of the associated catchment area. Analysis revealed only a weak, insignificant correlation between catchment productivity and settlement size. Two of the settlements, McPhee Village and Grass Mesa Village, were much larger in terms of population than predicted by the catchment data. This discrepancy is attributable to other factors perhaps including the relative success of the leaders at these settlements in attracting followers. Other points in the settlement data that support the social model include: a strong tendency toward even spacing (indicative of intersettlement competition) among upper-tier settlements if the prehistoric settlement pattern is considered as east and west systems separated by the Dolores River; the clustering of small settlements around large settlements during Periods 4 and 5 perhaps indicating the larger central settlements were administrative centers; and the poor temporal correlation between aggregation and resource mix intensification. Points in the settlement data that supported the economic model include the nearly random spacing of the upper-tier settlements if they are considered as one group, the clustered distribution of all Period 3 settlements, the log-normal rank-size distribution of settlements during Period 4 (indicative of a well-integrated system), and the statistically significant positive correlation between aggregation and population. In conclusion, while points support both models of change in the settlement data, certain aspects seem to indicate the influence of social factors in shaping the settlement system. These aspects include the relative great success of Grass Mesa Village and McPhee Village in attracting population beyond the potential productivity of their catchments and the spacing among the large settlements, which conforms to the expectations if intersettlement competition was an influential factor in settlement location.

The architectural data also contained characteristics that could be used to support either model of change. However, considered as a whole, the architectural data seems to better correspond to the expectations of the economic model. Architectural data favoring the social model include the general correlation between the sizes

of architectural facilities and hypothetical intercommunity and intracommunity architectural status groupings. Larger sized facilities, perhaps indicative of relatively high status, are found at predicted locations of centralized management or biologically successful groups. The sizes of pitstructures exhibit greater size variation at assumed high status locations, perhaps indicating functional differentiation and control of ritual facilities by leadership groups. In general, the sizes of storage, habitation, and pitstructure facilities increase through time; the capacity of storage facilities appears to increase at a relatively high rate in the A.D. 840-860 period, or before the period of maximum demographic and environmental stress. Architectural data supporting the economic model include the included storage space to habitation space ratio after A.D. 860, the absence of identifiable extrahousehold storage facilities, and the absence of demonstrable high-status residences. Potential high status household architecture, based on large room sizes and artifact content, was not correlated with locations of power or management. These last 2 points seem particularly telling. They suggest that the emergence of overt leadership at Dolores was hindered by social convention and that social "overhead" in the form of special facilities reflecting the power of management or leadership groups was minimized. This conforms to a major expectation of the economic model.

Temporal changes in economic organization or the organization of economic production appear to result both from social and economic sources and from sources of change not accommodated in the model. Two fundamental shifts in production organization are believed to have occurred according to the architectural and intrasettlement pattern data. The first occurred during the A.D. 760-780 portion of Period 2 when economically autonomous single family households were replaced by cooperating multiple-family households. "Replaced" appears to be an appropriate term, as rather than being a local development, the record indicates groups already possessing the more complex organization integrated into the Dolores area. The groups with the simpler organization were either assimilated or forced to emigrate. The immigration to Dolores may have been a budding or colonization of the Dolores area from already established adjacent aggregated communities. The multiple-family organization was apparently remarkably stable until a general social and demographic collapse of the entire Dolores system in the late ninth century. This history appears generally consistent with the expectations of the social model: the multiple-family organization and favorable climate of the early ninth century would have been conducive to biological success and production of a surplus, conditions that would have favored the emergence of management institutions and differential wealth. Once established, the management groups would have acted conservatively to perpetuate the economic system responsible for their existence even in the face of increased environmental and demographic stress, which became a significant factor in the late ninth century. When faced with an increasingly intolerable situation, the Dolores communities did not modify economic organization in the direction of intensification as predicted by the economic model, but rather chose to leave the area. Some groups remained and reverted to a simpler and probably more flexible single family economic organization. The exodus from the Dolores area and the return to a simpler economic organization (termed the Grass Mesa Subphase) can be viewed as a classic example of system overload and subsequent collapse.

In conclusion, it appears that cultural change at Dolores, specifically the ninth century intensification, was not significantly affected by the overt political or power-seeking action of managerial groups or community leadership. However, the Dolores system was probably covertly influenced by social factors. Vertical differentiation, or the conspicuous presence of powerful or wealthy individuals, households, or extrahousehold groups, is not visible in the archaeological data sets. The variability in architectural facilities suggests that household groups at large settlements and with direct access to ritual facilities were more successful and had a higher standard of living. However, household architectural forms are very standardized in the period A.D. 780-880 suggesting the enforcement of a conformist and egalitarian ethic. It appears, therefore, that Anasazi society at Dolores in the ninth century had many parallels with the model of ritually regulated society developed by Rappaport (1969) and with the possible Dolores applications of this model suggested by Wilshusen (1985).

Social factors appear to have influenced direction in ninth century settlement pattern development. The high attractiveness of McPhee Village and Grass Mesa Village to foreign households may have been due to the relative success of the leadership at these communities. The spacing of large settlements and the clustering of small, lower tier hamlets around upper-tier villages suggests intercommunity competition, perhaps including feuding, but there is no direct evidence of the latter. Economic organization remained basically unchanged throughout most of the period in question (A.D. 780-880), which perhaps reflects the general conservative nature of the society or the influence of the groups in power who acted to conserve the organization that was responsible for their positions. The fundamental shift from cooperating households to independent households observable as the Grass Mesa Subphase in the late ninth century is not an "intensification" response but appears to reflect "system overload" due to environmental factors and consequent social and demographic collapse.

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Chapter 15

EXCHANGE AND INTERACTION IN THE DOLORES AREA

Eric Blinman

INTRODUCTION

In a modern or ethnographic sense, "exchange" encompasses an extremely wide variety of transfers (both material and nonmaterial) between individuals or groups. These transfers form parts of complex systems of interaction that are integrated with the economic and social systems of cultures (e.g., Rappaport 1968:105-109; Ford 1968:220-224). Transfers may be reciprocal with a bidirectional flow of material, or transfers may be one-sided with obligation or status imbalance accruing from the transaction. From an economic viewpoint, transfers can be viewed as spatial buffering mechanisms, moving materials from areas of abundance to areas of scarcity. From a social viewpoint, exchange is a byproduct of, or a means of expressing, the social relationship between the parties to a transfer. Although often dichotomized into formalist and substantivist conceptualizations, these perspectives are neither mutually exclusive nor independent in the operation of cultural systems (Earle 1982).

Prehistoric Exchange

The varied roles of exchange within modern cultural systems provide the stimulus and justification for studies of the distributions of nonlocal materials in archaeological contexts. Since so many behavioral considerations influence the distribution of exchanged goods, exchange provides a theoretical linkage between archaeological data and a wide array of past behavior. Although some of this behavior is also accessible through other theoretical linkages (e.g., suggested relationships between style and social interaction [Hantman and Plog 1982; Kintigh 1985; Plog 1980]), exchange has received greater attention due to somewhat simpler conceptual frameworks and data requirements.

Ethnographic descriptions of exchange include a wide variety of distinctions not amenable to archaeological investigation. Nonmaterial reciprocations (services as opposed to goods, or the status implications of transfers as defined by Pryor [1977:27]) cannot be observed in archaeological contexts and must be inferred from negative evidence.

Similarly, intervening nodes of exchange networks (those between the origin of an item and its final archaeological provenience) can be assumed or inferred to exist but cannot be described. Consumption and discard subsequent to exchange also biases archaeological perceptions, under-representing some exchanged material (food) and over-representing exchange items that are both nonperishable and fragile (pottery).

The necessary linkage between archaeological studies and material evidence further influences and restricts studies of prehistoric exchange. Perishable materials and valued and conserved (curated) subsets of exchanged material culture will be under-represented in archaeological collections, complicating archaeological inferences. Further, weaknesses in the perception of origins of items (both the precision of archaeological definitions of "nonlocal" and the precision of subsequent sourcing) can mask the existence of some exchanges or limit directional inferences. Finally, long-distance procurement (e.g., salt, turquoise, shell) not involving any exchange transactions will be misinterpreted as exchange, since most archaeological studies must rely on some distance-related assumption for the definition of what is "local."

Despite these weaknesses, the concept of exchange remains a valuable theoretical tool in archaeological investigations. Although exceptions are abundant, status markers within a society will likely include things restricted in supply, nonlocal, and obtained through exchange. Spatial buffering of resource variation requires interaction at some level (from exchange to raiding [Ford 1972]) between the residents of adjacent areas. Long-distance procurement often entails social interaction with residents in the source area analogous to the interaction associated with actual exchange. Kinship obligations and ritual obligations often entail material assistance or the exchange of gifts as byproducts of the maintenance of the social relationship. Thus, exchange both is a useful framework for the interpretation of culture process and is a required consideration in explanations of material culture distributions.

Exchange and Culture Change in the Dolores Area

Anasazi occupation in the Dolores area spans the A.D. 600-1200 period, and within this period considerable evidence of change exists, in many aspects of the cultural system. Resource supply, population density, settlement organization, technology, and social organization all appear to fluctuate, leading to questions about the nature of the observed changes, their interrelationships, and potential causal factors. Changes in exchange can also be identified, and these can be used both to reconstruct systemic change and to evaluate potential causal interpretations.

Lipe (chap. 6) outlines a general model of the operation of cultural systems based on economic principles. Within this framework, expectations for exchange are based on both economic considerations and on patterns of social interaction consistent with the "efficient" integration of the local and regional populations. Contrasted with these economic generative principles is a mode of leadership development (cf. Lightfoot 1984) in which efficiency is secondarily important to the maintenance of political control by individuals. Expectations for exchange based on this latter model parallel those of the former in many aspects, but the emphasis on individual control or power would tend to emphasize unevenness in participation in some aspects of exchange.

Within the context of the economic model, exchange is expected to vary in response to change in a wide range of systemic variables. Subsistence resource supply is a factor, and this includes the relationship between human population, available agricultural land, and climatic influences on crop yields in various areas. Buffering needs (beyond storage) are assumed to influence the direction and extent of exchange networks and "alliance formation" (Plog 1984). The degree of economic specialization (horizontal differentiation) is assumed to influence exchange through control of the relationship between the sources of a material or product and the consumers. This specialization can be a consequence of inequities in the spatial distribution of resources or it can be a consequence of socially defined patterns of production. Kinship and ritual obligation networks are also assumed to influence exchange through their definition of the spatial extent of regular social interaction with attendant gifts and donations. The ritual obligation network also encompasses the maintenance of whatever leadership positions or institutions are appropriate for the "efficient" management of the social aggregate.

Although the development of management hierarchies is expected within the context of economically generated change in the Dolores area cultural system, elaborations of management hierarchies have been proposed as potentially independent causal factors in culture change (Lightfoot 1984). Such leadership development is in contrast with economic expectations in that individual self-interest carries with it a level of "overhead costs" (in excess of those associated with the efficiency assumptions of economic decision-making principles). Exchange is assigned a role in the identification of such leadership development (Lightfoot 1984:30-31) on the assumption that exercise of leadership would extend to the control of the distribution of material goods. These would include some control over stored food surplus, but emphasis is placed on the control of rare and valued (usually exchanged) goods as status markers and as tokens of alliance between leaders of local cultural systems.

DATA, ASSUMPTIONS, AND FOCI OF INVESTIGATION

Exchange is treated by the DAP as a category of interactions rather than as a single variable within the operation of cultural systems. As such, exchange encompasses a vast array of individual phenomena, each of which can be viewed as a variable, reflecting and instigating changes in other aspects of the cultural system. In most cases, the action of the cultural system on an exchange interaction is interpreted as the effects of independent variables on exchange, the dependent variable. However, in some instances, an exchange relationship can be interpreted as an independent variable that appears to be serving as an impetus for change in other portions of the cultural system.

Given the adoption of exchange as a cover term for a wide variety of relationships, the potential roles of exchange in cultural systems (and the potential targets of archaeological investigations) are numerous. In an effort to reduce this to manageable proportions, discussion will be concentrated on potentially important exchange relationships as defined by their implications for aspects of the models under consideration. This reduction is simplified by the types of archaeological data available for evaluation and the quality of those data for specific inferences.

Data Categories

Data sets for the discussion of exchange in the Dolores area are dominated by nonperishable material goods (stone and ceramics). Both faunal and botanical materials have been identified that are unlikely to have been obtainable within the immediate Dolores area, but almost all could have been obtained through logistic strategies within a short distance of the Dolores area. The exceptions are marine shell and a single occurrence

of what may be cotton fiber. Although marine shell is included in the discussion of exchange, the other faunal and botanical materials are not because of the possibility of logistic procurement and because their relative scarcity limits the confident interpretation of their presence or absence in specific archaeological contexts.

Each of these material classes (lithic, ceramic, and shell) entails different sets of assumptions and different limitations on use in support of exchange studies. These assumptions and limitations include the precision with which items are identified as nonlocal, the sourcing of items, the quantification of abundance, and the reliability of arguments based on negative evidence. Whereas some of these assumptions and limitations are appropriate to all material classes, some are not, and each material class will be reviewed individually.

Lithic Materials

Stone artifacts considered include items described by 1 of 3 analysis systems: flaked lithic tools, flaked lithic debitage, and nonflaked lithic tools (Phagan and Hruby 1984). Within all of these systems, materials are defined as local if they fall within the range of variation observed in Dolores area geologic formations or in alluvial deposits of the Dolores River. This use of "local" probably under-represents the true quantity of nonlocal materials for two reasons. First, logistic procurement strategies are assumed to extend site catchments to include the entire Dolores project area, such that "local" materials may actually be nonlocal to a specific site location within the Dolores area. Second, the same geologic formations that occur within the Dolores Project area are extensively exposed within the Mesa Verde region as a whole, and many tools or raw materials obtained by exchange from outside of the Dolores area could not be distinguished from locally procured materials.

Given this broad definition of local, those lithic items that are designated as nonlocal materials are confidently classified as such. However, specific sourcing of lithic materials is variable in both confidence and precision. Although local flaked lithic tools and nonflaked lithic tools are attributed to specific material sources (geologic formations), most nonlocal materials are classified only to rock or mineral class (e.g., nonlocal chalcedony, nonlocal quartzite). Exceptions are Washington Pass chert that can be identified by macroscopic examination and obsidian artifacts that have been subjected to x-ray fluorescence analysis (Phagan 1985). Unlike the flaked lithic tools and nonflaked lithic tools, material classifications of flaked lithic debitage are limited to a description of material grain size. A separate count of nonlocal items is recorded for each lot of debitage (using the same local-nonlocal definition applied for flaked lithic tools), but grain size or rock or mineral class of the nonlocal materials is not recorded. Some of the rare pieces of obsidian debitage have been sourced as part of the x-ray fluorescence study.

All lithic materials are quantified by count and weight. For flaked lithic tools and nonflaked lithic tools, weight is recorded for each item. For flaked lithic debitage, weight is recorded for each grain size class, but no weight is recorded for the nonlocal subset of each debitage lot. Thus, only counts can be used to quantify nonlocal materials for all lithic artifact classes. Proportions of nonlocal materials are conceptually appropriate for comparison within the flaked lithic debitage category (representing the intensity of tool manufacture from local versus nonlocal materials), are somewhat appropriate within the flaked lithic tool category (representing the frequency of nonlocal tools or tools produced from nonlocal materials), but are less appropriate within the nonflaked lithic tools category. Nonflaked lithic tools are dominated by abrading and pounding implements and mealing equipment, and nonlocal nonflaked lithic tools are limited to ornaments and rare polished stones. Thus, the significance of varying proportions of nonlocal items within the entire nonflaked lithic tool category is questionable, and proportions based on subsets (i.e., all ornaments) appear to be more appropriate for interpretation.

In addition to problems related to quantity expressions, variable excavation techniques provide a source of bias in the quantification of nonlocal lithic materials. Excavation crews were instructed to recover exotic materials (e.g., turquoise and obsidian) whenever encountered (Kane and Robinson 1984:table 4). This positive bias in "item-mode collections" contrasts with unbiased or "assemblage-mode" collections in which all materials encountered are collected. Site collections that have large proportions of "item-mode" material are likely to have higher proportions of nonlocal lithic materials than site collections with mostly "assemblage-mode" material. Also, the recognition of distinctive (nonlocal) lithic material in the field occasionally resulted in alteration of recovery techniques (such as the implementation of water screening) to collect quantities of small debitage. Since nonlocal debitage must be quantified by count only, the presence of one or more concentrations of small materials can strongly affect observed frequencies of nonlocal material.

Ceramic Materials

Ceramic artifacts consist of fired ceramic materials and unfired clay suitable for ceramic manufacture. The latter category includes both tempered and untempered clay and several basketliners probably not intended for

firing. Unfired ceramics are considered to be local regardless of temper or lack of temper. Fired ceramics are considered to be local (Dolores Manufacturing Tract) if they are gray or white wares and if tempered with any one of several varieties of crushed igneous rock (Blinman et al. 1984:68-69). Tempers similar to those defined as local were used over a wide area of the Mesa Verde region (fig. 15.1), and a better interpretation of the Dolores Tract category is that the ceramics are not demonstrably nonlocal.

Nonlocal ceramics are defined on the basis of temper, style, and technological differences from those ceramics considered to be local (Blinman et al. 1984:69-75). Nonlocal sherds are assigned to source areas based on clusters of attributes, of which temper, firing atmosphere, and paint type are most important. Within the Mesa Verde region, nonlocal sherds are assigned to tracts whose approximate geographic locations are presented in figure 15.2. Overlap between tract boundaries (compare with the extent of the Dolores Tract [fig. 15.1]) reflects both the "imperfect" temper selection behavior of the prehistoric potters and imperfections in archeological analysis techniques and spatial data coverage. The Blanding Tract is unique in that it represents red ware manufacture within the Mesa Verde region, and red ware manufacture is believed to be localized in the southeastern Utah area (Lucius and Wilson 1980; Lucius and Breternitz 1981). All Mesa Verde region red wares (San Juan Red Wares) are assigned to the Blanding Tract, but temper use in the red wares is not distinct from that of the other wares, and there is no criteria by which white and gray ware sherds can be assigned to the Blanding Tract.

Non-Mesa Verde Anasazi ceramics are attributed to source regions within the greater Southwest called "culture categories" (Wilson and Blinman 1985). These correspond to broad regions, branches, or ceramic traditions, and the approximate geographic correlates are presented in figure 15.3. Differences between the ceramics from the Kayenta and Cibola regions are not observable on all sherds (most gray ware sherds and unpainted white ware sherds from the 2 culture categories cannot be distinguished), and those sand-tempered sherds that cannot be assigned to a specific culture category are assigned to the "Kayenta or Cibola Culture Category) but may be low in others Some use of sand temper has been documented within the Dolores area (a single sample of unfired clay), and although many sand-tempered sherds are extraregional in origin, as evidenced by the numerous associations of sand temper with organic paint (a Kayenta rather than Mesa Verde characteristic), some sherds assigned to the Cibola or to the Kayenta or Cibola categories may be Mesa Verde in origin.

Sherds and unfired clay are distinguished in the analysis system, and only sherds contribute to the data sets used for exchange interpretation. Quantification of sherds is by count, rim count, and weight, but count is routinely used for most comparisons. The sherd, rather than vessels or vessel equivalents (Orton 1982), is both the unit of analysis and the unit of quantification, regardless of whether the presence of a reconstructible vessel is recognized.

The emphasis on sherd units creates comparability problems where reconstructible vessels contribute to an archaeological collection. Each vessel or portion of a vessel recovered contributes a cluster of sherds that will cause sherd-based proportions to vary to a much greater extent than would be expected under conditions of random sampling from a population of sherds. Fortuitous recovery of most of a single nonlocal vessel can result in over-representation of that source relative to its abundance at the site as a whole. This problem is commonly associated with structure floor proveniences where whole or partial reconstructible vessels are most likely to be encountered. The problem is less extreme in refuse (midden) deposits where sherds, rather than vessels, tend to be the unit of discard, and the problem is also minimized by exceedingly large samples. Systematic evaluation of potential vessel effects is carried out when appropriate to particular comparisons.

Excavation biases are somewhat less important in their effect on ceramic collections than on lithic collections. Most nonlocal ceramics are identifiable only after microscopic examination, and field personnel are unlikely to be able to differentiate local from nonlocal sherds. Potential over-representation of decorated ceramics (white and red wares) exists where item-mode collection was practiced, but this over-representation is not expected to be as strong as that affecting exotic lithic materials. What may be more important is the tendency for excavation strategies to focus on structure floor materials where cluster effects on ceramic data tend to be at their most extreme, but this potential bias can be controlled through the systematic evaluation of the effects of reconstructible vessels in a collection.

Marine Shell

Marine shell is nonlocal and could be derived from sources along the Gulf of Mexico, the Gulf of California, and the Pacific Coast of California. Comparative material in the Anasazi Heritage Center faunal reference collection (Dolores, Colorado) is limited to a few specimens from Gulf of California and Pacific Coast sources, and published references and keys have been used to supplement the comparative material where

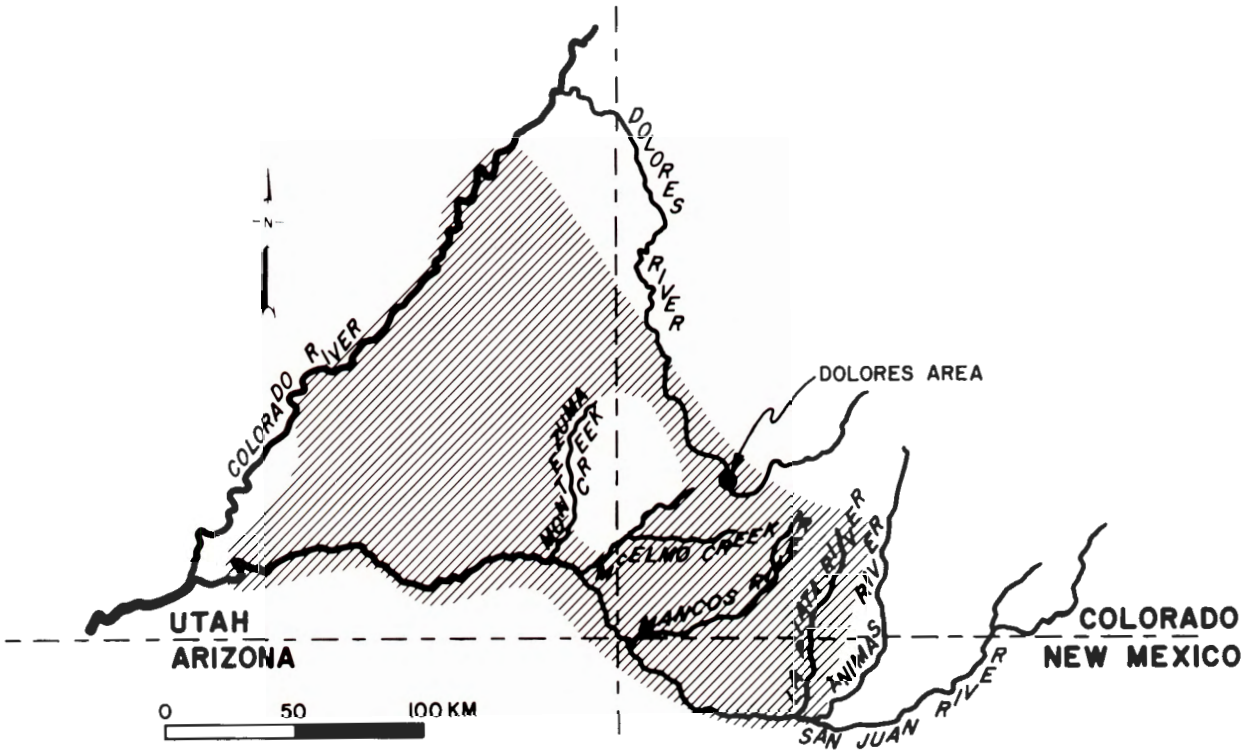

Figure 15.1 – Approximate geographic extent of the Dolores Manufacturing Tract. Boundaries are tentative but are believed to be appropriate for the A.D. 600-980 period.

possible.[1] Where modification of the shell has not obliterated diagnostic features, shells have been attributable to Gulf of California sources. Modified abalone shell items may have been derived from the Pacific Coast of California, and no shell can be specifically attributed to the Gulf of Mexico. Style of bracelet and bilobe bead modification is compatible with Hohokam manufacture (Haury 1976; Jernigan 1978), but some styles of modification cannot be attributed to a specific culture area.

Shell artifacts occur both as isolated items and as clusters in caches and burials. Quantification is by count, and counts associated with clusters (e.g., necklaces) will result in over-representation of shell for some comparisons. The effects of excavation bias on shell collections is a somewhat lesser problem than the effects on lithic or ceramic materials due to the extreme scarcity of shell and to the more significant biases that result from cluster effects.

Dynamics of Exchange and Material Distributions

The patterns of exchange of lithic, ceramic, and shell materials are assumed to be broadly determined by availability (production) on a local and regional level and by the context of use of the materials within the cultural system. Context of use includes the concepts of demand (consumption rates) and symbolic characteristics associated with the material. The exchange patterns of each material category (or subsets thereof) will probably be unique or at least will have the potential to be unique, and each material must be evaluated independently.

Flaked Lithic Items

Exchange of flaked lithic materials can occur as the exchange of raw materials or the exchange of finished products. Either case can occur as commodity exchange when a particular type of raw material is not available within a given catchment and when the particular material is functionally valued. Raw materials available within the Dolores area are characterized by a wide range of physical properties, ranging from microscopic-grained (well-suited for production of sharp thin edges and controlled outlines) to medium-grained material (well-suited for thick and strong edges while sacrificing some control over item shape). This range of locally available material does not limit the manufacture of any of the flaked tool categories, and exchange of raw

[1]Marine shell identification and stylistic comparisons were conducted by G. Timothy Gross, DAP.

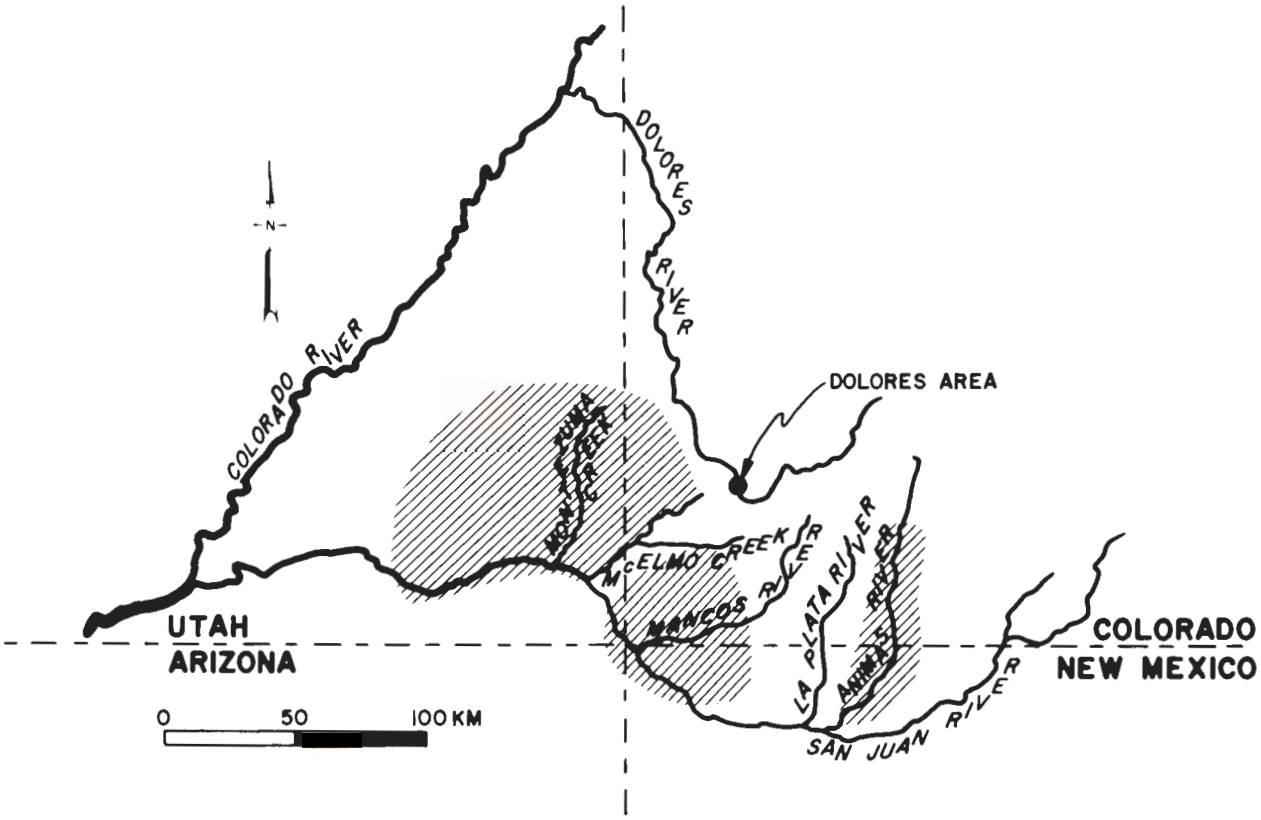

Figure 15.2 – Approximate geographic extent of ceramic manufacturing tracts other than the Dolores Tract. Some or all of the ceramics manufactured in these areas can be identified as nonlocal if they occur in Dolores area archaeological collections.

material into the Dolores area is unlikely to be motivated purely by a local lack of suitable stone. However, in the context of economic principles, microscopic-grained material would be the most likely category for exchange into the Dolores area, and if commodity considerations were influencing exchange, they should be reflected in the exchange of raw material as well as finished products.

A second influence on the exchange of flaked lithic items could be specialization in manufacture. Production of high-input tools (e.g., projectile points or thin bifaces) is potentially subject to specialization at the level of skilled individuals (cf. Ambler 1983). There is no indication that specialization was present through the A.D. 600-840 period of Dolores area occupation, but debitage characteristics support the possibility of household or interhousehold specialization after A.D. 840 (Hruby 1985:66-69). This specialization is evident as widely varying amounts of small debitage without cortex in collections, and it is interpreted as evidence of uneven participation in the final stages of bifacial reduction and biface retouch. Although other explanations are possible, specialized manufacture and increasing interdependence would not be unexpected in the context of the sharp increase in population aggregation that took place at that time (chap. 8). Such specialization would tend to concentrate debitage of finer-grained materials at loci of manufacture, and since exchanged raw materials are likely to have microscopic grain sizes, such specialization could produce concentrations of nonlocal material (primarily debitage).

Symbolic value inherent in the exchanged material is another possible motivation for exchange. If symbolic considerations are significant, visual distinctiveness of nonlocal raw materials is expected to be strong. (This raises the possibility of analytic bias, since the more distinctive the material, the greater the likelihood the nonlocal item will be identified as such during analysis.) Symbolically motivated movement of nonlocal materials could occur in contexts of kinship or ritual obligations (gifts) or in exchange that is part of the alliance cementation process. If symbolic motivations exist, spatial occurrences of these symbols are expected to range along a continuum depending on the degree of status associated with the symbol. The widest distribution is expected when nonlocal materials are symbols of relationships with little status involvement, and the

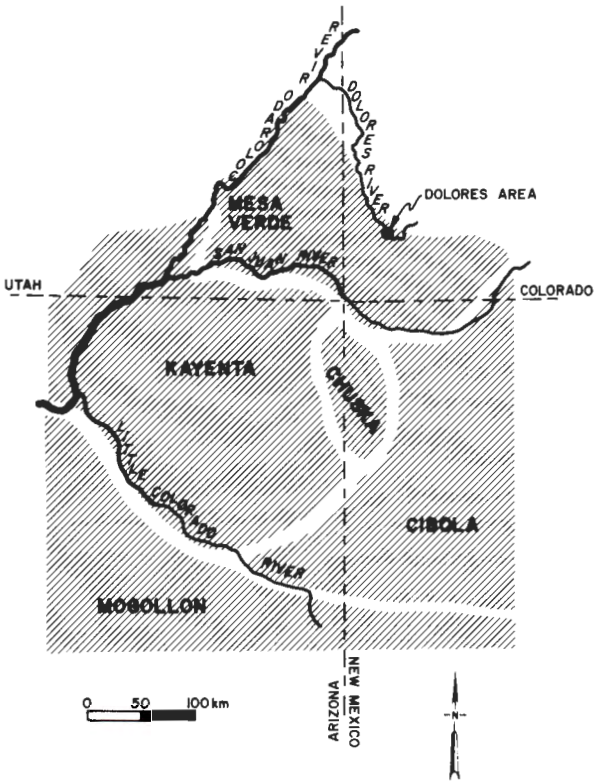

Figure 15.3 – Approximate locations of ceramic culture categories represented by sherds in Dolores area collections.

narrowest distribution is expected when non-local materials are heavily invested with social or political status.

Symbolic or commodity motivations for exchange are not exclusive factors, and weighted combinations of the 2 are expected. Demand originating from both functional and symbolic motivations can lead to specialized manufacture and the political control of that manufacture (such as obsidian blade production in Mesoamerica [Spence 1982]). While the expected complexity of political organization within the Dolores area is not comparable with that of Mesoamerica, the process of leadership development outlined by Lightfoot (1984) could accommodate proprietary access to functionally valued and distinctive (i.e., nonlocal) lithic materials. Reinforcement of this pattern would result in an increased demand and an increase in the absolute amount of nonlocal lithic materials in the regional exchange system.

Nonflaked Lithic Items

Nonflaked lithic tools are narrowly defined in terms of technology of production, but they include an extremely broad range of functional classes, ranging from mauls to pendants (Phagan and Hruby 1984). Raw materials are readily available in the Dolores area for grinding, pounding, and chopping tools, and no need for commodity exchange of these items or of suitable raw materials is apparent. Ornaments compose a small subset of the nonflaked lithic tools, and although some locally available materials are suitable for ornament manufacture, the range of local materials is small compared to the types of materials known to be used in the prehistoric Southwest (Jernigan 1978). Types of materials rare or not present in the Dolores area include jet, turquoise, malachite, azurite, and obsidian (Keane and Clay 1985; Phagan 1985). Commodity motivations for exchange of nonflaked lithic materials are likely to be limited to ornaments and raw material for ornament manufacture.

Lithic ornaments also carry with them a strong symbolic implication. This derives from the distinctive visual characteristics of materials used for stone ornaments, the provision for display incorporated into their shape (e.g., pendants), and the relatively great effort expended in their manufacture. As was discussed in the context of flaked lithic items, such symbolism could vary from simple tokens of relationships to proprietary status markers. Given the assumed function of ornaments as a class, symbolic factors are likely the major determinants of ornament distribution. However, a commodity need for suitable raw material is expected to affect exchange in situations where ornaments were locally manufactured. No formal workshops for ornament production have been recognized in the Dolores area, but small-scale production of some ornaments cannot be ruled out.

Archaeological distributions of ornaments should be relatively even across the population if ornaments served as tokens with relatively little status value within the local population. Under conditions of high status investment (such as would be expected as part of leadership elaboration), the spatial distribution of ornaments should be relatively restricted and should coincide with other measures of status. The occurrence of exchanged ornaments relative to local ornaments need not be significantly different under either condition, but concentrations of exchanged ornaments relative to dispersed local ornaments would be more likely if they were functioning symbolically within a regional alliance system with greater leadership control of interaction.

Ceramic Materials

Pottery is similar to nonflaked lithic tools in that the definition of the archaeological material class is relatively narrow, but the range of functions of ceramic

materials within the cultural system can be very broad. The best approximation of ceramic function is vessel form (Blinman 1985), but a coarse approximation consists of archaeological ware classifications (cf. Fry 1980). This latter approximation is advantageous for exchange discussions since ware classifications also incorporate production and stylistic characteristics of ceramic materials. Four wares are used to describe the Anasazi ceramics in Dolores area sites, and each ware has different implications for production, use, symbolism, and ultimately, exchange.

Gray wares. – Gray ware sherds are defined as those sherds neither polished nor painted and fired or intended to be fired in a neutral or reducing firing atmosphere (Blinman et at. 1984:75-77). This definition encompasses vessel forms commonly classified as utilitarian and dominated by cooking jars. Bowls, ollas, seed jars, effigies, and other forms do occur as gray ware vessels, but cooking jar sherds constitute more than 86 percent of gray ware sherds for all time periods after Period 1. (The number of gray ware storage jars in Period 1 decreases the sherds attributable to cooking jars to 48 percent of the total gray ware sherds [chap. 2]). Assuming that cooking jars have relatively short uselives (Foster 1960; DeBoer and Lathrap 1979; Longacre 1985), demand for gray ware production would have been relatively high for all time periods.

Clays suitable for gray ware production are ubiquitous within the Dolores area (Wilson et al. 1985). Preferred temper sources are less ubiquitous, but all raw materials for gray ware manufacture (including fuel) are well within the procurement distances observed for ethnographic potters (Arnold 1981). This abundance places no resource-based constraints on gray ware production and eliminates one potential explanation for commodity exchange of gray ware raw materials or vessels.

Organization of production is another potential reason for commodity exchange, and some specialization of ceramic manufacture does appear to exist in the Dolores area. Prior to A.D. 800 (Periods 1 and 2), evidence of ceramic manufacture is rare and appears to be concentrated in association with specific households (Blinman and Wilson 1985a). This pattern is interpreted as representing small-scale specialization at the level of skilled individuals, with one potter providing vessels for several households. The inference of specialization is not strong because it is dependent on negative evidence in the face of variable excavation intensity (sample sizes), but depending upon the assumptions made, ratios of producing to consuming household vary from 1:1 to 2:1. The instances of ceramic production are assumed to have been focused on gray ware production, but there is no direct evidence apart from the lack of suitable pigments for white ware manufacture.

Production evidence is equivocal for A.D. 800-840 (Period 3), but no evidence shows specialization continuing after A.D. 840 (Periods 4 and 5) (Blinman and Wilson 1985b). This is in contrast to the apparent specialization of some households in high-input flaked lithic tool production and rejuvenation, but no evidence indicates that any household or interhousehold group did not participate in ceramic manufacture. Focus of production on gray ware manufacture must be assumed in most cases (based on the scarcity of evidence of white ware production), but unfired gray ware vessels have been recovered in some instances. This lack of specialization in gray ware manufacture is likely to persist into Period 6, but its persistence cannot be independently evaluated for lack of sufficient data.

This changing pattern of production organization provides a changing motivation for commodity exchange of gray ware vessels. Prior to A.D. 800, a subset of the Dolores area households would have had to obtain all of their gray ware vessels by exchange. The relatively small scale of specialization at this time would have resulted in a wide dispersal of pottery sources, and the geographic extent of gray ware exchange is expected to vary with population density. After A.D. 840, no commodity motivation for gray ware exchange is anticipated, unless the net movement of vessels is outward from the Dolores area.

The symbolic implications of gray ware vessels are assumed to be minor. This assumption is based on the minimal surface decoration (limited to neckbanding after about A.D. 800), the abundance of cooking vessels as a functional class, and the high turnover associated with a short uselife. Cooking jars are standard subsistence equipment for all households, and apart from variation in jar volume (chap. 2) and possibly total inventory of cooking jars, any status-related associations of gray wares are unlikely.

A motivation for gray ware exchange not applicable to non-ceramic materials is exchange ancillary to the exchange of vessel contents. Ceramic containers provide a high degree of security to their contents, but vessels are heavy and fragile. As such, cooking jars are relatively inefficient containers for the long-distance transport of large quantities of comestibles, and long distance transport is more likely to be accommodated in bags or baskets (cf. Lightfoot 1979). However, weight and fragility are less of a liability in short-distance movement of foodstuffs, and vessels are appropriate containers for the transport of partially or totally prepared food. This situation is analogous to the modern potluck, in which contributions or gifts of prepared food are moved between households. The vessel may break at the site of the potluck resulting in its deposition

in the host midden, an equivalent vessel may be substituted for the original, or the vessel may be returned after consumption of its contents. In either of the 2 scenarios, archaeological analysis will perceive that exchange of vessels has taken place.

The patterns of production, use, and ancillary movement of gray ware jars as containers are assumed to be the primary determinants of gray ware exchange in the Dolores area. Prior to A.D. 800, sites without evidence of ceramic manufacture are expected to have higher frequencies of nonlocal gray wares due to a reliance on exchange for provisioning the household with vessels. Regardless of the production involvement of particular households, some exchange of gray wares is expected as part of hosting behavior associated with kinship or ritual obligations. The geographic extent of this movement of vessels should reflect the geographic extent of the kindship network, and based on the assumption of a standard mating network size (cf. Wobst 1974), geographic extent of gray ware exchange should decrease as population density increases. No concentrations of gray ware exchange for any time period are expected to result from status or symbolic associations, but differential hosting activity as part of ritual or leadership obligations could conceivably result in concentrations of nonlocal gray wares.

White wares. – White ware sherds are defined by the presence of a polished surface or paint and evidence of a neutral or reducing firing atmosphere. White ware sherds are predominantly derived from bowls (62 percent), but white ware vessel forms also include storage jars, ollas, and effigies. Although many white ware sherds are identified as such only on the basis of polished surfaces, the vast majority of white ware vessels are decorated with painted designs on parts of their visible surfaces (interiors of bowls and exteriors of jars).

Part of the decorative aspect of painted white ware vessels is the contrast between the background color of the vessel body and the paint color. The need to establish this contrast places greater requirements on both raw material selection and artisan skill than is true for gray ware manufacture. Although many of the same clays may be used for gray and white ware manufacture, some potential gray ware clays are poorly suited to white ware production because of their color. As a consequence, white ware clays are slightly less common than are gray ware clays in the Dolores area (although still ubiquitous). Pigments used in white ware manufacture within the portion of the Mesa Verde region that includes the Dolores area are powdered minerals, but the range of minerals used and the geographic limitations on their availability are not known. Based on ethnographic descriptions, pigment raw materials are obtained from greater distances than are other ceramic resources (Arnold 1981), and lack of pigments in the local area is unlikely to constrain ceramic manufacture. Thus, resource constraints could be a motivation for white ware exchange, but this possibility is only slightly greater than that for gray wares.

White ware sherds are considerably less abundant than gray ware sherds in Dolores area collections (about 7 percent as compared with 88 percent). One implication of this is that white ware production, if present, was much less common than gray ware production. No direct evidence of white ware production has been recovered from pre-A.D. 800 sites, and only scant evidence has been recovered from post-A.D. 840 sites. Although all ceramic manufacturing households in all time periods may have produced white wares as well as gray wares, the relatively greater complexity of white ware technology (pigment selection and greater control of firing atmosphere) could encourage the development of specialization at the level of skilled individuals (Ambler 1983). This possibility cannot be evaluated for the pre-A.D. 800 manufacturing contexts due to small samples, but the few recovered polishing stones suitable for ceramic manufacture and the lack of pigment stones provide weak evidence that white ware production, if present, was not as common as gray ware production.

White ware vessels are assumed to have greater potential as carriers of symbolic meaning than gray ware vessels. This assumption is based on the presence of visible decoration, relative scarcity, and the predominance of vessels forms associated with food consumption rather than preparation. Decoration also conveys a degree of uniqueness to white ware vessels, providing much more prominant visual clues of vessel origin and history than is true for gray ware vessels. Greater symbolic potential could motivate white ware exchange in the sense of tokens of relationships, and this potential could further support expressions of differential social and political status.

The vessel form characteristics of white wares as a whole are less suited to material (e.g., food) transport than are gray ware vessels, but some potential for vessel movement ancillary to content movement remains. White ware storage jars often are relatively small, and they could provide high security containment for valued dry materials (e.g., seed corn or noncomestibles). Bowls could serve as containers for short-distance movement of fully prepared foodstuffs or unprepared foodstuffs, but the containment security would be low. Use of bowls rather than gray ware jars in these contexts would probably result only if the bowls were also intended for use in food consumption at the site of a potluck or if symbolic considerations were more important than the risk of content loss.

Motivations for white wares exchange in the Dolores area are likely to be determined primarily by the organization of production and symbolic considerations and only secondarily by aspects of use or containment. Frequencies of nonlocal white wares in collections should be greater than frequencies of nonlocal gray wares because commodity exchange would be necessary to provision the needs of most households. In addition, the geographic extent of white ware exchange should be greater than that of gray ware exchange because of the lower density of production sources within the population. As visible markers of interactions and relationships, clustering of nonlocal white wares is expected to correlate with status differentiation and leadership involvement in the maintenance of long-distance alliances. However, clustering of white ware vessels is also possible as a consequence of the breakage of vessels at the hosting locations of potlucks.

Red wares. – Red ware sherds are defined on the basis of a polished or painted surface in association with an iron-rich clay fired in an oxidizing atmosphere or intended to be fired in an oxidizing atmosphere. Most (72 percent) red ware sherds are derived from bowls, and most of the remainder are derived from small storage jars, especially seed jars. Painted decoration is present on the visible surfaces of nearly all red ware vessels, and the firing of red ware vessels was manipulated to emphasize contrast for the decorated areas (e.g., firing settings were arranged so that fire-clouding rarely affects bowl interiors but often affects bowl exteriors).

Red ware manufacture requires an iron-rich clay that will oxidize to a bright red or orange color during firing. Suitable clays are present within the Dolores area but are not abundant. Refiring analyses of archaeological clay samples from the Dolores area indicate that red-firing clays were rarely used in ceramic manufacture. Furthermore, no appropriate pigment stones have been identified, and no "wasters" associated with red ware production have been recovered. This lack of evidence supports the inference that red ware manufacture, if carried out within the Dolores area, was rare, and that red ware vessels were a commodity that had to be obtained by exchange.

A frequency cline in red ware abundance exists across the Mesa Verde region. Contemporary sites (the last quarter of the eighth century) in the vicinity of Durango, Colorado (east) (Carlson 1963; Ellwood 1980), the Dolores area (central), and Site 13 on Alkali Ridge (west) (Brew 1946; Blinman 1983) have increasing frequencies of red ware sherds as proportions of total ceramic collections. First occurrences of red wares are also considered to be earlier in the western Mesa Verde region (Breternitz et al. 1974), and regional specialization of red ware manufacture in southeastern Utah has been proposed based on the spatial abundance of Brushy Basin Formation clays in that area (Lucius and Wilson 1980; Lucius and Breternitz 1981). This specialization appears likely, and it effectively creates a point source for red ware vessels and a strongly directional commodity exchange system to accomplish their distribution.

The emphasis on decoration and the vessel form characteristics of red ware vessels are comparable to white ware vessels and would support a similar potential for symbolic roles in use and exchange. However, the distinct color differences between red ware vessels and those of all other wares could enhance that potential. Circumstantial support for a proportionately greater role of red ware vessels in ritual contexts after A.D. 840 is provided by their slightly greater frequencies in association with a subset of pitstructures (Wilshusen 1985). These pitstructures are interpreted to have broader ritual functions than other pitstructures based on the presence of suites of floor features that have no economic interpretation. Thus, symbolic considerations likely shaped some of their exchange.

Parallels between red and white ware vessels also extend to the possibility of vessel exchange as an ancillary occurrence to content exchange. Although most red ware vessels are bowls, the seed jar form is common, and seed jar rims were often drilled or punched for securing covers (Blinman 1985). Red ware seed jars are relatively small in volume (less than 3.5 L), and would be well suited to the transportation of small quantities of valued or perishable materials.

The greatest factor affecting red ware exchange is likely to have been the regional centralization of production and the need for long-distance linkages in vessel distribution. However, the motivations for exchange (why go to such great lengths to obtain a bowl?) are likely to have been symbolic. Symbolic overtones could vary from functional associations in an egalitarian context (red ware vessels as the appropriate vessels for public consumption) to functional associations in a status differential context (red ware vessels as status markers for individuals). In either case, the transfer of red ware vessels could serve as visible markers of relationships, and in the latter case, a much more clustered distribution would be expected. However, as is the case with white ware bowls, clustering could result as a consequence of the breakage of vessels at the hosting locations of potlucks.

Smudge ware. – Occasionally sherds are recovered in the Dolores area that are polished, unpainted, and deeply smudged on the polished surface. Such sherds

could result from firing accidents (extreme fire-clouding), but smudging is also a recognized decorative technique among Mogollon potters. The occurrences of these sherds are so rare that recovery of production evidence is extremely unlikely, but an evaluation of the clays and tempers used in smudged ware production indicate some are locally made and the others are nonlocal (Mogollon) (Wilson 1985). Smudged sherds are almost exclusively derived from bowls.

Application of a non-Mesa Verde firing technique to local ceramic resources could indicate innovative copying, the immigration of individuals from the Mogollon region or the immigration of individuals familiar with Mogollon technology. In the first instance, copying would likely be subsequent to be appearance of exchanged vessels. No similar restrictions can be imposed on the immigration explanations since immigration could be linked to prior exchange, could encourage subsequent exchange, or could be totally independent of preceding exchange patterns. The apparent restriction on local production would provide some commodity motivation for exchange of both the local and nonlocal smudged vessels.

Motivation for the exchange of smudged vessels is likely to have included symbolic potential similar to that inherent in white or red wares. This implies movement as tokens of relationships with or without status implications. Concentrations of smudged sherds could be interpreted as reflecting status; but the uncertain production organization and the uncertain, but potential, relationship between local producers and residents of the Mogollon region could also explain concentrations. The almost total restriction of vessel forms to bowls makes content exchange unlikely in any case.

Marine Shell

Marine shell is present in Dolores area collections in the form of beads, bracelets, pendants, and fragments of these 3 forms. There is no indication that these forms were produced in the Dolores area from imported raw material, but modification of some of the fragments suggests that broken shell objects could have been modified or recycled within the area. Since no local production appears likely, commodity movement is a likely motivation for shell exchange.

Shell objects are similar to the exotic subset of nonflaked lithic tools because their shapes are designed to be displayed. These symbols could be desired items obtainable only through exchange or could be used as tokens of relationships, and in either context they may have had status overtones. Under relatively egalitarian conditions, the status overtones are unlikely to result in extreme concentrations of shell materials. However, under the implications of status differentials associated with leadership development, unequal access to shell ornaments could be expected.

EXCHANGE AND THE DOLORES ANASAZI CULTURAL SYSTEM

Three general aspects of the Dolores area cultural system are expected to have significant effects on the patterns of material exchange. These are the social and spatial organization of production, regional social, economic, and political systems of interaction, and the degree to which participation in material accumulation is unequally distributed within the Dolores area population. Specific expectations for effects on exchange differ slightly for the economic versus leadership models as generative forces for culture change, although exchange alone is unlikely to provide convincing differentiation between the 2 models.

Patterns of Ceramic Production and Exchange

Changing levels of ceramic production specialization are evident through the A.D. 600-920 period. These consist of regional specialization of red ware manufacture, probable specialization of white ware manufacture at the level of skilled individuals, and probable specialization of gray ware manufacture at the level of skilled individuals, but only for the A.D. 600-800 period. Implications for exchange can be most easily evaluated for gray and white ware ceramics based on contrasts between the relative frequencies of local and nonlocal sherds of the wares. Red ware exchange implications are more difficult to assess for lack of information from the source region, but some relationships between changing Mesa Verde cultural systems and changes in red ware vessel frequencies can be postulated.

Specialization and Gray Ware Production and Exchange

Assuming households not involved in ceramic production must obtain vessels by exchange, nonproducing households should be associated with collections that have higher frequencies of nonlocal gray ware sherds. For purposes of this comparison, nonproducing households are defined as those whose associated collections lack manufacturing tools, raw material, or unfired vessels. This definition ignores sample size, and, as a consequence, it is likely that the nonproduction category will mistakenly include some collections from ceramic-producing households where sampling error resulted in the failure to discover evidence of production. The effect of the probable errors in assignment that result from the definition will be a dilution of the differences (if any) in the proportions of nonlocal gray wares in the

producing and nonproducing groups. Under these conditions, the expectation of higher exchange frequency at nonproducing households will have to be robust to be observed.

Frequencies of nonlocal gray wares were compiled for ceramic-producing and -nonproducing households for the A.D. 600-800 period (fig. 15.4). The nonproducing household group is believed to include some collections from households not engaged in ceramic manufacture and some collections that lack production evidence due to sampling error. Although most gray ware sherds in both groups are classified as local (originating from within the Dolores Tract), the frequency of sherds from outside of the Dolores Tract is over twice as great in the collections without associated production evidence. This difference is assumed to be significant since the aggregate collection sizes on which the percentages are based are in excess of 12 000 sherds each.

During the A.D. 840-920 period, no specialization in gray ware manufacture seems to have occurred (Blinman and Wilson 1985b).[2] However, some collections lack ceramic manufacturing evidence (presumably due to small collection sizes).[3] Assuming that all interhousehold groups did produce ceramics, the division of the A.D. 840-920 collections into those with and those without manufacturing evidence should not result in any significant differences in nonlocal gray ware frequency. As indicated in figure 15.5, results support this expectation: the nonlocal gray ware frequency is actually 0.5 percent greater in those collections with evidence of ceramic manufacture (fig. 15.5). Although the collection size for the ceramic-producing groups is over 20 000 sherds, the nonproducing collection size is less than 4000 sherds, and the small difference is not interpreted as significant.

Specialization and White Ware Production and Exchange

In contrast with the changing pattern of specialized gray ware production, specialization in white ware production appears to have been continuous in the Dolores area for the A.D. 600-980 period. This should make most households reliant on exchange for white ware vessels. No households (or later, interhouseholds) can be unequivocally associated with white ware production, but the proposition of relatively uniform commodity exchange can be evaluated with the ceramic-

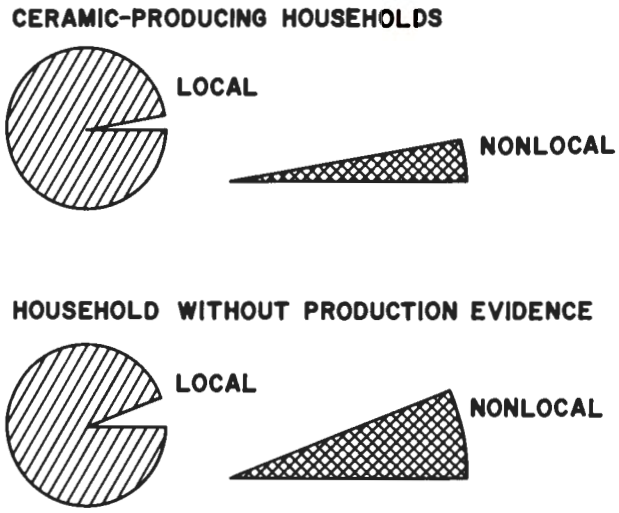

Figure 15.4 – Frequencies of nonlocal gray ware sherds in A.D. 600-800 collections that include ceramic manufacturing evidence or lack ceramic manufacturing evidence.

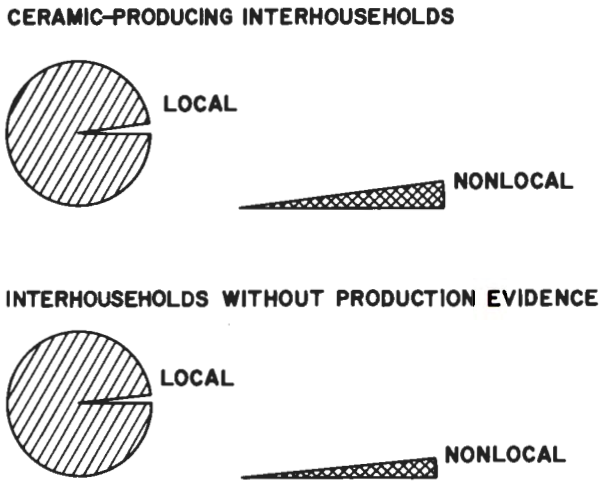

Figure 15.5 – Frequencies of nonlocal gray ware sherds in A.D. 840-920 collections that include ceramic manufacturing evidence or lack ceramic manufacturing evidence.

producing and -nonproducing groups described in the discussion of gray ware production and exchange. Within both temporal subdivisions, proportions of nonlocal white ware sherds should be comparable, since the presence or absence of production evidence (assumed to be associated with gray ware rather than white ware manufacture) should have little influence on the need to obtain white ware vessels as a commodity.

Similarity in nonlocal white ware proportions is evident for the A.D. 600-800 collections (fig. 15.6). The ceramic-producing group has slightly more (16.4 percent) nonlocal white ware sherds than the nonproducing

[2]The A.D. 800-840 period is not discussed because insufficient data are available to evaluate ceramic production during this period.

[3]Spatially segregating the architectural space used by a single household is difficult due to the sharing of pitstructures by several households. For this reason, definitions and comparisons of producing and nonproducing groups are focused at the interhousehold level. Interhousehold clusters usually consist of a pitstructure, 2 or more surface roomsuites, and spatially associated deposits (Kane 1983 and chap. 5).

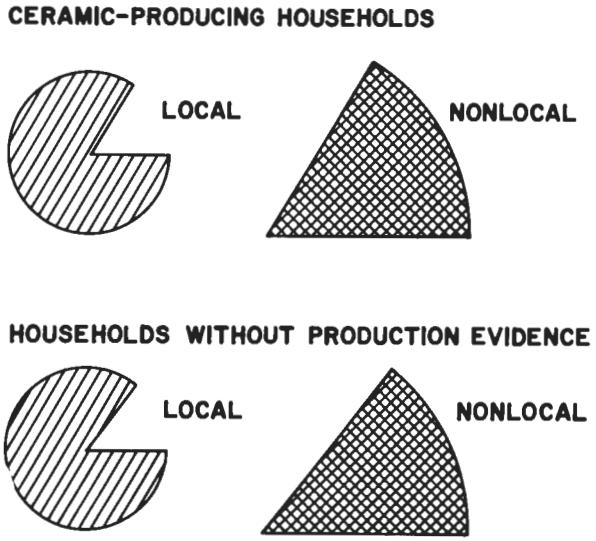

Figure 15.6 – Frequencies of nonlocal white ware sherds in A.D. 600-800 collections that include ceramic manufacturing evidence or lack ceramic manufacturing evidence.

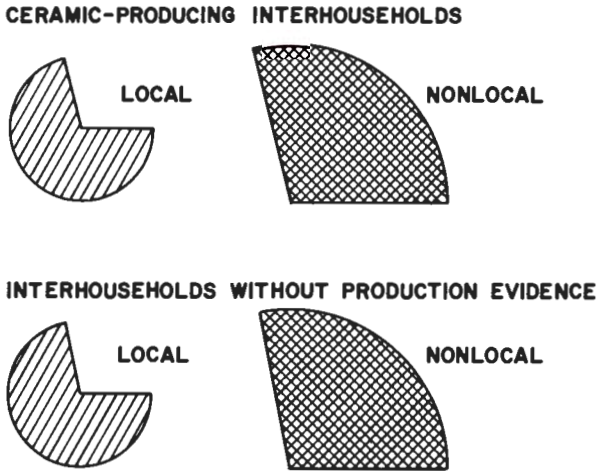

Figure 15.7 – Frequencies of nonlocal white ware sherds in A.D. 840-920 collections that include ceramic manufacturing evidence or lack ceramic manufacturing evidence.

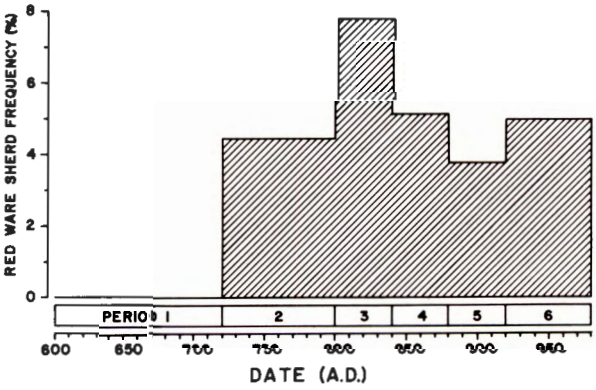

Figure 15.8 – Frequencies of red ware sherds in screened refuse collections.

group (14.7 percent). This difference is the opposite of that expected, but the magnitude of the difference (1.4 percent) is not considered to be significant at the relatively small sample sizes involved (706 and 641 sherds, respectively) (Blinman and Wilson 1985a). The A.D. 840-920 comparison produces similar results (fig. 15.7), with marginally more nonlocal white ware sherds in the ceramic-producing collections (28.7 percent) than in the nonproducing collections (27.8 percent). This difference is also not considered significant; although the proportion for the ceramic-producing collections is based on over 1700 sherds, the proportion for the nonproducing collections is based on just under 2000 sherds and is probably unstable.

Red Ware Production and Exchange

The relationship between red ware production and exchange cannot be directly evaluated using Dolores area data. Instead, temporal variation in proportions of red ware sherds in Dolores area collections can be described as an index to either changes in production or changes in the efficiency of the exchange network responsible for red ware vessel distribution to the Dolores area. Some of the observed changes may be related to the population history of the Mesa Verde region as a whole.

Red ware frequencies for dated Dolores area collections of screened refuse are presented in figure 15.8. Screened refuse was chosen to avoid any bias due to selective collection, to minimize the possible cluster effects of reconstructible vessels, and to more closely reflect vessel consumption rates than static vessel assemblage composition. The choice of refuse may result in some time lag or smoothing of actual temporal trends in exchange. Sample sizes for the collections are the same as those noted in figure 12.1, and differences in frequencies are considered for discussion if they could not have been attributed to chance variation within a single population ($p < 0.05$) had the collections been obtained through random sampling (differences in percentages were evaluated following Sokal and Rohlf [1969:607-610]). The sherd collections are **not** random samples, but use of this selection criterion focuses discussion on frequency differences that have the greatest likelihood of being significant.

Red ware vessels first appear in the Dolores area shortly after A.D. 720 and quickly occur in sufficient numbers to account for over 4 percent of Period 2 refuse sherds.

This frequency increases to just below 8 percent in Period 3 but falls in Periods 4 and 5 with a slight rise in Period 6. Peak production appears to have been relatively shortlived, and the decline coincides with the extreme population increase in the Dolores area after A.D. 840. Part of the decline may reflect the distribution of a limited number of red ware vessels over an increasing population, but most of the population increase can be attributed to immigration, probably from areas immediately adjacent to the Dolores area. These populations were likely to have been consumers within the Period 3 red ware exchange system, and their relocation should have reoriented rather than diluted the supply of red ware vessels, keeping the per capita supply (the rate of red ware refuse accumulation) relatively constant.

Another possible explanation for the decline in red ware vessels could be the concurrence of population movements in both the Dolores and source areas. The motivation behind the Dolores area population dislocation in Period 4 appears to be an impairment of agricultural potential at lower elevations (chap. 6, chap. 8). This climatically induced stress may have had similar effects on the resident red ware potters in southeastern Utah, resulting in the abandonment of lower elevation settlements (such as Site 13 on Alkali Ridge [Brew 1946; Honeycutt and Fetterman 1984]) and establishment of settlements at higher elevations such as those to the west of Alkali Ridge (Louthan 1977). This probable relocation of red ware potters, coupled with the relocation of intervening populations, may have temporarily but thoroughly disrupted both the production and distribution systems for red ware vessels.

This scenario is not confirmed as an explanation for the observed variation in red ware frequency, but it receives some support from the contrast between refuse and vessel data within the Dolores area. Red ware vessels as part of static vessel assemblages reach their greatest frequency in Period 3 (31.5 percent of 54 vessels), and decrease dramatically in Period 4 (1.6 percent of 64 vessels) (Blinman 1985:fig. 16). In contrast with the low frequency in the Period 5 refuse data, red ware vessels in Period 5 increase again to 10.3 percent of 136 vessels (data are not available for Period 6). The vessel frequency proportions are unstable due to small samples and to the difficulty in controlling affects of abandonment conditions on vessel assemblage composition, but the observed trends conform well to the model of serious disruption of red ware production (or distribution) in Period 4 followed by a reestablishment of production (and distribution) once settlements stabilized at the beginning of Period 5. This interpretation must assume that the refuse data are exhibiting some lag in the translation of vessels into refuse.

Interaction Between White and Red Ware Production and Exchange

White ware vessels and red ware vessels could have been substitutable to a great degree. The vessel form complements are similar, both are decorated, and the major distinguishing feature is the distinctive background color of the red ware vessels. Similarity between the 2 wares suggests the advent of red wares and the variations in their availability through the exchange network may have influenced the production of white ware vessels. If red ware vessels were being adopted as functional replacements for white ware vessels, their frequencies should reflect a complementary distribution.

Frequencies of decorated wares in screened refuse are presented in figure 15.9 and are broken down into the contributions of white ware sherds (and nonlocal white ware sherds) and red ware sherds. In an effort to minimize the constraint inherent in percentages, frequencies of each ware category are expressed as percentages of the total sherd collections less the number of white and red ware sherds. This approximates the ratio of the decorated ware categories to the gray ware category. Contrary to expectations, the introduction of red wares in Period 2 is accompanied by a doubling of the decorated sherd category as a whole, rather than by replacement of white ware vessels by red ware vessels. However, in Period 3 the large increase in red ware frequency does appear to have a significant effect on the consumption of white ware vessels. White ware sherds increase slightly in frequency as red ware sherds decline through Periods 4 and 5, and both wares increase in frequency in Period 6. The decline in red ware sherds in Periods 4 and 5 is accompanied by a decline in total decorated sherds that is reversed in Period 6.

The nonlocal contribution of the white ware sherds covaries with the total white ware sherd frequency. A slight increase occurs in Period 2, followed by a decrease and then stability in Periods 3 and 4. The increase in nonlocal white wares in Period 5 coincides with an increase in total white wares, but the magnitude of the nonlocal increase is much greater than the increase for the ware as a whole. This is followed by another slight increase in Period 6. Intensity of white ware exchange appears to be stimulated slightly by the introduction of red ware vessels into the exchange system, but the intensity falls to a background level as red ware exchange becomes dominant. White ware exchange intensity increases again in Period 5, perhaps in response to unfilled demand resulting from the decrease in red ware availability.

Static vessel assemblage composition roughly parallels the ware frequency in refuse data with some exceptions.

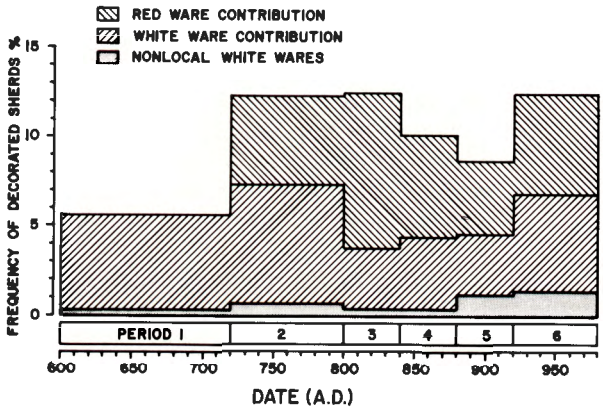

Figure 15.9 – Frequencies of decorated sherds in screened refuse collections. The contributions of white and red ware sherds are indicated, as is the contribution of nonlocal white ware sherds. Smudge ware sherds occurred in several of the period collections, but their frequencies were too low to represent graphically.

White ware vessels remain stable in frequency (5.6 percent) through Periods 2 and 3, increase marginally in Period 4 (7.8 percent), and more than double in Period 5 (16.9 percent) (Blinman 1985). The static vessel assemblage data do not reflect the Period 3 decline in white ware sherd refuse, but (assuming a lag between vessel and refuse characteristics) the increase in white ware vessels in Period 5 presages the increase in white ware refuse in Period 6. These data indicate the loss in numbers of exchanged red ware vessels in Periods 4 and 5 was not compensated for by increased white ware production until Period 5. However, the static vessel assemblages do reflect a possible replacement of red ware vessels with gray ware vessels in both Periods 4 and 5. Only 2 gray ware bowls occur in pre-A.D. 840 vessel assemblages, but 12 (30 percent) of the Period 4 and Period 5 bowls are executed as gray wares rather than as decorated wares.

Summary

These comparisons indicate the variety of reciprocal influences between ceramic production and ceramic exchange through the A.D. 600-980 period. Simple relationships exist between the level of household specialization in ceramic manufacture and the level of exchange at the household level. In general, increased exchange of a ware is correlated with the degree of specialization in manufacture, and non-producing households have larger proportions of nonlocal gray wares. While this relationship between production and exchange can explain a significant component of exchange motivation, the background frequency of nonlocal sherds in collections associated with ceramic production remains unexplained except that the exchange is not likely to be a consequence of commodity motivations.

More complex relationships are evident in the regional specialization in red ware production and the effect of fluctuations in red ware production volume on other wares. The introduction of red ware vessels did not result in an immediate replacement of white ware vessels, but the subsequent (Period 3) increase in volume of red ware production did adversely affect white ware production. Both the initial acceptance of red ware vessels and the eventual replacement of some white ware vessels by red ware vessels is likely to have been fostered by the visual appearance of the latter ware and by its presumably greater symbolic potential.

The production and distribution of red wares appears to have been disrupted in Period 4, presumably by climatically induced population relocations in the production area. The reduction in red ware supply appears to have been compensated for by an increase in the use of gray ware replacements (at least for bowls), and by increases in white ware production in Periods 4 and 5. Nonlocal white wares increase in frequency in Period 5, and white ware production increases sharply in Period 6, despite a concurrent increase in red ware frequency.

Regional Patterns of Interaction

Although relationships between ceramic production and ceramic exchange can be demonstrated, many observed aspects of ceramic and other material exchange cannot be explained by variation in production alone. These include the background levels of ceramic exchange that do not coincide with the pattern of production specialization, directional changes within ceramic exchange independent of known regional specialization in production, and long-distance movement of ceramic, lithic, and shell material. These aspects of exchange are expected to be related to social interaction through the kinship and ritual obligation networks, and some aspects may be related to the development and maintenance of economic and political alliances.

Population Distributions and Social Interaction

Two characteristics of population distributions appear to be influencing the archaeological perception of exchange. These are the local population density and the regional distribution of population. The former is expected to influence the spatial extent of the kinship and ritual obligation network by defining the space necessary to satisfy basic mating network needs (cf. Wobst 1974) and the space within which population is sufficient to fill all necessary positions within the social

structure. The latter influences exchange by determining the visibility of nonlocal materials in archaeological perception. Interaction between these 2 effects of population distributions must be evaluated as part of Dolores area exchange interpretations.

Changes in population density are assumed to be adequate proxies for changes in the geographic extent of intensive social interaction networks. Other studies (e.g., Neitzel 1984) have assigned values to the expected size of mating networks based on the simulations of Wobst (1974), but the tendency for the institution of marriage restrictions within the relative high population densities of sedentary agriculturalists makes such estimates problematic (Wobst 1974:169). Instead, this discussion only assumes that the direction of change (shrinkage or expansion) in mating network size can be predicted from the direction of changes in population density.

The influence of spatial population distribution on archaeological perception limits the study of Dolores area social interaction to the ceramic data set. Lithic materials originating outside of, but adjacent to, the Dolores area cannot be identified as being nonlocal and therefore cannot be used to define the extent of exchange linkages between the Dolores area and surrounding areas. Similarly, shell materials and those lithic materials that can be reliably identified as nonlocal originate outside of the presumed maximum extent of the local interaction sphere, and the intermediate nodes of exchange networks that may be within the Dolores interaction sphere cannot be traced.

Although ceramic materials are less subject to these limitations, the large geographic extent of the Dolores Tract places some limits on the resolution of exchange perception. The most important of these is an elevational bias. Upslope movement of settlement systems in the Cahone and Sandstone Tracts brings them closer to sources of igneous rock temper (the Dolores River valley) and brings them into the Dolores Tract. Thus, a given geographic extent of interaction, as measured by distance, will be detectable while population is dispersed across a broad elevational range. However, this same extent (distance or area covered) will not be detectable if settlements are concentrated at higher elevations.

With these limitations in mind, gray ware vessel movement (beyond that associated with specialized production and commodity exchange) is assumed to be a consequence of the movement of small quantities of prepared food. This movement is, in turn, assumed to reflect the intense social interaction of mating and ritual obligation networks. Frequencies of nonlocal gray ware sherds in Dolores area screened refuse collections are presented in figure 15.10. The highest frequency of nonlocal gray wares occurs in Period 1 and coincides with the smallest estimated momentary population level for the Dolores area (fig. 15.11 and Schlanger, chap. 8). The increase in population in Period 2 is accompanied by a decrease in nonlocal gray ware sherds, and the lowest nonlocal gray ware frequencies (Periods 4 and 5) coincide with the largest local population.

Given the interpretative assumptions, these observed differences in nonlocal gray ware frequency support the geographical contraction of the intensive social interaction network as population density increased. However, the extreme population increase between Periods 3 and 4 is not accompanied by a correspondingly large decrease in nonlocal gray ware sherds. Part of the lack of response in Period 4 could be due to the presence in refuse of the nonlocal personal belongings of the immigrants who constituted the majority of the population increase. However, this explanation cannot account for the persistence of nonlocal gray wares in Period 5, some 10 to 30 years after immigration had ceased. A threshold of population density may have been reached in Period 3 and subsequent increases in population did not alter the geographic extent of the intensive social network (i.e., a minimum extent of the interaction network was maintained, perhaps as an adaptive subsistence buffering or alliance measure, but no independent evidence supports this assertion).

A probable confounding influence on this perception of the intensive interaction network is the problem of the definition of nonlocal ceramics, but acknowledging this influence does not necessarily support the threshold interpretation. The pattern of regional population movement reported by Schlanger (chap. 8) within areas to the west of the Dolores area would tend to mask the perception of gray ware exchange. Regional population generally moved out of areas of distinctive temper use and into the area of the Dolores Tract for the A.D. 800-920 period. Thus, some of the observed decreases in nonlocal gray ware sherds (especially between Periods 3 and 4 [fig. 15.10]) could be the result of settlement location shifts rather than shrinkage of the intensive interaction network.

Although they are plausible explanations, population shifts and weaknesses of archaeological perception are not totally responsible for the observed changes in nonlocal sherd frequencies. When the nonlocal Mesa Verde Gray Ware category is broken down into its component parts (fig. 15.12), a shift in the direction of intensive interaction is apparent, and this shift is relatively independent of the changing frequencies of nonlocal gray ware sherds. Western sources (Cahone and Sandstone Tracts) are the only nonlocal Mesa Verde Gray ware sources in Period 1, but sherds from the south (the San

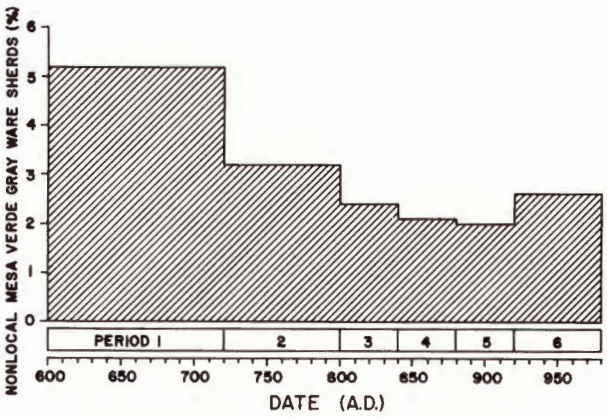

Figure 15.10 – Frequencies of nonlocal Mesa Verde Gray Ware sherds in screened refuse collections.

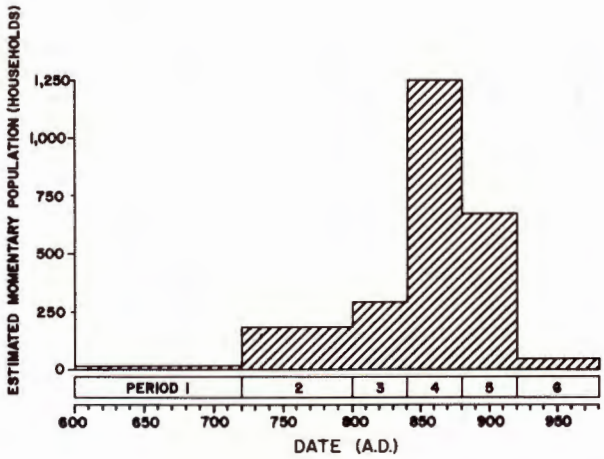

Figure 15.11 – Estimated momentary population of the Dolores area (after Schlanger, chap. 8).

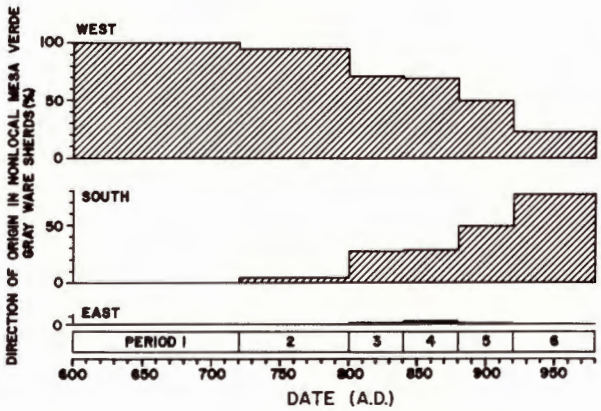

Figure 15.12 – Relative frequencies of source directions represented in the nonlocal Mesa Verde Gray Ware sherds in screened refuse collections.

Juan Tract) appear in Period 2 and increase steadily through Period 6. Although sharp increases in San Juan Tract sherds occur in Periods 3, 5, and 6, only the Period 5 and Period 6 increases coincide with probable expansion of population downslope and out of the Dolores Tract. There is no simple explanation of why the regional population shifts should be accompanied by a southerly shift in interaction as opposed to a return to the western direction of previous centuries.

Resource Buffering and the Shape of Alliances

Another potential explanation for the observed directional changes in exchange is the development of regional alliances. Alliances have been proposed as adaptative systems that rely on long-distance exchange as a subsistence buffering mechanism (Plog 1984). Since the need to invoke large-scale movement of subsistence resources should be relatively infrequent, such alliances are assumed to be maintained during intervening periods by patterns of social or political interaction. Alliance formation is predicated both on the existence of population aggregates whose density limits lower cost responses to scarcity and on patterns of scarcity that can be characterized as highly variable. High variability (spatial as well as temporal) would foster "resilient" adaptations such as alliances and exchange rather than permanent structural adaptations. In addition, alliances, once formed, can be perpetuated as part of the consolidation of political power within the context of leadership development (Upham 1982; Lightfoot 1984).

Plog (1984) reports that high frequency climatic variation is indicated by Southwestern tree-ring records for the A.D. 750-1000 period. Large population aggregates are known to exist in the Mesa Verde region during the early part of this time period (corresponding to Period 2 [Brew 1946]), but the levels of population density and aggregation (and presumably potential alliance participation) within the Dolores area are relatively low until Period 4 (Orcutt 1985a). High density and aggregation (households per rubble area) occur in Periods 4 and 5, and high aggregation persists in Period 6 despite a sharp drop in population density. The Period 4 and 5 settlement systems can be characterized as two-tiered decision-making hierarchies, and although the Period 6 settlement system is characterized as a single-tier decision-making hierarchy, the rank size distributions suggest a "primate" organization (chap. 10). This latter characterization reflects the presence of an unusually large settlement at the edge of the Dolores area and suggests the Dolores area settlements are spatially peripheral to a more complex settlement organization during this period.

Potential alliances involving Dolores area populations are assumed to be limited by the distribution of contemporary population aggregates, by the physical efficiency of foot transportation as a redistribution mechanism, and by the need for complementarily in agricultural risk. A simulation of the long-distance movement of food resources suggests the maximum extent to be expected for large-scale food redistribution in the Southwest is approximately 50 km (Lightfoot 1979). Knowledge of Period 4, 5, and 6 population aggregates within a 50-km radius of the Dolores area (fig. 15.13) is incomplete due to partial survey coverage, but survey or excavation data are available for some portions of the area, primarily to the west and on Mesa Verde.

Schlanger's (chap. 8) compilation of survey data from 2 areas to the west of the Dolores area identified only minor Period 4 and 5 occupations, but substantial Period 6 occupations in the Woods Canyon area. A Period 4 and 5 village was excavated by Martin (1939) in the Ackmen-Lowry area, and a probabilistic survey of the Bureau of Land Management's Sacred Mountain Planning Unit (Chandler et al. 1980) reported few sites that can be attributed to Periods 4, 5, or 6, but many that can be attributed to earlier or later time periods (Blinman 1983). Sites occupied within Periods 4 and 5 are also present to the southwest of the Dolores area in the vicinity of Crow Canyon, to the north of Sleeping Ute Mountain.[4] Occupation on Mesa Verde to the south of the Dolores area appears to be continuous through the A.D. 840-920 period (Hayes 1964; Rohn 1977; Smith 1985). Although dating resolution is limited somewhat by the use of phase assignments as temporal classifications of the Mesa Verde sites, tree-ring dates from excavated sites support the presence of at least some population aggregates through Periods 4, 5, and 6 (Hayes and Lancaster [1975]; dates reported by Robinson and Harrill [1974]).

Complementarity in agricultural risk is difficult to evaluate for the potential buffering region. The Dolores area is near the upper elevation of the dry-farming belt (chaps. 4 and 7) and should receive adequate precipitation in most years, but is subject to risk associated with short growing seasons. The Crow Canyon area is believed to be subject to variability in precipitation due to its low elevation location and in spite of the tendency for Sleeping Ute Mountain to foster thunderstorms in the vicinity, but the Crow Canyon area is unaffected by shortened growing seasons. The Woods Canyon and Ackmen-Lowry areas are intermediate in risk related to precipitation variability and also should be less susceptible to short growing season affects than the Dolores area. Mesa Verde has little risk related to precipitation (similar to the Dolores area) and has no risk related to short growing seasons (Petersen and Clay 1985). Although the types of risk evident at Crow Canyon and Ackmen-Lowry are relatively complementary to the risk associated with the Dolores area, the most consistent of the potential buffering areas would be Mesa Verde.

Direct evidence of exchange interaction within the potential buffering region is limited by archaeological perceptions of nonlocal materials. Lithic material from most of the buffering region cannot be differentiated from material local to the Dolores area, and those materials that could be identified as nonlocal could not be traced exclusively to any specific buffering area. Ceramic material from the Crow Canyon area cannot be identified as nonlocal because of the use of temper identical to that used in the Dolores area. Ackmen-Lowry is close to the boundary between the Dolores Tract and the Cahone and Sandstone Tracts, and some ceramic materials originating in the Ackmen-Lowry area would be identifiable. Most of the Woods Canyon area is within the Cahone and Sandstone Tracts, and most ceramic materials should be identifiable as nonlocal to the Dolores area. Examination of Mesa Verde collections has resulted in the assignment of large numbers of sherds to both Dolores and San Juan Tracts.[5] Although temper associated with archaeological samples of unfired clay was not examined, the frequency of San Juan Tract sherds was higher in the Mesa Verde collections than in any other collection examined from the Mesa Verde region as a whole. Based on this abundance, at least some of the ceramics manufactured on Mesa Verde are assumed to be identifiable as originating from the San Juan Tract.

The combination of a limited number of potential buffering areas and limitations on archaeological perception allows a partial evaluation of the degree to which buffering alliances may have influenced Dolores area exchange. Alliance formation with the Crow Canyon area (or other unknown potential buffering areas within the Dolores Tract) cannot be identified and cannot be evaluated. Interaction with sites in the Ackmen-Lowry vicinity will be reflected by the presence of some Cahone and Sandstone Tract ceramics, but undetectable Dolores Tract ceramics may be involved as well. Alliance formation with sites in the Woods Canyon area should also be detectable through the presence of Cahone and Sandstone Tract ceramics. Finally, alliance formation with sites on Mesa Verde will be reflected in San Juan Tract ceramics in addition to some undetectable Dolores Tract ceramics.

[4]William D. Lipe, DAP, personal communication.

[5]Examination of Mesa Verde collections was carried out by C. Dean Wilson, DAP.

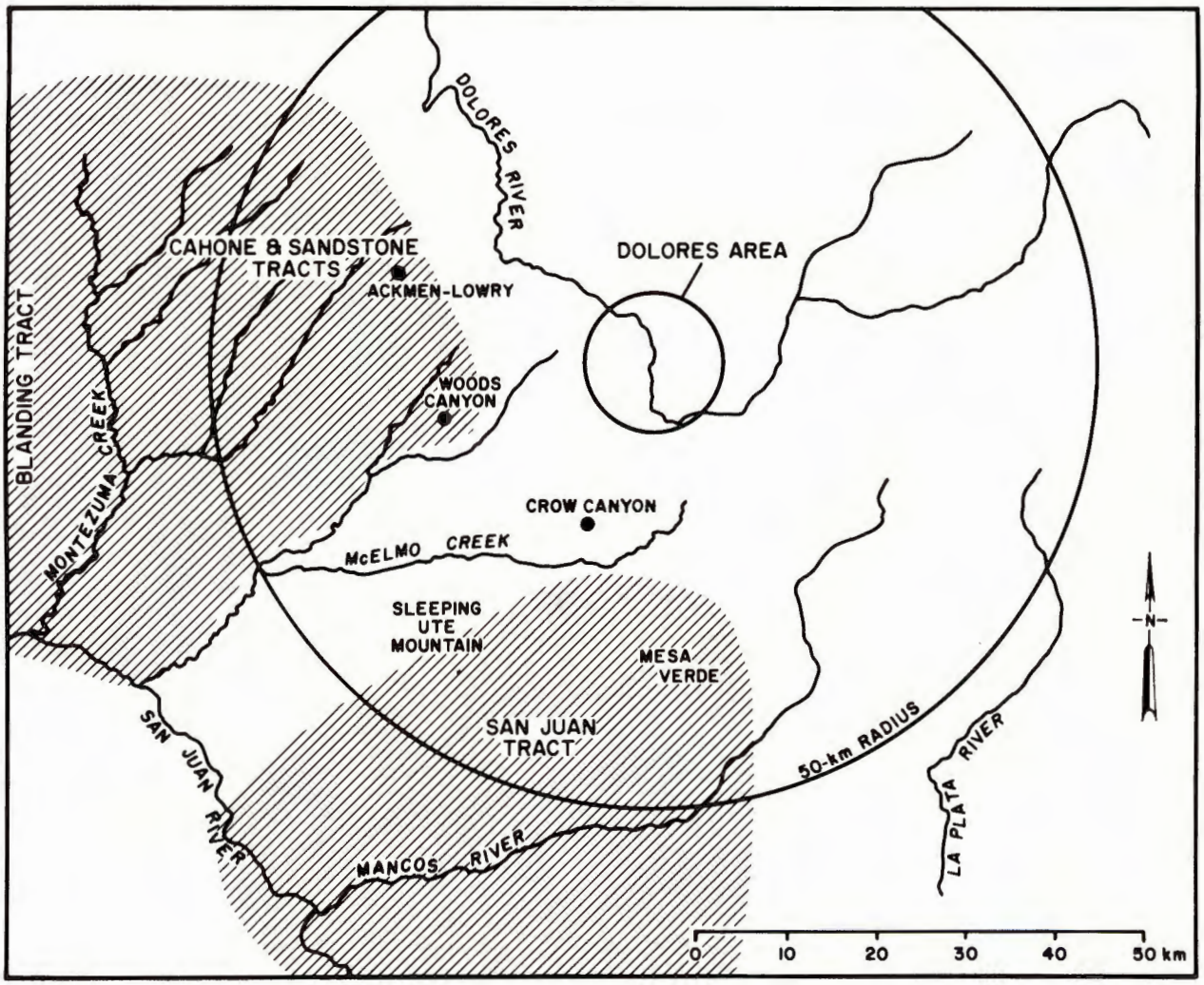

Figure 15.13 – Possible resource buffering areas within 50 km of the Dolores area. Ceramic manufacturing tract boundaries are approximations for the A.D. 600-980 period and are tentative. Areas to the north and east of the Dolores area are generally too high in elevation for corn agriculture and are not considered to be potential buffering areas.

The Mesa Verde, Ackmen-Lowry, and Crow Canyon areas could serve as buffers in Periods 4 and 5, but only alliances with Mesa Verde and the Ackmen-Lowry area would be detectable if ceramic exchange were involved. In Period 6, the Woods Canyon and Mesa Verde areas could serve as buffers, and ceramic exchange with both would be detectable. Mesa Verde provides the most stable subsistence complement to the Dolores area (and to most areas of the Mesa Verde region), but the sources of agricultural risk in the Ackmen-Lowry and Woods Canyon areas (moisture deficits) would be complementary to those in the Dolores area (early or late frosts) for some years.

Although alliances are defined as adaptive mechanisms in a subsistence or political sense, the social interactions associated with alliance reinforcement could take various forms. If strong obligations of support between alliance participants were maintained by kinship or ritual obligation bonds with a broad community base, gray ware vessel exchange could be expected. If alliance maintenance were a ritual or political activity at the level of leader interaction, symbolic expressions and exchange of white or red ware vessels could be expected. Distance could alter these expectations in that intensive social relations (frequent food sharing at potlucks) would be relatively expensive to maintain if long distances were involved. Under these conditions, even close kinship or ritual obligation ties could emphasize symbolic aspects of exchange and movement of white and red ware vessels.

The directional changes within the nonlocal gray ware category indicate a significant amount of intensive interaction to the south (with residents of the San Juan

Tract) as early as Period 3. This relative level is maintained during Period 4, despite the presumably greater distance involved in southern interactions and despite an absolute decline in total nonlocal intensive (gray ware) interactions (fig. 15.10). San Juan Tract interaction makes further gains in Period 5 despite continued decline in nonlocal gray wares, and in Period 6, intensive interactions with residents of the San Juan Tract account for more than 75 percent of the nonlocal gray wares as nonlocal gray wares increase in frequency.

These increases in San Juan Tract gray ware sherds are neither explainable by known changes in archaeological perception nor by reference to models of local population density changes and fluctuating mating network extent. Alliance formation is a viable alternative explanation, but alliance formation would have to be preferentially with the Mesa Verde area (and perhaps with undetectable areas of the Dolores Tract such as Crow Canyon) rather than with either the Ackmen-Lowry area or, later (Period 6), the Woods Canyon area. Alliances with the latter areas are possible, but the observed gray ware exchange frequencies could also conform to mating network expectations.

The distance (about 35 km) involved in a possible Mesa Verde alliance and the formidable northern scarp of Mesa Verde would be expected to select for symbolic rather than intensive interaction. Since the exchange of red ware vessels can only be traced to their origin in the Blanding Tract rather to intermediate points, only white ware exchange can be evaluated for potential alliance involvement. Frequencies of nonlocal Mesa Verde White Ware sherds in Dolores area screened refuse collections are presented in figure 15.14. Nonlocal sherds increase from about 5 percent in Period 1 to about 10 percent in Periods 2, 3, and 4. The Period 5 frequency increases sharply to over 25 percent, and nonlocal sherds fall to about 20 percent of Period 6 collections. The directional breakdown of these data (fig. 15.15) indicates a strong southern (San Juan Tract) component of white ware exchange beginning in Period 1. Proportions of San Juan Tract white ware sherds increase gradually through Period 3 and increase more sharply to over 90 percent in Period 4. The highest frequency is slightly over 95 percent in Period 5, and the Period 6 frequency falls slightly but remains at more than 90 percent of the nonlocal Mesa Verde white wares.

Gray ware sherds are generally more abundant than white ware sherds in Dolores area collections, and the ratio of the 2 wares is 12.6. The absolute numbers of white and gray ware sherds from the San Juan Tract in screened refuse collections reflect considerably lower ratios, the largest of which is 2.17 (table 15.1). Given the assumptions about the differences in movement be-

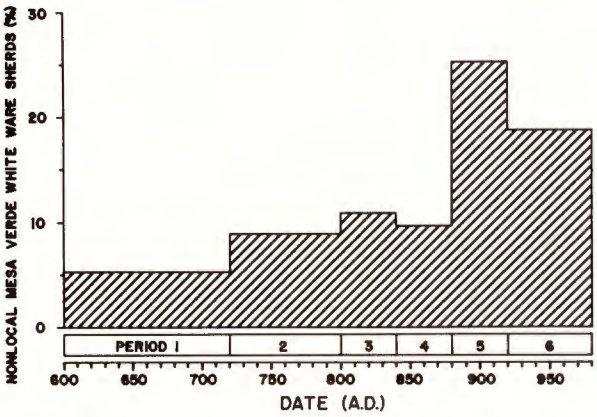

Figure 15.14 – Frequencies of nonlocal Mesa Verde White Ware sherds in screened refuse collections.

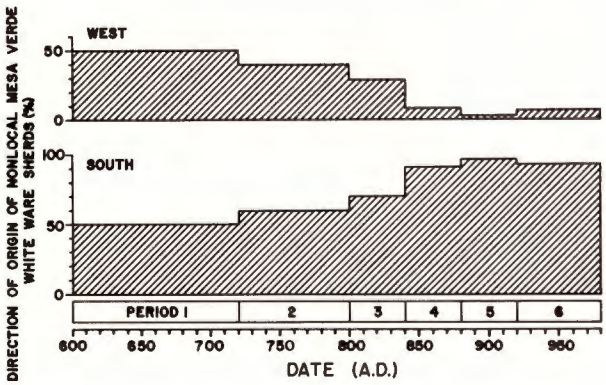

Figure 15.15 – Relative frequencies of source directions represented in the nonlocal Mesa Verde White Ware sherds in screened refuse collections.

tween the 2 wares, the low ratios can be interpreted as a consequence of relatively even emphases on both symbolic and intensive social levels of interaction. This interpretation is compatible with the expectations about alliance behavior in the context of broadly based community or area interactions.

Unfortunately, the timing of the increase in San Juan Tract sherds is not perfectly compatible with expectations for alliance development with residents of Mesa Verde. Gray ware sherd frequencies indicate increased interaction with the San Juan Tract at an intensive level in Period 3. This is prior to the onset of high population densities and prior to the presumed need for long-distance buffering strategies. Period 4, when alliance strategies are expected to be initialized, shows no change in intensive interaction, but a preferential shift occurs in symbolic exchange toward San Juan Tract sources. Period 5 is the period of relatively greatest subsistence stress experienced by the Dolores area residents (Orcutt 1985b), and the doubling of symbolic

Table 15.1 – Numbers of San Juan Tract sherds in screened refuse

Period	Gray ware (N)	White ware (N)	Gray:white ratio
1	0	2	0.00
2	8	24	0.33
3	63	29	2.17
4	58	45	1.29
5	137	169	0.81
6	26	14	1.86

interaction (and perhaps slight increase in intensive interaction) with the San Juan Tract does coincide with buffering expectations. However, these temporal coincidences may not be significant if the time lag suggested by the refuse and static vessel assemblage comparisons is correct.

Participation in Extraregional Interaction

In addition to the temporal variation in nonlocal but still Mesa Verde region materials, temporal variation is evident in materials whose sources lie outside of the Mesa Verde region. These materials include ceramics, obsidian, all nonlocal lithics, and marine shell, and the great distances to their sources weaken arguments as associating them with particular regional alliance or interaction systems. The ceramics and obsidian can be attributed to specific sources and these materials are amenable to directional evaluation. The other nonlocal lithic and shell items can only be discussed in terms of temporal variation in frequency of occurrence.

Ceramics. – Extraregional ceramic materials make up only 0.5 percent of all DAP collections, but the number of sherds is just under 3000 and provides a reasonable basis for interpretation. The number of extraregional sherds in the screened refuse data set is too small for analysis, and a data set was generated for all confidently dated materials without restrictions on the mode of collection. This data set could contain some bias toward differential collection of items perceived in the field as being rare or unique, but this bias is less likely to affect ceramic materials than other material types. Reconstructible vessels are present in the data set, but few of these are extraregional in origin, and the trends described in this section are not believed to be unduly influenced by cluster effects.

Frequencies of extraregional sherds are greater within the white ware category than the gray ware category (fig. 15.16). This is expected based on the interaction between ceramic production, potential symbolic motivations for exchange, and the economics of transporting vessels over long distances. Extraregional gray

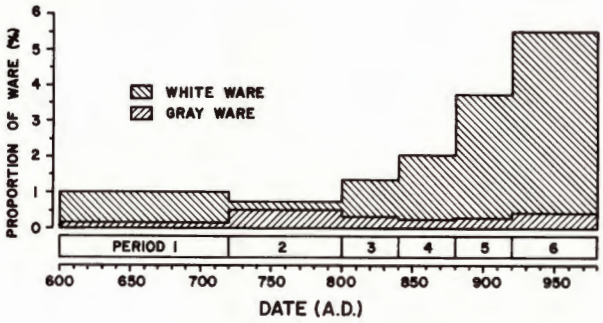

Figure 15.16 – Frequencies of extraregional white and gray ware sherds in confidently dated collections. Sherd frequencies are expressed as percentages of all sherds of the ware.

ware frequencies are lowest in Period 1 and range between 0.26 and 0.53 percent for Periods 2 through 6. Because these fluctuations are so small, they are not believed to be interpretable. In contrast, extraregional sherds compose 1 percent or less of white wares through Period 2 and then increase steadily to more than 5 percent in Period 6. The observed variation through Period 2, and perhaps through Period 3, could be explained by sampling error, but the consistent increases in Periods 4, 5, and 6, and perhaps in Period 3, are significant.

Sources represented in extraregional sherds (including red and smudge wares) include the Kayenta, Chuska, Cibola, and Mogollon Culture Categories. Numbers of sherds attributed to specific sources are too low in Periods 1 through 4 to evaluate changing source frequencies, but frequencies observed in the Period 5 and 6 collections are more likely to be stable (fig. 15.17). Kayenta ceramics are the only extraregional sherds in Period 1 that can be attributed to a specific source, and occasional Kayenta sherds also occur in Periods 2 and 4. Kayenta sherd frequencies in Periods 5 and 6 are lower than those in the other categories (except Mogollon) and the decline from Period 5 to Period 6 conforms with a subjectively perceived decline that begins at least as early as Period 4.

A single Chuskan sherd occurs in a Period 1 collection, but its presence is believed to be the result of contamination from overlying late ninth century debris, and is not reported in figure 15.17. The first confident occurrences of Chuskan sherds are in Period 3, and Chuskan sherds are present in all subsequent collections. Frequencies in Periods 5 and 6 are stable at about 30 percent, but subjective evaluation suggests Chuskan sherds are steadily increasing in frequency and the observed stability is a characteristic of the sample and not necessarily of the population.

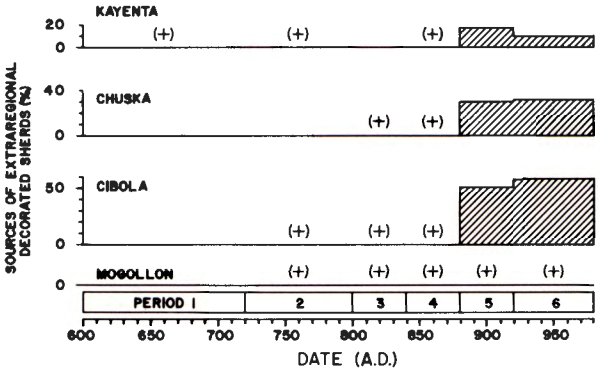

Figure 15.17 – Source frequencies of extraregional sherds in confidently dated collections. Presence/absence, rather than percentage contribution, is noted where the total number of extraregional sherds was so low that source percentages were unlikely to be stable due to sampling error.

Most of the extraregional sherds that can be assigned to specific sources are derived from the Cibola Culture category. This may reflect analysis error since sand temper and mineral paint may characterize some Mesa Verde as well as Cibola white ware ceramics, but the magnitude of error resulting from this analysis assumption is believed to be minor. Cibola sherds are continuously present, beginning in Period 2, and their frequencies increase across the Period 5 and 6 boundary. This increase agrees with subjective perception of temporal trends in abundance, and the increase is believed to have begun as early as Period 4.

Mogollon sherds are first present in Period 2 and occur continuously thereafter. The strongest presence is in Periods 2 and 3 with 5 sherds in each collection, and never more than 2 sherds appear in the later collections. A Period 2 emphasis (possibly due to immigration) is suggested in the evaluation of both Mogollon and Dolores Tract smudged sherds (Wilson 1985), but there is no indication that exchange of Mogollon ceramics ever reached significant proportions within the extraregional sherd complement.

The increasing frequencies of extraregional sherds within the white ware category implies increasing participation in a system of broad regional interaction. This participation may have begun in Period 3, but data quality only permits a confident inference of increased involvement beginning in Period 4. A background level of extraregional gray ware exchange is always present, but this level is minor and does not appear to change through time.

The preferential involvement of white ware vessels in the regional exchange system may stem from 2 or more motivations. Sources of white ware vessels are expected to be restricted (specialization at the level of skilled individuals), and some commodity motivation for white ware vessel exchange may have been present. The generally low frequency of extraregional sherds and the variety of sources represented minimizes the possibility that "trade" was involved, and down-the-line, or random walk models of commodity movement may provide adequate explanations for the presence of the small number of extraregional vessels. The second motivation may be embedded in the symbolic potential of the decorated vessels. Some of the styles of decoration (e.g., Kana-a style) are recognizable as non-Mesa Verde in execution, and the knowledge of origin may have enhanced the perceived "value' of the extraregional vessels. Exchange of valued vessels would contribute to the status of the donor (Dalton's "ceremonial-delayed-reciprocal exchanges of primitive valuables" [1977:202]), resulting in the preferential movement of at least some of the extraregional vessels over local or regional vessels and their subsequent wide distribution. This symbolic motivation is not necessarily dependent on political alliance ties and may coincide with more broadly based kinship or ritual obligation linkages.

Obsidian. – Obsidian materials are widely scattered across the Southwest, and considerable effort has been expended in characterizing both sources and materials (Findlow and Bolognese 1982a, 1982b; Cameron and Sappington 1984). Value of obsidian lies in its excellent knapping qualities and to some degree in its aesthetic appeal, and obsidian is assumed to have been a preferred and desired raw material for flaked lithic tools. The nearest known sources of obsidian are more than 200 km away from the Dolores area, and the few obsidian artifacts in Dolores area collections (less than 0.1 percent) are assumed to be the result of exchange.

Sourcing of DAP obsidian was carried out by Sappington using x-ray fluorescence analysis (Phagan 1985). Although 230 items were analyzed, not all could be given reasonably narrow temporal assignments within the A.D. 600-980 period, and only 134 items are included in this discussion. Within this subsample, 10 sources are believed to be represented, 4 of which are in the San Francisco Peaks area of Arizona (fig. 15.18). Discriminant analysis was used for the classification, and items are associated with the source that they are most similar to (from the sources considered in the analysis). The probabilities used in reporting these source assignments (fig. 15.19) reflect the likelihood that an artifact from that source would have characteristics exhibited by the item in question. Low probabilities reflect either incomplete characterization of the source by reference materials or the presence (and misassignment) of items from sources other than those used in the discriminant analysis. Given the occurrence of some extremely low probability assignments in the

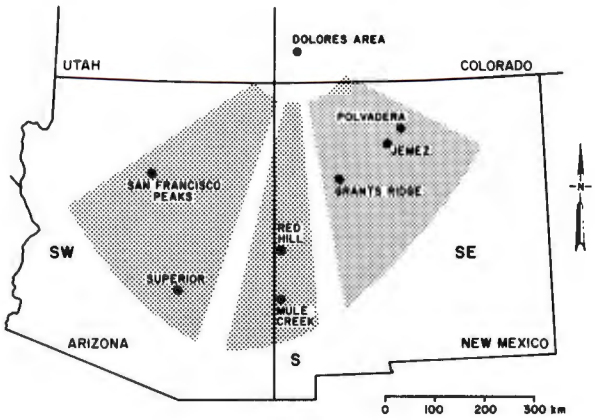

Figure 15.18 – Obsidian sources believed to be represented in A.D. 600-980 collections. The San Francisco Peaks area of Arizona includes the Crater Lake, Government Mountain, Kendrick, and Sitgreaves Peak sources. Shaded areas represent sources that have been combined for the directional summaries.

Dolores area obsidian materials, some materials are likely derived from currently unknown (or uncharacterized) sources.

Temporal occurrences of obsidian materials are displayed by source assignment in figure 15.19. Each item is represented by a line, and the length of the line is determined by the precision for the date estimate for the archaeological provenience of the item. Date estimates are based on ceramic dates (Blinman 1984), architectural style, or tree-ring dates rather than on obsidian hydration measurements (Winter 1983; Phagan 1985). The probability that an item is a member of the group to which it was assigned is expressed by the continuity of the line ($P[X/G]$, Hughes 1984:5). Most items are attributed to the Jemez and Red Hill sources, and most items are derived from proveniences dating to the ninth century. Only materials attributed to the Red Hill and Polvadera sources appear to be well characterized, but all source assignments (regardless of low prior probabilities [Phagan 1985]) are assumed to be correct in the following discussion.

The temporal occurrence data are summarized by direction in figure 15.20. Sources were grouped into southwest, south, and southeast categories (fig. 15.18), and items were totaled by time period. If the dating of an item is imprecise, it is assigned to all of the time periods it could be affiliated with. Thus, the number of data points used to prepare figure 15.20 is in considerable excess of the number of items analyzed. This procedure results in errors of temporal classification and artificially smooths the directional trends, but the procedure was chosen to maintain a reasonable sample size for the source direction comparison.

Obsidian is derived from a wide geographic area for all time periods (no southwestern sources are present in Period 6, but only 12 items can be dated to this period). Southern sources (primarily Red Hill) dominate materials that could be dated to Periods 1 and 2, and southeastern sources (primarily Jemez and Polvadera) dominate materials that could date to Period 3. These southeastern materials continue to increase in abundance through Period 6 where they account for 75 percent of the sample. Southwestern sources are poorly represented through all periods, but reach their highest frequencies in Periods 2 and 3.

Although the trends are smoothed somewhat by the procedures used to cope with imprecise dating, a strong trend is evident in the replacement of material from southern sources with material from southeastern sources. Support for this observation is evident in mapped frequencies of obsidian materials in the vicinity of the Jemez source in New Mexico (Findlow and Bolognese 1982b:figs. 3.5 and 3.6). Frequencies of obsidian in lithic assemblages to the northeast of the source increase in the A.D. 700-900 period, and the higher frequencies persist in the A.D. 900-1100 period. These trends also agree with the temporal distribution of materials at Chaco Canyon sites (Cameron and Sappington 1984), but do not agree well with temporal patterns of obsidian procurement reported for sites in the source area (Winter 1983). This latter discrepancy may be the result of incomparability between temporal control based on obsidian hydration and that based on other archaeological data.

The shift to more material from southeastern sources does not perfectly match the changing directional orientation of interregional ceramic exchange. Southern ceramics from the Chuska Culture Category appear to be increasing in collections through the same period that the southern obsidian materials are decreasing in abundance. However, distance may be a consideration since the southeastern sources are only about 250 km away from the Dolores area while the southern sources are nearly 400 km away. Also, obsidian associated with Chuska area sites is attributed to Jemez sources (sourcing technique unknown [Chapman 1977:429]).

Nonlocal lithic materials. – Although most of the nonlocal lithic materials cannot be attributed to specific sources, this category of material can be used as a measure of changing intensity of interregional interaction. Nonlocal debitage is not identified to material type in the computerized data file, and this category includes obsidian as well as other material types. For this reason, obsidian items are included in the nonlocal lithic totals used for the following discussion. The flaked lithic debitage and flaked lithic tool data are based on dated refuse screened through 1/4-inch mesh; due to the low

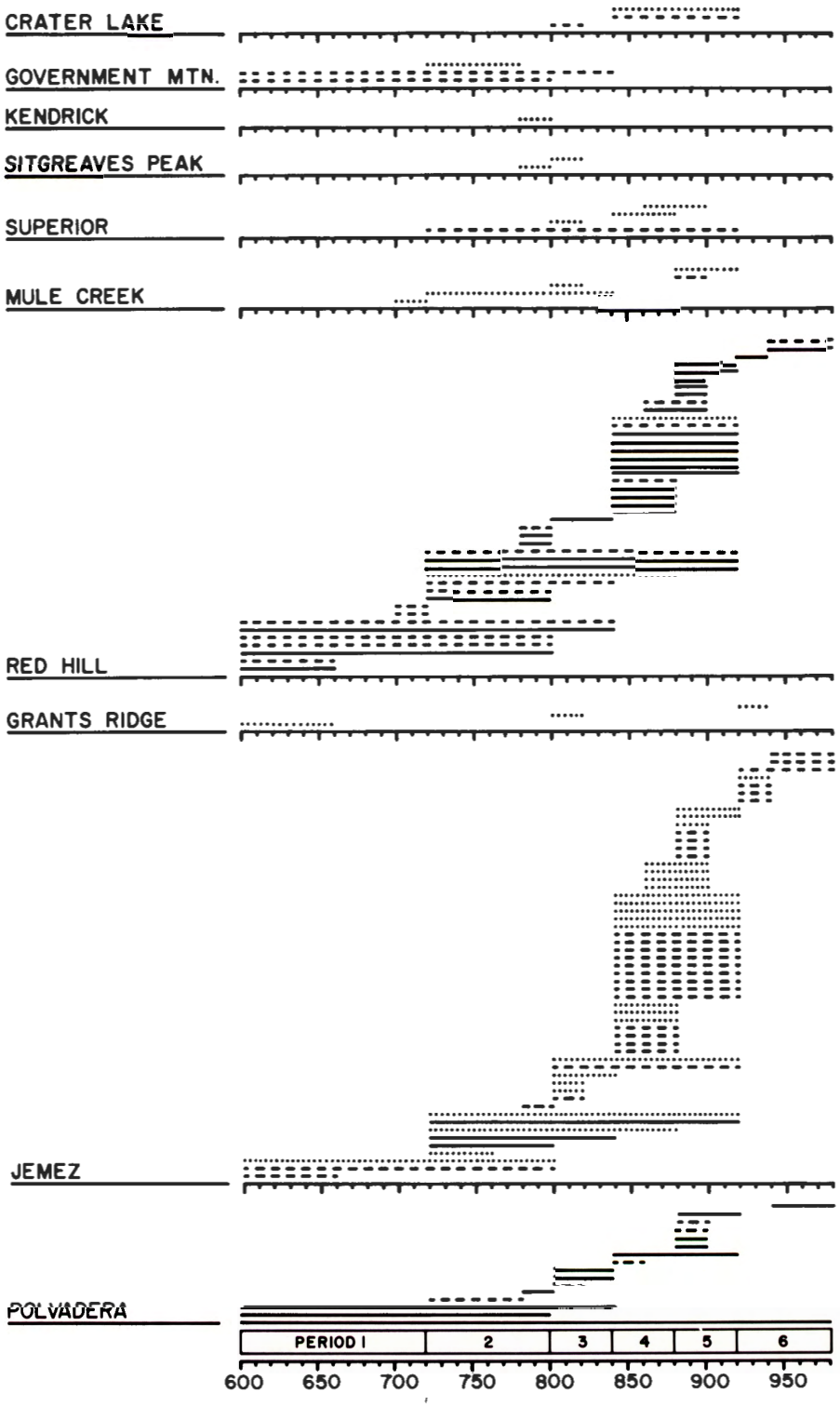

Figure 15.19 – Obsidian items occurring in A.D. 600-980 collections. Each line represents a single item, and the length of the line represents the date estimate for the provenience of the item. The continuity of each line represents the probability that a reference specimen from the source would have the observed characteristics of the item. Solid lines indicate $p > 0.68$, dashed lines indicate $0.68 > p > 0.05$, and dotted lines indicate $p < 0.05$.

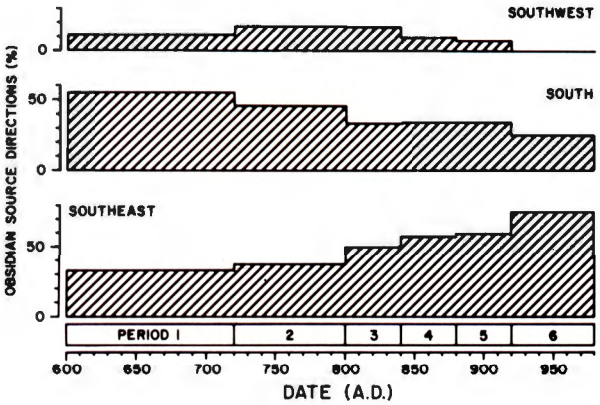

Figure 15.20 – Directional frequencies of obsidian sources represented in A.D. 600-980 collections.

numbers of nonflaked lithic tools in refuse, the nonflaked lithic ornament data are based on all confidently data collections.

Nonlocal materials comprise from 1.9 to 3.6 percent of the flaked lithic tool category (table 15.2). The lowest frequency (Period 1) is based on a relatively small sample size and is not believed to be significantly different than the other frequencies. The remaining nonlocal material frequencies span a range of 1 percent, and the slight differences are not likely to be significant. The nonlocal tools generally are characterized as high input items, with an average production "cost" that exceeds the production cost associated with tools of local materials. The lowest production input in nonlocal materials occurs in Period 3 due to the presence of 12 used but unmodified flakes (9 in a single site collection).

Nonlocal materials are much less abundant within debitage than within the flaked lithic tool category (table 15.2). The Period 1 and Period 6 debitage collections are moderate in size, and their associated nonlocal percentages are likely to be unstable. The remaining collections consist of at least 5000 items, and the associated percentages are assumed to be robust. Within these larger collections, nonlocal debitage accounts for less than 0.1 percent of the total in Periods 2 and 3. This percentage increases in Periods 4 and 5 to 0.5 and 0.6 percent, respectively. Although the observed increases are small in absolute magnitude, the sample sizes are large and the difference across the A.D. 840 boundary is probably significant.

The increase in nonlocal debitage frequency raises the debitage to tool ratio in Periods 4 and 5, and this can be interpreted as a change in the technological manipulation of nonlocal materials. This change could be an increase in the instances where tools were produced from nonlocal raw materials by knappers within the Dolores area, or the change could represent an increase in the rejuvenation of nonlocal tools. The latter change would imply that either larger nonlocal items were being brought into the Dolores area after A.D. 840 (larger items being more amenable to either rejuvenation or further reduction than smaller items), or demand for nonlocal raw material increased to the point that rejuvenation became more common.

Nonlocal materials within the nonflaked lithic tool category are almost exclusively limited to ornaments. Frequencies of ornaments as a proportion of total nonflaked lithic tool collections remain relatively stable through all time periods (table 15.2). Proportions of nonlocal materials within the ornament class do vary somewhat, increasing from Period 1 through Period 5, and decreasing slightly in Period 6. These changes within the ornament category, however may not be significant given the small numbers of ornaments in the nonflaked lithic tool collections.

Shell. – Marine shells are widely distributed as ornaments in the Southwest and are assumed to have been valued commodities. Those shell items in Dolores area collections that are not too fragmentary for evaluation are all modified into beads, bracelets, or pendants. Taxa definitely represented are olivella shells (*Olivella gipli-cata* and *Olivella dama*), abalone (*Haliotis* sp.), and glycymeris (*Glycymeris* sp.). Although many shell items cannot be attributed to these specific taxa because of their condition, all could be derived from these taxa, and no other taxa are believed to be represented.

Quantification of shell items is difficult because of the tendency for shell items to be used as clusters in jewelry. A single item in an archaeological collection may be as meaningful in terms of jewelry occurrence as a complete necklace of several hundred beads. Expressions of quantity used here are intended to estimate a minimum number of individuals of jewelry items. The estimation procedure assumes that shell items of a particular ornament class and taxon were part of one occurrence (jewelry item) if they were recovered from a single provenience (e.g., a pitstructure floor). For example, recovery of 5 olive shell beads and an abalone shell pendant from a structure floor is interpreted as the recovery of 6 items representing 2 occurrences (this particular example may overestimate actual occurrence frequency, because the beads and pendant may have been combined into a single necklace).

Quantification is also complicated for comparisons of temporal or spatial frequencies. Complicating factors are the preferential recovery of shell items and the effects of varying intensities of excavation on numbers of items. The former bias is difficult to compensate for,

Table 15.2 – Temporal frequencies of nonlocal lithic items

	Period					
	1	2	3	4	5	6
Flaked lithic tools:						
Total items	108	440	745	2183	1458	135
Nonlocal items	2	12	27	56	46	4
Percent nonlocal	1.9	2.7	3.6	2.6	3.2	3.0
Mean local input cost	10.20	9.01	8.83	8.67	9.08	9.12
Mean nonlocal input cost	15.00	17.50	9.96	12.67	15.39	18.50
Flaked lithic debitage:						
Total items	1773	5290	10 671	19 239	15 322	2111
Nonlocal items	4	5	7	88	86	0
Percent nonlocal	0.2	0.1	0.1	0.5	0.6	0
Debitage/tool ratio						
Local materails	16.69	12.23	14.85	9.00	10.79	16.11
Nonlocal materials	2.00	0.42	0.26	1.57	1.87	0.00
Nonflaked lithic tools:						
Total items	485	1403	1171	1215	2832	1104
Local ornaments	6	4	7	7	9	5
Nonlocal ornaments	0	5	13	13	24	7
Total ornaments	6	9	20	20	33	12
Percent ornaments	1.2	0.6	1.7	1.6	1.2	1.1

and the comparisons carried out assume the effects related to this bias are insignificant relative to the effects related to intensity of excavation. Numbers of ceramic materials have been adopted as a proxy for excavation intensity, and shell abundance is expressed as ratios of occurrences to numbers of sherds assigned to the same Periods.

Shell occurrences are attributable to all Periods, although the numbers of occurrences are highly variable (table 15.3). A single burial accounts for all of the shell in Period 1, single occurrences at each of 2 sites provide all of the shell in Period 2, and a single site accounts for all of the shell (and nearly all of the sherds) for Period 6. Occurrences increase in frequency by a factor of 4 at A.D. 800 (Period 3), and occurrences increase slightly again at A.D. 880 (Period 5) and A.D. 920 (Period 6). The observed increase at A.D. 800 is the most likely to be significant, but the later increases, though small, are based on extremely large amounts of excavation and may be significant as well. If the later increases are valid, there is a large increase in the availability of shell jewelry at A.D. 800 and a slow but steady increase in its availability from that point through Period 6.

Summary. – While the existence of a resource buffering alliance with residents of the Mesa Verde area remains equivocal, some mechanisms are operating to change the geographic scope of social interactions involving Dolores area populations. Exchange of white ware ceramics across regional boundaries increases in the ninth century, and a tendency exists for greater interaction with the Cibola and Chuska regions than with the Kayenta region. Interregional exchange of gray ware vessels does not change over the same period, and the white ware exchange may be motivated by either symbolic or commodity needs. Most nonlocal lithic materials do not change in abundance as the extraregional white ware frequency changes, but there is a change in the direction of obsidian procurement, emphasizing southeastern sources at the same time that the Cibola and Chuska white ware frequencies are increasing. The single change in the lithic category is an increase in the amount of nonlocal debitage in Dolores area collections that may reflect increased importation of raw material, as opposed to finished tools, or increased intensity of repair and rejuvenation. Shell jewelry increases abruptly in occurrence frequency at A.D. 800 and then increases gradually, paralleling the increase in extraregional white wares.

These changes coincide to a degree with the directional changes in ceramic exchange within the Mesa Verde region as discussed in the context of the potential alliances. Unfortunately, whether the data that support

Table 15.3 – Marine shell occurrence and item frequencies

Site number	Occurrence/frequency					
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
5MT23		1/2	2/2	8/10	10/18	
5MT2161		1/1	1/1			
5MT2182			1/2		5/5	
5MT2320			1/1		1/2	
5MT4475				2/23	13/32	12/15
5MT4477					3/3	
5MT4479					3/3	
5MT4480				1/1	1/1	
5MT4512			1/1			
5MT4545	1/172					
5MT4650				1/1		
5MT4671			4/10	1/28		
5MT4683			2/2	2/2		
5MT4725					2/2	
5MT5104					2/2	
5MT5106					1/1	
5MT5107				2/2	1/1	
5MT5108					1/1	
Total	1/172	2/3	12/19	17/67	43/71	12/15
Sherds	14 640	32 863	47 209	65 474	126 623	26 835
Occurrences/sherds	0.00007	0.00006	0.00025	0.00026	0.00034	0.00045

the existence of alliances are surficial consequences of the broader regional trends or whether the broader regional trends are explained by the development and operation of alliances cannot currently be distinguished. The emphasis on increased white ware vessel movement in inter-regional exchange without significant increases in other potentially symbolic items (except for perhaps shell) suggests commodity motivations may be underestimated as an explanation. This still leaves open the possibility that alliance ties served as vehicles for the commodity exchange of the extraregional white wares and the ancillary movement of obsidian, but unless no symbolic value was attached to obsidian, turquoise, or other nonlocal lithic materials, alliance ties were not necessarily based on gifts of tokens or symbols.

Social Determinants of Exchange Patterns

The preceding discussions have focused on generalizations about exchange and regional aspects of economic and population histories. However, these broad patterns may be influenced on both local and regional levels by organizational states within the social systems involved. Population aggregation into large communities is assumed to be concurrent with development of complex social and political institutions, and the operation of these can conceivably influence exchange. Such influences can be characterized as fostering differential access to resources, and the degree of differential access is assumed to vary from minimal to extreme (chaps. 6 and 14). Minimal exchange influence is expected under conditions where social integration is accomplished through ritual activity without the investment of differential status (standard of living) on role positions. Maximum influence is expected under an elaboration of leadership positions (Lightfoot 1984; Upham 1982) driven by the investment of roles with status. Given these assumptions, the degree of differential access to exchanged goods (measured by the concentration or centralization of exchange goods) can be used as an indication of the causes of changing social complexity within the Dolores area.

Measures of Social Complexity

Site size is assumed to reflect the size of the associated population, and the distribution of population among sites can be used as a proxy measure of complexity in social organization (Lightfoot 1984; Orcutt, chap. 10). Site size frequencies for the Dolores area conform to a single-site-size tier for Period 1, a two-tiered organization for Periods 2 and 3, a three-tiered organization for Periods 4 and 5, and a return to two-tiered organization for Period 6. The Period 6 pattern of site size ranks is not redundant (Benson 1984) within the extent

of the Dolores Project takeline, and the observed sites may only be a portion of a larger or more complex settlement pattern. With the possible exception of Period 6, the increases in tiers conform to the pattern of changing population for the Dolores area as a whole (fig. 15.11), and the changes are likely an organizational response coincident with changes in population density.

Two-tiered organizations consist of small- and medium-sized sites and are described as simple decision-making hierarchies; three-tiered organizations consist of small, medium, and large sites, and represent complex decision-making hierarchies (Lightfoot 1984; Orcutt, chap. 10). Based only on site size rankings, changes in social and political institutions (the development of complexity) would be expected to occur first in Period 2 and then in Period 4. Period 2 changes are of small scale and are not expected to affect exchange, but the Period 4 change represents the establishment of villages of up to 200 households and a relatively great potential for influence on exchange.

Concurrent with village formation is the existence of hierarchies of architectural form (chap. 14). These are described in terms of isolation of roomblocks, roomblock shape, and access to oversize pitstructures. Kane (chap. 14) has ranked these in terms of expected roles in ritual or political activity. Four architectural complexity groups are recognized: U-shaped roomblocks with oversized pitstructures are limited to the largest sites and are assumed to be foci of ritual activity (group 4). Other village roomblocks with direct access to oversized pitstructures are assumed to be secondary foci (group 3); and village roomblocks without oversized pitstructures, but which are adjacent to primary or secondary foci, are assumed to compose another rank (group 2). Isolated roomblocks (those not part of villages) without oversized pitstructures (group 1) are assumed to have little involvement in ritual or political activity. In addition to these 4 formally recognized categories, a fifth group has been identified in the post-A.D. 880 occupations (Grass Mesa Subphase) at Grass Mesa Village (Site 5MT23 [Lipe et al. 1985]) and at Rio Vista Village (Site 5MT2182 [Wilshusen 1985]). Classification of this last group is based on the apparent dissolution of formal architectural organization at these villages in Period 5, and these occupations are believed to have the least involvement in ritual or political activity.

These observations of the development of site size rankings and architectural typologies do not in themselves predict the extent to which economic or social determinants are influencing social complexity. The apparent coincidences of timing between population growth in the Dolores area (chaps. 8 and 10) and the changes in site-size tiers and architectural organization leave open the possibility that either or both forces for cultural change could be operating. However, the directional effect of the 2 forces on exchange is expected to be different in intensity.

If leadership development is a motivation for development of the more complex sites or roomblocks, one expression could be the concentration of nonlocal goods, including status symbols, at the large and architecturally complex sites. However, since role differentiation without status investment may still entail symbolic identification of participants, some concentration of status symbols would also be expected without undue leadership elaboration. Unfortunately, thresholds for distinguishing the expected intensities of exchange effects resulting from the 2 mechanisms cannot be specified, and interpretation of the relative influence of economic motivations or leadership development must be subjective.

Nonlocal Ceramics

Frequencies of nonlocal ceramic materials are assumed to reflect the intensity of interaction between the population associated with the collection and outside populations. These interactions include both ritual and kin-based obligations and commodity exchange. Greater intensity of such interactions is presumably characteristic of populations (sites) that have larger (more complex) roles in community integration, and the consequence should be a higher frequency of nonlocal ceramics of all wares at more complex sites.

Proportions of nonlocal ceramics in collections from Orcutt's site size rank categories (chap. 10) are presented in figure 15.21. Data are not presented for Period 1 (characterized by a single site size tier) or for Period 6 (excavated collections are available for only one of the site size tiers). Collections used here consist of all confidently associated ceramic materials, and potential biases due to types of proveniences (surfaces versus refuse), recovery techniques, and vessel clusters are assumed to be minor in the context of the large sample sizes used. Nonlocal sherds are more abundant at the largest site size tier for each time period. In Period 4, where 3 tiers are present and are represented by collections, the largest sites have more nonlocal ceramics, but no differentiation appears to exist between the small and medium size sites.

Similar data are organized by architectural complexity groups in figure 15.22. The complexity groups are ranked from least complex (group 1: isolated roomblocks without oversized pitstructures) to most complex (group 4: U-shaped roomblocks with oversized pitstructures), and the Grass Mesa Subphase collections are presented for comparison. The architectural group

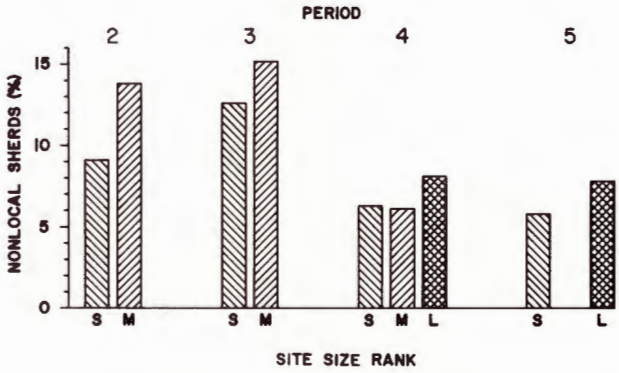

Figure 15.21 – Frequencies of nonlocal sherds in site size rank collections (S - small; M - medium; L - large).

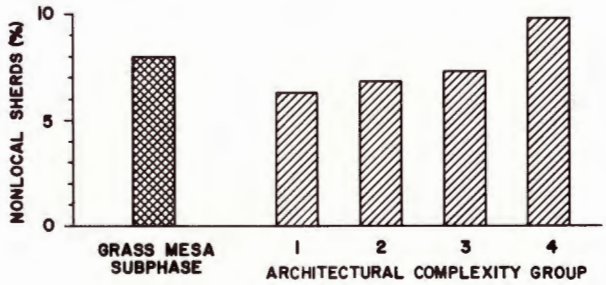

Figure 15.22 – Frequencies of nonlocal sherds in architectural complexity group collections.

collections consist of materials dating to both Periods 4 and 5, and the Grass Mesa Subphase collections are restricted to Period 5. This temporal difference is not believed to be a significant factor in accounting for the observed differences. Frequencies of nonlocal ceramics increase across the architectural groups, with the greatest increase associated with group 4. The Grass Mesa Subphase collections include fewer nonlocal ceramics than the U-shaped roomblock collections, but they have more nonlocal ceramics than group 3.

Both site size ranks and architectural complexity appear to be good predictors of the proportions of nonlocal ceramics in associated collections. One qualification is that a division between the largest sites and smaller sites would be a better predictor than the three-part division, since medium-sized sites in Period 4 are similar to small sites rather than being intermediate in nonlocal ceramic frequency. The second qualification is that the frequency of nonlocal ceramics in the Grass Mesa Subphase collections does not conform to the complexity ranking. This is an important exception since most of the Grass Mesa Subphase collections and collections from the top 3 architectural ranks contribute to the collections of the largest site size tier. Thus, although architectural complexity is a good predictor of nonlocal ceramic frequencies within formally laid out villages, site size appears to be a slightly better predictor of nonlocal ceramic frequency in general. Also, site size can be used as a predictor of nonlocal sherd concentrations prior to the appearance of the architectural groups in Period 4.

Although the association of nonlocal ceramics with larger sites and more complex roomblocks within larger sites is relatively clear, the meaning or mechanism of that association is complex. The patterns evident in figures 15.21 and 15.22 are based on all ceramics, but most of the nonlocal sherds are from white and red ware vessels. Sherds assigned to these wares are dominated by bowl sherds, and the existence of unusually high red and white ware frequencies could coincide with an unusual vessel form distribution as well as a concentration of exchanged goods.

Ratios of cooking jar sherds to bowl sherds were calculated for the collections. Ratios for the site size tier collections (fig. 15.23) do not exhibit consistent trends through the time periods. The largest tiers for all but Period 3 do have similar ratios, but the Period 3 and the middle size class in Period 4 do not conform to a gradational relationship. This provides only equivocal support for a positive relationship between greater numbers of bowl sherds and site size. The trends within the architectural complexity groups are more consistent (fig. 15.24). A steady decline in the ratio from group 1 to group 4 occurs, and the Grass Mesa Subphase ratio is more like the low complexity roomblocks than the high complexity roomblocks. As was true in the nonlocal sherd frequency, the greatest difference in the ratio is between group 4 and the other roomblocks. These trends support a consistent relationship between excess bowl sherds and architectural complexity, and to the degree the site size ranks coincide with the complexity ranks, roomblock complexity may be the primary determinant of the observed variation in the site size ranks.

The 2 ceramic measures (nonlocal sherd frequency and cooking jar to bowl sherd ratio) are clearly linked, and the interpretation of the association with the 2 complexity measures is not simple. The ratio of cooking jar to bowl sherds should be a robust functional measure of cooking versus consumption activity, since broken and discarded materials compose most collections and since breakage of vessel forms is a function of their use. If higher frequencies of valuable (exchanged) but little used bowls were maintained in static inventories, this should not be strongly represented in the collections due to the low breakage rates involved. Thus, the observed ratio suggests an excess of food consumption over food preparation at the more complex roomblocks.

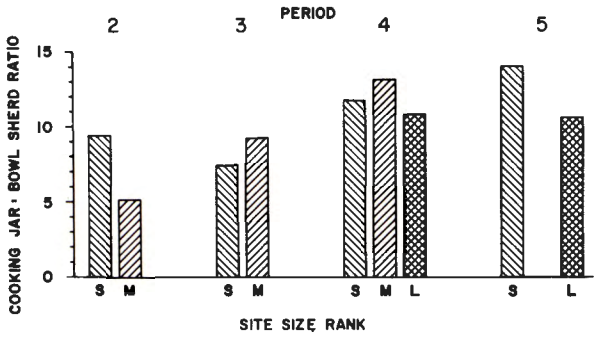

Figure 15.23 – Ratios of cooking jar sherds to bowl sherds in site size rank collections (S - small; M - medium; L - large).

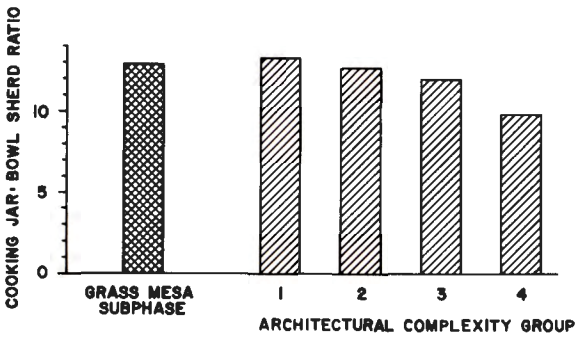

Figure 15.24 – Ratios of cooking jar sherds to bowl sherds in architectural complexity group collections.

This implies that food prepared elsewhere was consumed at the complex roomblocks, but how does this interact with exchange?

The observed exchange frequency at the complex roomblocks could be accounted for by 1 of 2 mechanisms. Hosts resident at the complex roomblocks could have maintained stores of bowls for use at potlucks, with attendent breakage and deposition during use. This would imply a greater exchange participation by the hosts to maintain the vessel stores. The second mechanism would be through the contribution of prepared food and bowls for consumption by attendees at potlucks. Breakage occurring at the potluck would result in a differentially large accumulation of bowl sherds (exchanged ceramics) at the complex roomblocks despite an equal access to exchanged goods by all members of the community. Thus, the observed exchange pattern may be functional in origin rather than implying differential access to nonlocal ceramics.

Although hosting of ritual gatherings involving food consumption is a probable explanation for the higher frequencies of bowls, and therefore for the higher frequency of exchanged goods at the architecturally complex roomblocks, it cannot explain the higher frequency of nonlocal ceramics observed in Grass Mesa Subphase collections. Nonlocal sherds in these collections are almost as abundant as at the complex roomblocks, but the cooking jar sherd to bowl sherd ratio is second highest, indicating an excess of food preparation. Based on this discrepancy, site size likely does have some influence on the distribution of exchanged ceramics. This is probably true for the large sites associated with the complex architecture as well, but at these sites, site size effects cannot be distinguished from the probable effects of hosting ritual gatherings.

Nonlocal Lithics

Nonlocal flaked lithic materials generally are high-quality raw materials that have the potential to serve as symbols or tokens due to their distinctive appearance. Whatever the motivation for their exchange, concentration of such materials would be expected if individuals (leaders) had differential access to interregional exchange linkages. Concentrations could also be expected if residents of larger sites had differential access to interregional exchange linkages, but such concentrations are expected to be less extreme than under conditions of extreme leadership development.

Frequencies of nonlocal flaked lithic tools and debitage in screened refuse from the site size rank tiers provide equivocal support for the existence of concentrations of materials (table 15.4). Increasing frequencies of nonlocal materials across the tiers are evident in Periods 2 and 4, but the reverse trend is present in Period 3. In Period 5, nonlocal tools increase across the tiers, but nonlocal debitage decreases. These patterns suggest that factors other than site size are affecting the distribution of nonlocal flaked lithic materials.

Nonlocal tool and debitage data for the Period 4 and 5 architectural complexity groups are presented in table 15.5. Trends are again equivocal, with no consistent correlation of nonlocal material frequency with the 4 architectural ranks. Also, the Grass Mesa Subphase materials are more similar to the most complex group (group 4) than to the less complex groups they were expected to resemble. Thus, architectural complexity, like site size, is an incomplete explanation of the distribution of nonlocal flaked lithic materials.

Nonlocal nonflaked lithic materials are predominantly ornaments and are subject to the same expectations for the concentrations of nonlocal flaked lithic materials. They are too rare to quantify with the screened refuse data set, and ornament frequencies are expressed as ratios of ornaments to total sherds recovered. Numbers of sherds serve as an approximation of the total amount

Table 15.4 – Frequencies of nonlocal flaked lithic items in screened refuse from site size rank tiers

Period	Size rank	Source	Tools		Debitage	
			(N)	(%)	(N)	(%)
2	Small	Local	386	97.7	4 646	100.0
		Nonlocal	9	2.3	2	0.0
		Total	395	100.0	4 648	100.0
	Medium	Local	40	93.0	606	99.7
		Nonlocal	3	7.0	2	0.3
		Total	43	100.0	608	100.0
3	Small	Local	469	95.1	7 706	99.9
		Nonlocal	24	4.9	7	0.1
		Total	493	100.0	7 713	100.0
	Medium	Local	247	99.2	2 851	100.0
		Nonlocal	2	0.8	0	0.0
		Total	249	100.0	2 851	100.0
4	Small	Local	382	98.7	3 127	100.0
		Nonlocal	5	1.3	1	0.0
		Total	387	100.0	3 128	100.0
	Medium	Local	286	98.6	3 578	99.7
		Nonlocal	4	1.4	12	0.3
		Total	290	100.0	3 590	100.0
	Large	Local	1454	96.9	12 433	99.4
		Nonlocal	47	3.1	75	0.6
		Total	1501	100.0	12 508	100.0
5	Small	Local	651	97.3	6 675	99.2
		Nonlocal	18	2.7	53	0.8
		Total	669	100.0	6 728	100.0
	Medium	Local	749	96.6	8 267	99.6
		Nonlocal	26	3.4	31	0.4
		Total	775	100.0	8 298	100.0

of excavation conducted to recover the ornaments. Ornament frequencies (both nonlocal ornaments and total ornaments) are presented by site size rank tiers in figure 15.25. With one exception (Period 4), total ornament frequency is greater at larger sites within time periods, but when only nonlocal ornaments are considered, larger sites consistently have a greater frequency. Thus, it appears that residents of larger sites both have more nonflaked lithic ornaments and have a differential access to ornaments manufactured of nonlocal materials.

Nonflaked lithic ornament data are summarized by the Period 4 and 5 architectural complexity groups in figure 15.26. Except for group 3 (roomblocks with direct access to oversized pitstructures) and the Grass Mesa Subphase collections, the complexity groups are good predictors of ornament frequencies. Only one local ornament was recovered out of group 3 collections that included 404 nonflaked lithic items and over 19000 sherds. The Grass Mesa Subphase collections rank second in ornament frequency to the group 4 collections.

Table 15.5 – Frequencies of nonlocal flaked lithic items in screened refuse from Period 4 and 5 architectural complexity groups

Complexity group	Source	Tools (N)	Tools (%)	Debitage (N)	Debitage (%)
Group 1	Local	402	98.8	3139	100.0
	Nonlocal	5	1.2	1	0.0
	Total	407	100.0	3140	100.0
Group 2	Local	548	97.9	6534	99.6
	Nonlocal	12	2.1	25	0.4
	Total	560	100.0	6559	100.0
Group 3	Local	87	95.6	1512	99.7
	Nonlocal	4	4.4	4	0.3
	Total	91	100.0	1516	100.0
Group 4	Local	1223	96.9	9017	99.2
	Nonlocal	39	3.1	74	0.8
	Total	1262	100.0	9091	100.0
Grass Mesa Subphase	Local	905	96.9	9734	99.4
	Nonlocal	29	3.1	62	0.6
	Total	934	100.0	9796	100.0

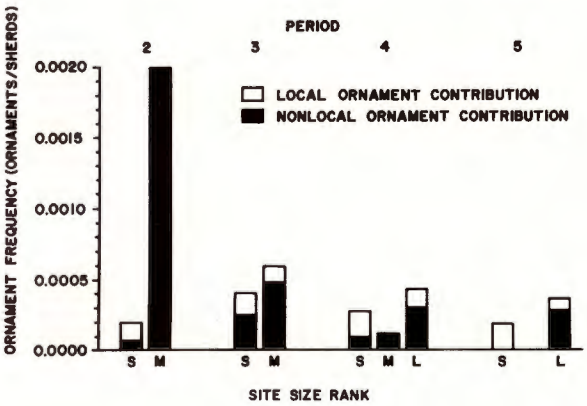

Figure 15.25 – Nonflaked lithic ornament frequencies in site size rank collections. Frequencies are expressed as ratios of ornaments recovered to total sherds recovered (S - small; M - medium; L - large).

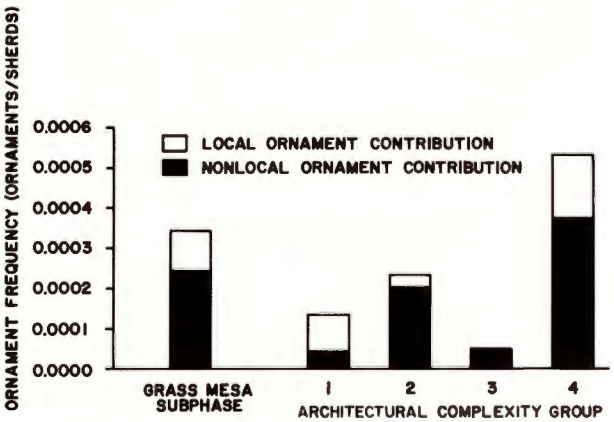

Figure 15.26 – Nonflaked lithic ornament frequencies in architectural complexity group collections. Frequencies are expressed as ratios of ornaments recovered to total sherds recovered.

Although group 1 includes a high proportion of local ornaments, nonlocal ornament frequency is high in all of the other groups (except group 3), including the Grass Mesa Subphase. This agrees with the observations based on site size, since groups 2, 3, and 4, and most of the Grass Mesa Subphase collections are from the largest site size tier. Given the somewhat greater contradictions within the complexity ranking, it appears that apart from group 3, site size is a better predictor of both ornament and nonlocal ornament frequency than is architectural complexity.

Marine Shell

Marine shell occurrences are also expected to be concentrated to the degree that social roles provide differential access to these materials, either through status or through easier access based on residence at a larger site. The problems associated with the quantification of shell are similar to those for nonflaked lithic ornaments, and abundance is expressed as the ratio of shell occurrences to ceramics recovered. Shell frequencies within the site size ranks conform partially to the expectation of increasing abundance with increasing site size (fig. 15.27). Medium size sites in Period 4 lack shell artifacts in collections of more than 17000 sherds, and small sites in period 5 have slightly more shell than contemporary large sites. Of the 6 shell occurrences at the Period 5 small sites, 5 are associated with a single small Grass Mesa Subphase occupation. Based on the general trends, site size appears to be a fair but inconsistent indicator of shell occurrences.

Architectural complexity is a somewhat better predictor based on increasing shell frequency through the 4 architectural groups and large concentrations at the most complex roomblocks (fig. 15.28). However, frequencies at groups 2 and 3 are nearly equivalent rather than reflecting a gradation, and Grass Mesa Subphase collections again rank second in shell occurrences to group 4 and thus are out of sequence. This pattern of frequencies corresponds somewhat to that observed for the nonflaked lithic ornaments, in that group 4 stands out with the consistently highest frequency but that the remaining ranks are considerably less well ordered.

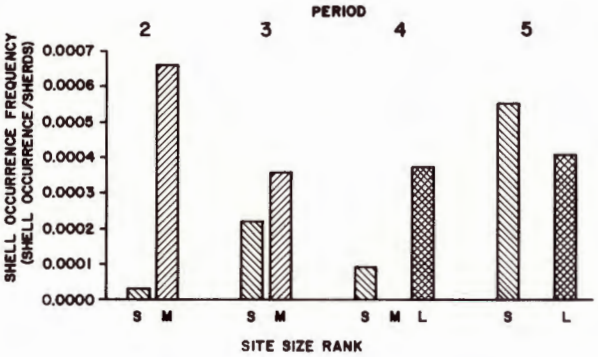

Figure 15.27 – Shell occurrence frequencies in site size rank collections. Frequencies are expressed as ratios of ornaments recovered to total sherds recovered (S - small; M - medium; L - large).

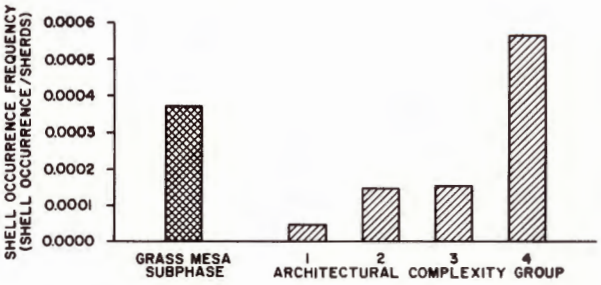

Figure 15.28 – Shell occurrence frequencies in architectural complexity group collections. Frequencies are expressed as ratios of ornaments recovered to total sherds recovered.

Discussion

Most nonlocal materials are differentially distributed in Dolores area sites, at least from Period 2 through Period 5. Larger sites tend to have higher frequencies of nonlocal ceramics, nonlocal lithic ornaments, and marine shell occurrences. Within the larger sites, concentrations of these materials tend to occur at the presumably more complex architectural units (U-shaped roomblocks), but gradations in abundance within Kane's architectural typology (chap. 14) are weakly expressed. Concentrations of nonlocal flaked lithic tools and debitage are much less clearly associated with either site size or complexity.

The mechanisms of nonlocal material concentration appear complex. Nonlocal ceramic material concentrations (predominantly bowls) are explained, at least in part, by an increase in the ratio of food consumption activity to food preparation activity at group 4 roomblocks. This is compatible with a functional interpretation of these roomblocks as settings for community ritual with an emphasis on concurrent eating of food prepared elsewhere (potluck behavior). However, this functional explanation is incomplete when site size data are considered, and there does appear to be some degree of enhanced access to nonlocal materials at the largest site in all time periods.

High frequencies of shell and nonflaked lithic ornaments at the group 4 roomblocks could also be a byproduct of the hosting function (loss of jewelry by nonresident participants), but this is unlikely to be more than a contributing factor. Shell occurrences tend to consist of multiple rather than single items, and the high frequency of nonlocal ornaments contrasts with the low frequency of nonlocal ornaments at the isolated roomblocks. The coincidence of high frequencies of these ornament classes with higher nonlocal nonflaked lithic frequencies suggests differential access is playing some role. However, this pattern of differential access extends to large sites in general as well as to the group 4 roomblocks. Thus, although the degree of ritual activity evidenced by the vessel form frequencies may emphasize the access of group 4 roomblock residents to shell and lithic ornaments, the same factors are pres-

ent to a degree at all large sites, regardless of the architectural expression of the hosting function.

SUMMARY AND CONCLUSION

Material transfers were a common occurrence during the A.D. 600-980 occupation of the Dolores area. Motivations for these exchanges appear to have included a range of factors, from economic considerations of procurement through expressions of social relationships. Changes in the abundance and distributions of exchanged goods appear to be related to changes in the organization of production, the location of population on the landscape, broader interregional relationships, and the character and intensity of ritual or integrative activity.

Ceramic exchange appears to have been shaped to a great degree by the organization of production. A low level of specialization in gray ware manufacture prior to A.D. 800 provided some impetus for commodity exchange of gray ware vessels. After A.D. 840, most if not all households participated in gray ware manufacture, and motivations for commodity exchange of gray ware vessels decreased. White ware manufacture appears to have been specialized at the level of skilled individuals for the entire A.D. 600-980 period, and commodity exchange was essential to the distribution of this ware. The geographic extent of exchange on a commodity basis may have increasingly exceeded the boundaries of the Mesa Verde region after A.D. 800 or 840. Red ware production was always regionally specialized, and a widespread distribution system moved these vessels as commodities across the entire Mesa Verde region. A decrease in numbers of red ware vessels in the middle ninth century may reflect the influence of region-wide population dislocations on both production and distribution of red ware vessels.

Changes in the amount of nonlocal ceramic materials appear to be a consequence of the population history of both the Dolores area and the northern Mesa Verde region. Increase in the Dolores area population between A.D. 600 and 880 is reflected in a decrease in the geographic extent of gray ware exchange. This decrease reflects both the proliferation of "local" sources for gray ware vessels and the probable spatial shrinkage of the mating or intensive interaction network. This latter explanation depends upon the assumption that intensive interaction as part of kinship or ritual obligations was accompanied by the exchange of prepared food in gray ware vessels. An additional factor in the decreasing frequency of nonlocal sherds is the A.D. 840-920 relocation of Anasazi populations into areas of the Mesa Verde region that are "local" in the limits of archaeological perception and the abandonment of areas that are "nonlocal."

During the A.D. 840-920 period, when Dolores area population was at high levels, buffering alliances may have been formed with other areas of the Mesa Verde region. The evidence for this consists of a directional change in exchange from the west and southwest to the south and southeast. This directional change occurs in apparent disregard for the existence of closer populations (at least in Period 6), and although the directional change is expressed in both gray and white ware vessel movement, white ware vessels are affected to a greater degree. The presumed geographic focus of the buffering effort was with residents of Mesa Verde, and that focus would be adaptive in an economic sense based on the relatively greater stability of agricultural risk in the Mesa Verde region as opposed to the Dolores area.

Although circumstantial evidence can be used to support alliance development, changing levels of regional and inter-regional interaction may be creating an illusion of alliances. Broad shifts in inter-regional exchange patterns are evident in ceramic materials and obsidian may precede the apparent alliance formation. These shifts suggest increased interaction with populations to the south and southeast at the expense of western or southwestern interactions. These broader regional shifts may actually have been determining the direction of interaction within the Mesa Verde region, but the converse is also a possibility.

Levels of social integration or complexity appear to influence exchange throughout the occupation of the Dolores area (at least for the A.D. 720-920 period). Larger sites appear to have differential access to exchanged goods as evidenced by higher frequencies of nonlocal materials. For the period of greatest population aggregation (A.D. 840-920), a further concentration of exchanged material is evident at the architecturally most complex roomblocks within the large sites. Part of this concentration can be attributed to the functions of these particular sites as hosting locations for ritual gatherings involving food consumption (potlucks), but there is a residual amount of material that may be related to either the enhanced access to nonlocal goods associated with residence in central places or to enhanced access based on status differentials. However, if status is playing a role in the distribution of nonlocal materials, there is no indication of exclusive access in the archaeological distribution, even at the height of aggregation and architectural complexity.

When compared with expectations based on the generative principles of the economic and sociopolitical models (chapt. 6), the observed states of and changes in Dolores area exchange can affirm the influence of the former but cannot discount the latter. Most of the observed change in our archaeological perception of

exchange conforms well to predictions based on subjective considerations of economic and social costs. The close correspondence between patterns of production and exchange, the changes that appear to be in response to changes in regional and local population distribution, and the early correspondence between larger sites and concentrations of nonlocal goods can be understood in reference to economic principles of decision making. The later concentration of exchange goods at both larger sites and ritually active roomblocks is less clearly an economic consequence, but this may simply be due to the lack of a theoretical basis for understanding the importance of conflict mediation through ritual in highly aggregated populations (chap. 9). Finally, if alliance formation is primary and the directional changes in extraregional exchange are epiphenomena, then the ninth century directional changes can also be understood in economic terms.

The weak affirmation of economic explanations for the concentrations of exchanged materials in the late ninth century provides the basis for retention of the leadership development as a possible motivating force in changes in the exchange network. The observed concentrations at the most complex roomblocks could reflect an increasing status differentiation. Alliance formation between leaders or establishment of broader regional interaction (perhaps with esoteric knowledge rather than subsistence buffering as a basis for interaction [Upham 1982]) could also reflect the influence of leadership development on regional systems. However, these explanations are also weak in that the evidence in support of leadership expectations is circumstantial, and the stronger concentrations that might be expected to follow from leadership expression (e.g., exclusive distributions of status-related nonlocal materials) are not in evidence.

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Chapter 16

EVALUATIONS OF THE MODELS WITH DOLORES AREA DATA

William D. Lipe and Allen E. Kane

In this chapter, results regarding the contrastive expectations for the 2 models are evaluated and some tentative conclusions are reached. Some suggestions are also made regarding further work that might improve the resolution of the tests.

REGIONAL ENVIRONMENT AND AGRICULTURAL ATTRACTIVENESS

The Dolores Project area is relatively high in elevation and is cool and moist compared to most areas occupied by the Anasazi in the Four Corners region. Under present climatic conditions, it is near the upper limit of the dry-farming belt, and short growing seasons pose the greatest risk to agriculture. Although the area is well protected from drought, relative to lower elevation areas, variations in precipitation undoubtedly had some effect on agricultural productivity. Petersen's data in chapter 4, section 6, show that at certain times in the past 1500 years, all or part of the Dolores Project area may have been outside the zone of farming feasibility. Petersen also provides evidence showing the lower elevation boundary of the "farming belt" fluctuated through time and this may also have contributed to the relative attractiveness of the Dolores area to Anasazi farmers.

The relative attractiveness of the Dolores area would have been greatest when the regional climate was both warm and dry. This would have ameliorated somewhat the risks of short growing seasons in the Dolores area, while increasing the stress on settlements near the lower border of the farming zone. Although severe droughts might have affected productivity even in the Dolores area, these effects would have been much less than in lower elevation areas. During the A.D. 600-980 time range, which is of primary interest to the DAP, the Dolores area was most attractive between about A.D. 760-900, or late Period 2 through early Period 5. The relative attractiveness of Dolores may have been greatest in Period 4, in the middle A.D. 800's. This era of relative attractiveness was affected by increasing frequency of short growing seasons and severe droughts in the late A.D. 800's, and the era was terminated by an interval of short growing seasons starting about A.D. 900. The dry-farming belt expanded through the A.D. 900's, providing a larger zone for settlement in the general region. Optimal locations for farming within this zone probably retreated downslope from the Dolores area during this period.

REGIONAL POPULATION DISTRIBUTION AND MOVEMENT

Schlanger's analysis of population (chap. 8) indicates regional population distribution and inferred interareal movements show generally good agreement with Petersen's estimates of relative attractiveness, and hence give general support to the economic model. The Dolores area appears to gain population in the late A.D. 700's and 800's as the lower border of the dry-farming belt contracts upward, at approximately the same time that the lower elevation settlements are losing population. This is not to assert that the Dolores area immigrants necessarily came from the specific lower elevation areas Schlanger studied. If the areas under discussion are viewed as samples of differing environmental zones, however, the data support the reference that population movement was from drier, low elevation areas (such as Mockingbird Mesa) to more moist, higher elevation areas (such as Dolores).

It is somewhat surprising that Dolores area population does not show a greater increase in Period 3. Perhaps the Dolores area population is somewhat underestimated in this period because the large Period 4 settlements obscured some of the evidence of Period 3 sites. Data from excavated sites are equivocal on this point – some Period 4 sites have indications of substantial Period 3 occupations, while others do not. The excavated and survey data sets need further examination with regard to this issue.

Schlanger does find some indication of lag effects in response to climatic change, as well as some evidence

of movement from areas of low to high population density, both of which might indicate that social factors were outweighing strictly economic responses at particular times and places. Future survey data from the area between Dolores and Woods Canyon areas would be helpful in "tracking" population responses. For example, some of the "missing" population for late Period 5 may have settled between these 2 areas.

Schlanger has shown that Petersen's generalized estimates of relative attractiveness have good predictive value for population change during the A.D. 600-980 period; to this extent, then, the data support a least cost, or risk avoidance, response in keeping with the economic model. Schlanger's model testing would be further improved if agricultural costs could be estimated for the Mockingbird Mesa and Woods Canyon study areas under differing levels of population density and climate. Kohler et al. (chap. 9) provide such estimates for the Dolores area in their cost study, but similar modeling for the other study areas would be useful. Futher, a separate assessment of agricultural risks, as opposed to costs, for all 3 areas would be desirable. Futher work on the existing theoretical models to more precisely develop expectations for responses to changes in risks as separate from costs would also be desirable.

DOLORES AREA AGRICULTURAL COSTS, POPULATION, AND AGGREGATION

Schlanger's regional data on population distributions suggest that interareal population changes reflect economic responses to changes in climate and population density. The data on agricultural costs and population distribution within the Dolores area (Kohler et al., chap. 9) suggest, however, that choice of settlement location within the area and patterns of settlement growth were not highly sensitive to variation in subsistence costs. A rather wide distribution of agricultural costs among settlements appears within the area at all time periods, and the range of costs tends to increase concurrent with the increase in population density (Schlanger, chap. 8) and evidence of social complexity displayed in Period 4 and 5. Kane, in his study of social organization, suggests that for the 7 largest settlements in the area during Periods 4 and 5, no correlation existed between the agricultural quality of the catchment and the size of the settlements. His interpretations indicate a tendency toward evenness in spacing of these large settlements during Periods 4 and 5 that cannot be explained by variation in agricultural resources and costs. All this indicates that either nonagricultural economic factors were at work, or that social factors were more important in determining location and size of settlements within the generally suitable habitat provided by the Dolores area. Within the limits of the approach taken, the latter conclusion is accepted.

The examination of interperiod agricultural costs at settlements indicates the settlements that grew the most tended to be those with average costs in the earlier periods, and that neither extremely high cost or low cost locations attracted population (Kohler et al., chap. 9). This does indicate some degree of economic selection with regards to settlement growth, through not exactly what was predicted by the economic response model.

Because costs are so strongly influenced by degree of population aggregation, and aggregation generally increased through time in the area, the results presented by Kohler et al. (chap. 9) indicate the Dolores area population was paying a price for aggregation, above and beyond the increases due to higher population densities. The larger settlements were the ones most likely to grow, with relative costs being only a secondary factor. Although this conclusion departs from a narrow least cost expectation, the economic response model did predict that aggregation was likely to occur as population density, agricultural intensification, and subsistence costs increased. This appears to be what happened. On the other hand, more rapid growth rates at the largest settlements is a direct expectation of the social model. Effective leaders at large settlements would attract relatively large groups of followers, and "successful" communities would be relatively more attractive to prospective immigrants. Thus, the exhibited trends in settlement growth lend support to the social model.

The results depart from the economic model's expectations when the growth and spacing of the largest settlements in Periods 4 and 5 show little correspondence to the general distribution of agricultural resources and costs within the Dolores area. This suggests that within this generally agriculturally suitable area, sociopolitical development and competition had more to do with patterns of settlement growth than did relative economic costs, at least in Periods 4 and 5.

Further work should be concentrated on attempting to separate costs from risks and including data on other resources in addition to arable land. The timings of growth of the larger settlements and of settlement aggregation in general – especially whether these were well under way in Period 3, before the Period 4 rise in costs and population – are important to this evaluation. The timing of growth at large settlements is addressed in chapter 14, and a strong case could not be made for rapid growth at most Dolores settlements before Period 4 (A.D. 840-880). The Grass Mesa site appears to be an exception; this settlement apparently was host to a

large influx of immigrant groups during late Period 2 (A.D. 760-800 [Lipe et al 1985:18.75]). A similar pattern of village growth, albeit on a smaller scale, may be manifested at Rio Vista Village, a few kilometers upstream from Grass Mesa. Therefore, much of the growth at the large settlements does appear to correspond to the Period 4 rise in costs and population; however, some indications of large settlement growth in Period 2 cannot be explained by cost factors.

The settlement behavior analyses reported by Orcutt (chap. 10) indicate aggregation increased with increasing population density and increased reliance on agriculture, although the latter is problematical because of the use of proxy measures to represent resource mix. Habitation site catchments in the pre-A.D. 920 periods indicate selection for locations with good quality agricultural lands, as do the catchments of limited activity and seasonal sites. Settlement complexity (as a possible proxy for political complexity) correlates with population density, proxied agricultural intensification, and aggregation. While the settlement behavior analyses lend substantial support to an economic-based model, the discussions in chapter 10 also point out the need to consider bridging the artifical gap between the economic and social models by estimating the cost of organizational change versus the costs of maintaining organizational structures that may become inefficient as population increases.

SUBSISTENCE AND TECHNOLOGY

The floral evidence indicates the same pattern of plant exploitation was maintained throughout the period, but some quantitative changes in emphasis were made. These changes are difficult to interpret, however, because they are often not consistent from one type of measure to the next, and because patterns of refuse disposal, preservation, or recovery may be strongly influencing the observed variability in the data. For example, in the floral ubiquity data (chap. 7:figs. 7.8-7.10), the overall ubiquity of floral remains is low in Period 1 features, rises substantially in Period 2, reaches a peak in Periods 4 and 5, and declines in Period 6 and 7. The data may be used to imply overall changes in the intensity of use of plants for subsistence, or to imply changes in patterns of food processing, discard behavior, or types of features selected for excavation. If the former, the data can be interpreted as supporting the economic model, but the latter explanation cannot be excluded based on current understanding of the archaeological record.

If the overall rates of deposition are held constant and the ubiquity measures for corn, ruderal plants, and wild plant foods are observed in relation to one another, some modest patterns can be discerned. Corn occurs in the largest percentage of features in Periods 2 through 5 contexts, but does not occur as frequently in features from Periods 1, 6, and 7 contexts. This provides some support for the argument that intensification was generally coincident with high populations, but does not allow us to discriminate between the implications of the economic and social models. It could be argued that a corn-dominated economy was established by Period 2 and that further intensification does not appear to accompany the major population increases documented for Period 4. It is not clear, however, whether the ubiquity data can support this level of resolution.

Another modest pattern discernible in the ubiquity data is that wild plant remains increase, relative to corn and ruderals, in Periods 5 through 7. Coupled with a relative decline in the numbers of features yielding corn, this may indicate a trend toward "de-intensification" in concert with population decrease. This would be in keeping with the implications of the economic model.

The faunal evidence, as interpreted by Blinman (chap. 12), also indicates some shifts that appear to be associated with supply-demand changes. Use of game appears to have been lowest during Period 4, the time of highest population density, which is in agreement with the expectations of the economic model that an agricultural strategy would be increasingly relied upon to keep up with increasing subsistence demand. In other words, it costs less to meet increased subsistence needs through increased agriculture than through more intensive exploitation of the more easily depletable wild plant and animal foods. In this context, the rise in use of game inferred for Period 5 is more difficult to explain. Population has begun to drop, but because of climatic reverses, agricultural costs have increased. The relative increase in game procurement may be related to higher uniform marginal costs in the system, to a more logistic strategy associated with increased distances to agricultural loci, with a "maxing-out" in a subsistence system under severe economic stress, or with other factors not yet understood. The increased evidence for game procurement found in Periods 6 and 7, coupled with the botanical and population evidence for these times, suggests a return to a lower cost, more balanced subsistence pattern in a situation where population density is low and game is relatively more abundant.

The technological evidence of subsistence patterns also shows changes in emphasis through time within a basic technological pattern. Specialized corn-grinding tools – 2 hand manos and trough metates – are used as a proxy for intensified corn processing (chap. 11). Their temporal distribution indicates agricultural intensification

follows a trajectory generally in agreement with the expectations of the economic model – rising with population density and agricultural costs, and declining as these factors decline. On the other hand, the expected rise in Period 2, when population increased substantially, is not present, but there does appear to be a very strong response in Periods 4 and 5, at the same time that evidence from pioneer plants and faunal remains indicates that intensification of agricultural and other food sources is highest.

The evidence of increase in nonlocal lithic materials from Periods 1 through 5, presented in the tools and technology study (Phagan, chap. 11), might be taken as evidence of an increasingly logistic strategy for acquiring nonagricultural subsistence resources, as local catchments became increasingly depleted because of higher population density and aggregation. This trend does not reverse itself, however, in Periods 6 and 7, when population density declined radically. The Dolores area occupation may actually be a marginal part of a new sociocultural system at this time, or the observed pattern may document increased travel or trade associated with development of regional sociopolitical alliances.

STORAGE

Studies by Gross (chap. 13) and Wolf et al. (1985) support findings of an apparent increase in storage volume in Periods 4 and 5, and Kane shows there is a tendency for storage volume to increase in the architecturally more complex roomblock units and communities. Gross (chap. 13) and Wolf et al. (1985) also indicate the observed storage volume is always much greater than that actually needed to house stored food supplies for the households associated with the storage facilities. The increase in "excess" storage volume in Periods 4 and 5 would appear to support the social model more than the least cost economic model. On the other hand, the location of storage facilities remains primarily at the household level throughout the period, and the variance among households even in Period 4-5 does not appear to very great. This tends to argue against any very great accumulation of stored goods by individuals or households as part of competition for leadership positions (Kane, chap. 14).

Simulations of crop yields and storable surpluses shows the subsistence system would have had the capacity to produce regular surpluses through Periods 3 and 4, but some problems began to be encountered after A.D. 860 (Wolf et al. 1985). These problems increased greatly in the very late A.D. 800's and the early A.D. 900's. This indicates the development of sociopolitical complexity may have occurred during times when climatic variability contributed little to economic stress (Kane, chap. 14). The simulation by Wolf et al. (1985) also shows the kinds of shortfalls encountered in the late A.D. 890's and early A.D. 900's would have been extremely difficult, if not impossible, to buffer with available storage technology, no matter whether social or economic factors were predominant in previous patterns of change.

ARCHITECTURE, EXCHANGE, AND SOCIOPOLITICAL DEVELOPMENT

In his chapter on social organization, Kane summarizes architectural data indicating a well-developed hierarchy of roomblock types during Periods 4 and 5. This clearly appears to represent a substantial increase in sociopolitical differentiation within communities at this time. Furthermore, the communities with the greatest evidence of internal complexity also tend to be the largest ones in population. Evidence presented in the social organization chapter showed that for these large communities a lack of correlation existed between agricultural productivity of catchment and community size and spacing. Taken together, these lines of evidence suggest sociopolitical factors were more important than economic ones in determining the growth of communities within the Dolores area during Period 4 and 5.

Kane also suggests these patterns began to emerge by A.D. 830 or 840, approximately at the transition between Periods 3 and 4. This is early enough to infer that the sociopolitical developments indicated by these patterns could have played a role in **attracting** population to the Dolores area, rather than being part of an organizational response to a population increase that occurred because the Dolores area was becoming a kind of regional refugium. Kane also argues that the initiation of sociopolitical complexity was at a time of extremely stable climate, so that subsistence surpluses could reliably have been produced at relatively low cost.

The timing of population increase versus the appearance of architectural and settlement pattern indicators of increased complexity is important to our assessment of the alternative models. Re-examination of excavation data for late Period 3 and early Period 4 should be made in an attempt to clarify this issue.

Kane's Period 3-4 roomblock hierarchy revolves around propinquity to "oversized" pitstructures, which he interpretes as housing both ritual and managerial activities controlled by leading individuals or kin groups. These structures differ little from other pitstructures except in size and occurrence of special ritual features. This suggests they may be more specialized

for ritual gatherings than for managerial functions per se. This would be consistent with use of ritual as a medium for sociopolitical control while at the same time maintaining an egalitarian ethic.

The distribution of potential artifactual markers of sociopolitical status has not yet been thoroughly studied, but Phagan and Blinman's papers shed some light on this issue. Phagan's contribution on tools and technology found that Period 4-5 corn-grinding tools tended to increase in proportion according to the higher levels of the roomblock hierarchy, suggesting the higher level locations were more involved with corn processing than the lower levels. This would be consistent with more hosting of ritual or other gatherings by the higher status groups residing at the higher level roomblock units. Blinman's study of containers and technology reveals that nonlocal ceramics were more abundant at the larger settlements and at the higher level roomblock units, and he attributes part of this abundance to increased hosting activities.

The evidence for presence of individuals of high status (as opposed to roomblock unit or community status) is weak. Residential architecture in Periods 4 and 5 is remarkably uniform in pattern, despite the quantitative differences in room and pitstructure size noted for suprahousehold units and communities. Truly exotic artifacts are quite rare and do not appear to be closely associated with the community and roomblock hierarchies, except that comparatively large numbers of shell and turquoise items were recovered from one "oversized" pitstructure at McPhee Village. Although some tendency for high-production-input lithic items and nonlocal materials occurs at the more complex communities and roomblocks, these trends are quite weak. Such items are also widely distributed throughout the population with the exception noted above. The pattern generally conforms to one of low-frequency, widespread exchange carried out within a network of trading partners. Higher status individuals, groups, or communities may be slightly more active within this network, but do not control it. In assessing individual status recognition, the relatively small number of burials encountered in the area hampers efforts, so an analysis of differential distribution of grave offerings has not been done.

In summary, evidence shows an increase in sociopolitical development in Periods 4 and 5. An argument can be made that this increase in complexity may have led to some of the Period 4 population increase, rather than being primarily a response to it. However, the evidence indicates the observed sociopolitical development could have emerged by processes incorporated in the economic model, as a least cost response to the management needs brought about by increased population density, agricultural intensification, and higher subsistence costs. The weak development of markers for individual status, as opposed to group status, and the apparent use of a ritual idiom for managerial functions, supports this interpretation.

CONCLUSIONS

Evidence shows a substantial increase in sociopolitical complexity in Periods 4 and 5, and patterns of community location and growth at this time appear to be responding more to social than to economic factors. The bulk of evidence, however, suggests that greater complexity during these periods may be a response to managerial demands brought on by increased population density, agricultural intensification, and higher subsistence costs. These factors can be related to regional patterns of population movement and settlement stemming from economic responses to shrinkage of the southwestern Colorado dry-farming belt during the A.D. 800's. The Dolores system in the late A.D. 800's was likely at a "takeoff point" for increasing sociopolitical determination of system growth and change, and it may have begun a "power cycle" such as that described by Stuart and Gauthier (1981). A brief period of very unfavorable crop years in the very late A.D. 800's and early A.D. 900's, however, appears to have truncated these developments, either by creating such great strains on the managerial hierarchy that it collapsed or by producing outright adaptive failure leading to rapid depopulation of the area.

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APPENDIX A

DATING

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 1 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Room n.o.							
Surface 1	1081	Hearth	AM	63	Poor results		
Room 3							
Stratum 2			DD	8		Ponderosa pine	
Surface 1	15	Posthole	DD	28		Ponderosa pine	
Surface 1	15	Posthole	DD	29		Ponderosa pine	
Surface 1	34	Posthole	DD	39	733fp / 831+vv	Douglas-fir	69
Surface 1	56	Posthole	DD	73		Douglas-fir	
Room 4							
Stratum 2			DD	23		Pinyon pine	
Room 6							
Stratum 2			DD	93		Ponderosa pine	
Stratum 4			DD	101		Ponderosa pine	
Surface 1	72	Posthole	DD	124		Ponderosa pine	
Surface 1	65	Burned pit	AM	5	pre-700-750; 865-895		
Room 7							
Stratum 3			DD	40		Ponderosa pine	
Room 9							
Surface 1			DD	43	740fp / 785vv	Pinyon pine	70
Surface 1			DD	183		Ponderosa pine	
Room 12							
Surface 2	50	Hearth	AM	4	pre-700-755; 865-895		
Room 13							
Stratum 1			DD	126		Populus	
Surface 1	73	Posthole	DD	128		Ponderosa pine	
Surface 1	147	Posthole	DD	155		Ponderosa pine	
Room 14							
Level 1			DD	160		Ponderosa pine	
Room 15							
Surface 1	176	Posthole	DD	174		Juniper	
Room 16							
Surface 1			DD	178			
Room 22							
Stratum 4			DD	161		Ponderosa pine	
Room 27							
Surface 3	244	Posthole	DD	279		Douglas-fir	
Surface 3	245	Posthole	DD	249		Juniper	
Room 30							
Surface 1	11	Hearth	AM	6	pre-700-725		
Room 34							
Surface 1	352	Posthole	DD	334		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 2 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23 (continued)							
Room 43							
Surface 1	438	Posthole	DD	346		Juniper	
Room 50							
	620	Posthole	DD	2021		Juniper	
	622	Posthole	DD	2022		Juniper	
Room 52							
Stratum 1			AM	22	860-900		
Surface 1			DD	1006		Populus	
Room 53							
Surface 1	633	Hearth	AM	23	Poor results		
Room 56							
Surface 1	733	Hearth	AM	31	Poor results		
Surface 1	737	Hearth	AM	30	Poor results		
Room 63							
Surface 1	751	Posthole	DD	3001		Ponderosa pine	
Room 64							
Surface 1	782	Posthole	DD	3004		Douglas-fir	
Room 65							
Surface 1			AM	45	Poor results		
Room 72							
Surface 1	1718	Hearth	AM	77	885-900		
Surface 1	1717	Fireplace	AM	71	850-865; 885-910		
Surface 1	1748	Fireplace	AM	78	885-900		
Room 74							
Surface 1			DD	3005		Ponderosa pine	
Room 79							
Level 1			DD	3010		Ponderosa pine	
Level 1			DD	3013		Juniper	
Level 1			DD	3011	691 / 737vv	Ponderosa pine	397
Surface 1			AM	39	Poor results		
Surface 1	869	Hearth	AM	38	pre-700-740; 915-1000		
Surface 1	873	Posthole	DD	3012	675p / 730vv	Ponderosa pine	398
Surface 1	877	Posthole	DD	3014		Ponderosa pine	
Room 83							
Surface 1			AM	65	Poor results		
Surface 1	909	Small floor cist	AM	43	Poor results		
Surface 1	910	Hearth	AM	44	Not near curve		
Room 85							
Surface 1	1100	Hearth	AM	64	Poor results		
Room 87							
Level 1			DD	2094		Ponderosa pine	
Surface 1	1187	Posthole	DD	2101		Ponderosa pine	
Room 88							
Surface 1	1403	Hearth	AM	51	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 3 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23 (continued)							
Room 90							
Surface 1	693	Hearth	AM	32	Poor results		
Surface 1	715	Posthole	DD	2051		Ponderosa pine	
Room 91							
Surface 1	709	Hearth	AM	33	Poor results		
Surface 1	712	Hearth	AM	35	Poor results		
Room 92							
Surface 1	967	Posthole	DD	2052		Ponderosa pine	
Room 95							
Surface 1	1654	Hearth	AM	68	870-900		
Surface 1	1725	Hearth	AM	70	Not near curve		
Surface 1	1661	Posthole	DD	3178		Juniper	
Surface 1	1683	Posthole	DD	3170	587 / 680+vv	Juniper	424
Surface 1	1686	Posthole	DD	3175		Juniper	
Room 97							
Level 1			DD	3173		Ponderosa pine	
Room 115							
Stratum 2			DD	3204		Ponderosa pine	
Surface 1	1964	Hearth	AM	96	700-750; 865-890		
Room 116							
Surface 2	1976	Hearth	AM	97	700-785; 855-915		
Room 139							
Surface 1	1988	Posthole	DD	3220		Ponderosa pine	
Surface 1	2006	Posthole	DD	3223		Ponderosa pine	
Room 152							
	2011	Posthole	DD	3222		Ponderosa pine	
Room 161							
Surface 1	2041	Hearth	AM	101	pre-700-750; 865-885; 910-940		
Room 175							
Surface 1	2075	Posthole	DD	3227		Juniper	
Room 218							
Surface 1	833	Hearth	AM	25	Poor results		
Pitstructure 1							
			AM	3	Used in Dolores Modification		
Stratum 10			DD	27		Ponderosa pine	
Stratum 10			DD	14		Populus	
Stratum 10			DD	22	668fp / 780vv	Ponderosa pine	68
Stratum 10			DD	25		Ponderosa pine	
Stratum 10			DD	15		Pinyon pine	
Stratum 10			DD	21		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 4 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 1 (continued)							
Stratum 10			DD	19		Pinyon pine	
Stratum 10			DD	24		Ponderosa pine	
Stratum 10			DD	18		Ponderosa pine	
Stratum 13			DD	13		Juniper	
Level 11			DD	2		Juniper	
Surface 1	16	Hearth	AM	2	935-1005		
Surface 1	21	Posthole	DD	35		Ponderosa pine	
Surface 1	22	Posthole	DD	32		Ponderosa pine	
Full cut			DD	17		Ponderosa pine	
Pitstructure 2							
	131	Posthole	DD	147		Ponderosa pine	
	132	Posthole	DD	148		Ponderosa pine	
	124	Wall cist	DD	146		Ponderosa pine	
	106	Ventilation system	DD	141	528fp / 827++v	Pinyon pine	87
Stratum 10			DD	50		Juniper	
Stratum 12			DD	134		Pinyon pine	
Stratum 12			DD	54		Populus	
Stratum 12			DD	55		Populus	
Stratum 12			DD	56		Populus	
Stratum 12			DD	125		Ponderosa pine	
Stratum 12			DD	57		Populus	
Stratum 12			DD	142		Ponderosa pine	
Stratum 12			DD	58		Populus	
Surface 1	114	Hearth	DD	144		Pinyon pine/ nonconiferous	
Surface 1	114	Hearth	AM	9	Used in Dolores Modification		
Surface 1	134	Posthole	DD	150		Ponderosa pine	
Surface 1	135	Posthole	DD	151	552p / 722+vv	Ponderosa pine	90
Surface 1	133	Post	DD	149	592p / 693vv	Ponderosa pine	89
Full cut			DD	30		Ponderosa pine	
Full cut			DD	31		Douglas-fir	
Pitstructure 3							
			AM	10	pre-700		
	207	Ventilation system	DD	285		Juniper	
	207	Ventilation system	DD	266	619+p / 852r	Juniper	288
	207	Ventilation system	AM	17	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 5 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 3 (continued)							
	207	Ventilation system	DD	261		Ponderosa pine	
	207	Ventilation system	DD	262		Ponderosa pine	
	207	Ventilation system	DD	284		Ponderosa pine	
	207	Ventilation system	DD	280		White fir	
	207	Ventilation system	DD	286		Juniper	
	207	Ventilation system	DD	258		White fir	
	207	Ventilation system	DD	281		White fir	
	207	Ventilation system	DD	257		Juniper	
	207	Ventilation system	DD	282		Ponderosa pine	
	207	Ventilation system	DD	259		Ponderosa pine	
	207	Ventilation system	DD	260		Douglas-fir	
Stratum 8			DD	64		Ponderosa pine	
Stratum 8			DD	67		Ponderosa pine	
Stratum 8			DD	60		Ponderosa pine	
Stratum 8			DD	63		Ponderosa pine	
Stratum 8			DD	66		Ponderosa pine	
Stratum 8			DD	65		Ponderosa pine	
Stratum 8			DD	62		Ponderosa pine	
Stratum 8			DD	51		Ponderosa pine	
Stratum 8			DD	61		Ponderosa pine	
Stratum 8			DD	59		Ponderosa pine	
Stratum 8			DD	52		Ponderosa pine	
Stratum 8			DD	53		Ponderosa pine	
Stratum 10			DD	198		Ponderosa pine	
Stratum 10			DD	112		Ponderosa pine	
Stratum 10			DD	76		Ponderosa pine	
Stratum 10			DD	195		Ponderosa pine	
Stratum 10			DD	202		Pinyon pine	
Stratum 10			DD	113		Ponderosa pine	
Stratum 10			DD	78		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 6 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 3 (continued)							
Stratum 10			DD	105		Pinyon pine	
Stratum 10			DD	106		Ponderosa pine	
Stratum 10			DD	194		Ponderosa pine	
Stratum 10			DD	74		Ponderosa pine	
Stratum 10			DD	219		Pinyon pine	
Stratum 10			DD	217		Ponderosa pine	
Stratum 10			DD	79		Ponderosa pine	
Stratum 10			DD	81		Ponderosa pine	
Stratum 10			DD	207		Ponderosa pine	
Stratum 10			DD	235		Ponderosa pine	
Stratum 10			DD	95		Juniper	
Stratum 10			DD	208		Ponderosa pine	
Stratum 10			DD	216		Ponderosa pine	
Stratum 10			DD	201		Ponderosa pine	
Stratum 10			DD	230		Pinyon pine	
Stratum 10			DD	231		Pinyon pine	
Stratum 10			DD	80		Ponderosa pine	
Stratum 10			DD	192		Ponderosa pine	
Stratum 10			DD	238		Ponderosa pine	
Stratum 10			DD	237		Ponderosa pine	
Stratum 10			DD	82		Ponderosa pine	
Stratum 10			DD	75		Ponderosa pine	
Stratum 10			DD	189		Ponderosa pine	
Stratum 10			DD	94		Ponderosa pine	
Stratum 10			DD	191		Pinyon pine	
Stratum 10			DD	187		Juniper	
Stratum 10			DD	190		Ponderosa pine	
Stratum 10			DD	203		Ponderosa pine	
Stratum 10			DD	236		Ponderosa pine	
Stratum 10			DD	199		Pinyon pine	
Stratum 10			DD	97		Ponderosa pine	
Stratum 10			DD	188		Ponderosa pine	
Stratum 10			DD	96		Ponderosa pine	
Stratum 10			DD	116		Ponderosa pine	
Stratum 10			DD	115		Ponderosa pine	
Stratum 10			DD	102		Ponderosa pine	
Stratum 10			DD	77		Ponderosa pine	
Surface 1			DD	104		Ponderosa pine	
Surface 1	100	Hearth	AM	13	Used in Dolores Modification		
Surface 1	251	Posthole	DD	247		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 7 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 3 (continued)							
Surface 2	312	Hearth	DD	287		Juniper	
Surface 2	312	Hearth	AM	14	Used in Dolores Modification		
Surface 2	66	Posthole	DD	114		Juniper	
Surface 2	247	Posthole	DD	248	694fp / 802vv	Juniper	278
Full cut			DD	9		Ponderosa pine	
Pitstructure 4							
Stratum 2			DD	70		Ponderosa pine	
Surface 1			DD	129	762 / 858+vv	Douglas-fir	84
Surface 1	119	Hearth	AM	8	Used in Dolores Modification		
Pitstructure 5							
			AM	11	785-805		
Stratum 18			DD	98		Pinyon pine	
Stratum 18			DD	138		Ponderosa pine	
Stratum 18			DD	86		Juniper	
Stratum 18			DD	83		Pinyon pine	
Stratum 18			DD	121		Nonconiferous	
Stratum 18			DD	122		Douglas-fir	
Stratum 18			DD	85		Juniper	
Stratum 18			DD	123		Douglas-fir	
Stratum 18			DD	84		Juniper	
Surface 1			DD	117		Juniper	
Surface 1			DD	103	579p / 650+vv	Ponderosa pine	79
Surface 1	68	Posthole	DD	136		Juniper	
Surface 1	85	Posthole	DD	135		Ponderosa pine	
Pitstructure 6							
Stratum 2			DD	110		Pinyon pine	
Stratum 2			DD	111		Pinyon pine	
Stratum 2			DD	119		Pinyon pine	
Stratum 2			DD	109		Juniper	
Stratum 2			DD	120	759 / 828vv	Pinyon pine	83
Stratum 2			DD	118	743fp / 798vv	Ponderosa pine	82
Stratum 2			DD	72		Juniper	
Stratum 2			DD	127		Juniper	
Stratum 2			DD	108		Juniper	
Surface 1	104	Hearth	AM	7	Used in Dolores Modification		
Pitstructure 7							
	473	Posthole	DD	1013		Juniper	
	473	Posthole	DD	1022		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 8 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 7 (continued)							
	474	Posthole	AM	66	Poor results		
	474	Posthole	DD	1023		Juniper	
	481	Posthole	DD	1018	392 / 598vv	Juniper	371
	522	Posthole	DD	1021	585 / 738+vv	Juniper	373
	1433	Posthole	DD	1027		Juniper	
	82	Bench	DD	1024		Juniper	
	82	Bench	DD	1025		Juniper	
Stratum 11			DD	1008	285± / 661++vv	Juniper	366
Stratum 11			DD	1017		Juniper	
Stratum 11			DD	1010	741 / 793vv	Pinyon pine	367
Stratum 11			DD	1012	741 / 802vv	Ponderosa pine	369
Stratum 11			DD	1009		Ponderosa pine	
Stratum 11			DD	1011		Juniper	
Stratum 12			DD	1020	689 / 735vv	Ponderosa pine	372
Stratum 12			DD	1007		Pinyon pine	
Level 2			DD	69		Pinyon pine	
Level 4			DD	130		Pinyon pine	
Surface 1			AM	50	760-785; 855-870		
Surface 1	479	Posthole	DD	1014		Juniper	
Pitstructure 8							
Level 8			DD	139		Juniper	
Pitstructure 9							
Surface 1	2054	Hearth	AM	106	700-750; 865-885		
Surface 1	157	Posthole	DD	143		Douglas-fir	
Pitstructure 10							
			AM	21	Used in Dolores Modification		
Stratum 4			DD	169		Ponderosa pine	
Stratum 4			DD	175		Ponderosa pine	
Stratum 4			DD	168		Ponderosa pine	
Stratum 4			DD	185		Ponderosa pine	
Stratum 4			DD	167		Ponderosa pine	
Stratum 4			DD	319		Ponderosa pine	
Stratum 4			DD	320		Ponderosa pine	
Stratum 4			DD	180		Juniper	
Stratum 4			DD	318		Ponderosa pine	
Stratum 4			DD	157		Ponderosa pine	
Stratum 4			DD	166		Ponderosa pine	
Stratum 4			DD	163		Populus	
Stratum 4			DD	171		Ponderosa pine	
Stratum 4			DD	251		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 9 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 10 (continued)							
Stratum 4			DD	173		Ponderosa pine	
Stratum 4			DD	172		Ponderosa pine	
Stratum 4			DD	181		Ponderosa pine	
Stratum 4			DD	176		Ponderosa pine	
Stratum 4			DD	158		Ponderosa pine	
Stratum 4			DD	177		Pinyon pine	
Stratum 4			DD	170		Ponderosa pine	
Stratum 4			DD	159		Ponderosa pine	
Stratum 4			DD	164		Ponderosa pine	
Stratum 4			DD	162		Ponderosa pine	
Stratum 4			DD	165		Ponderosa pine	
Surface 1			DD	182		Ponderosa pine	
Surface 1	178	Posthole	DD	184	692+fp / 867+r	Juniper	93
Surface 1	179	Posthole	DD	179		Juniper	
Surface 1	332	Posthole	DD	325	569p / 820vv	Juniper	305
Surface 1	332	Posthole	DD	340	582 / 856+r	Juniper	311
Pitstructure 11							
Surface 1	240	Hearth	AM	12	Not near curve		
Full cut			DD	343		Ponderosa pine	
Pitstructure 13							
	273	Other wall feature	AM	16	Not near curve		
Stratum 6			DD	2002		Douglas-fir	
Stratum 6			DD	229		Juniper	
Stratum 6			DD	2015		Ponderosa pine	
Stratum 6			DD	215		Juniper	
Stratum 6			DD	243		Douglas-fir	
Stratum 6			DD	223	632p / 794rB	Juniper	267
Stratum 6			DD	228		Ponderosa pine	
Stratum 6			DD	226		Ponderosa pine	
Stratum 6			DD	234		Juniper	
Stratum 6			DD	224		White fir	
Stratum 6			DD	2007		Juniper	
Stratum 6			DD	239		Ponderosa pine	
Stratum 6			DD	2012		Ponderosa pine	
Stratum 6			DD	2005		Ponderosa pine	
Stratum 6			DD	2010		Ponderosa pine	
Stratum 6			DD	2018		Juniper	
Stratum 6			DD	220		Juniper	
Stratum 6			DD	2001		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 10 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 13 (continued)							
Stratum 6			DD	2008		Juniper	
Stratum 6			DD	221		Ponderosa pine	
Stratum 6			DD	240		Ponderosa pine	
Stratum 6			DD	232		Ponderosa pine	
Stratum 6			DD	246		Juniper	
Stratum 6			DD	218	478fp / 570vv	Juniper	263
Stratum 6			DD	2014		Ponderosa pine	
Stratum 6			DD	233		Juniper	
Stratum 6			DD	2013	575 / 722+vv	Juniper	379
Stratum 6			DD	2004		Juniper	
Stratum 6			DD	225		White fir	
Stratum 6			DD	245		Juniper	
Stratum 6			DD	2011	738 / 797+vv	Ponderosa pine	378
Stratum 6			DD	2003		Ponderosa pine	
Stratum 6			DD	2006		Ponderosa pine	
Stratum 6			DD	222		Ponderosa pine	
Stratum 6			DD	227		Ponderosa pine	
Stratum 6			DD	2009		Juniper	
Surface 1			DD	2019		Ponderosa pine	
Surface 1			DD	2028		Ponderosa pine	
Surface 1			DD	2025		Juniper	
Surface 1			DD	2024	573+p / 766vv	Juniper	380
Surface 1			DD	2040		Ponderosa pine	
Surface 1			DD	2032		Pinyon pine	
Surface 1			DD	2035		Ponderosa pine	
Surface 1			DD	2033		Juniper	
Surface 1			DD	2027		Ponderosa pine	
Surface 1			DD	2039		Ponderosa pine	
Surface 1			DD	2037			
Surface 1			DD	2029		Douglas-fir	
Surface 1	256	Rectangular central pit	DD	330		Ponderosa pine	
Surface 1	644	Hearth	AM	24	pre-700-765; 860-935		
Surface 1	257	Posthole	DD	263	652+p / 795+vv	Juniper	287
Surface 1	258	Posthole	DD	253		Juniper	
Surface 1	259	Posthole	DD	254	446+p / 637vv	Juniper	282
Surface 1	261	Posthole	DD	256	732p / 850vv	Pinyon pine	283
Surface 1	262	Posthole	DD	268	572p / 712vv	Juniper	290
Surface 1	263	Posthole	DD	269		Juniper	
Surface 1	264	Posthole	DD	270	695fp / 761vv	Juniper	291
Surface 1	265	Posthole	DD	271		Juniper	
Surface 1	266	Posthole	DD	272		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 11 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 13 (continued)							
Surface 1	267	Posthole	DD	273	373 / 522vv	Juniper	294
Surface 1	284	Posthole	DD	267	436fp / 631+vv	Juniper	289
Surface 1	623	Posthole	DD	2036		Juniper	
Surface 1	624	Posthole	DD	2030		Juniper	
Surface 1	625	Posthole	DD	2042	640±p / 786+rG	Juniper	383
Surface 1	634	Posthole	DD	2041		Juniper	
Surface 1	635	Posthole	DD	2043		Juniper	
Surface 1	636	Posthole	DD	2044		Juniper	
Surface 1	637	Posthole	DD	2045		Juniper	
Surface 1	638	Posthole	DD	2048		Juniper	
Surface 1	639	Posthole	DD	2047		Juniper	
Surface 1	643	Posthole	DD	2046	518p / 745vv	Juniper	385
Surface 1	658	Posthole	DD	2049		Juniper	
Surface 2			AM	15	Used in Dolores Modification		
Pitstructure 14							
Stratum 2			DD	205	435fp / 551+vv	Juniper	260
Stratum 2			DD	206		Ponderosa pine	
Stratum 6			DD	283		Ponderosa pine	
Level 2			DD	335		Juniper	
Surface 1	1171	Hearth	AM	53	Poor results		
Surface 1	1076	Posthole	DD	2091		Juniper	
Surface 1	1156	Posthole	DD	2099		Juniper	
Surface 1	1194	Posthole	DD	2105		Juniper	
Surface 2	1511	Hearth	AM	52	Poor results		
Pitstructure 15							
Stratum 1			DD	214		Ponderosa pine	
Stratum 1			DD	242		Ponderosa pine	
Stratum 1			DD	241		Ponderosa pine	
Pitstructure 16							
Stratum 3			DD	264		Pinyon pine	
Stratum 3			DD	265		Pinyon pine	
Surface 1	296	Hearth	AM	18	pre-700-760; 865-950		
Surface 1	243	Posthole	DD	244		Ponderosa pine	
Surface 1	243	Posthole	DD	327		Juniper	
Surface 1	243	Posthole	DD	288		Pinyon pine	
Surface 1	268	Posthole	DD	328		Pinyon pine	
Surface 1	268	Posthole	DD	275	536fp / 595vv	Pinyon pine	295
Surface 1	268	Posthole	DD	322	545fp / 737vv	Pinyon pine	303
Surface 1	268	Posthole	DD	277	528+fp / 649vv	Pinyon pine	297
Surface 1	268	Posthole	DD	326		Pinyon pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 12 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Pitstructure 16 (continued)							
Surface 1	268	Posthole	DD	276	621fp / 786vv	Pinyon pine	296
Surface 1	268	Posthole	DD	250	657fp / 724+vv	Pinyon pine	279
Surface 1	268	Posthole	DD	338		Pinyon pine	
Surface 1	268	Posthole	DD	339	592fp / 740vv	Pinyon pine	310
Surface 1	268	Posthole	DD	278		Pinyon pine	
Pitstructure 17							
	1430	Ventilation system	DD	1026	737 / 782+vv	Ponderosa pine	375
Stratum 2			AM	19	Used in Dolores Modification		
Stratum 2			DD	1002		Juniper	
Stratum 2			DD	324	671p / 882++vv	Pinyon pine	304
Stratum 2			DD	323		Pinyon pine	
Stratum 2			DD	321		Douglas-fir	
Surface 1	1645	Hearth	AM	t67	940-1005(a); 700-735(b); 870-885(b)		
Surface 1	464	Posthole	DD	1005		Pinyon pine	
Pitstructure 18							
Surface 1	2307	Posthole	DD	317		Ponderosa pine	
Surface 1	2307	Posthole	DD	316		Ponderosa pine	
Surface 1	2307	Posthole	DD	315		Ponderosa pine	
Pitstructure 19							
Surface 1	380	Hearth	AM	20	860-940		
Pitstructure 20							
Surface 1			DD	2093		Ponderosa pine	
Surface 1	1095	Small floor cist	DD	2095	657 / 777+vv	Pinyon pine	394
Surface 1	1094	Posthole	DD	2092		Pinyon pine	
Pitstructure 23							
Surface 1	753	Posthole	DD	3002		Juniper	
Surface 1	755	Posthole	DD	3003		Juniper	
Pitstructure 27							
			AM	46	pre-700-750; 875-900		
	903	Posthole	DD	3017		Juniper	
Stratum 3			DD	3104	494 / 569+vv	Ponderosa pine	402
Stratum 3			DD	3021		Pinyon pine	
Stratum 3			DD	3106		Ponderosa pine	
Stratum 3			DD	3024		Ponderosa pine	
Stratum 3			DD	3022		Ponderosa pine	
Stratum 3			DD	3066		Douglas-fir	
Stratum 3			DD	3036		Douglas-fir	
Stratum 3			DD	3042		Douglas-fir	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 13 of 82)

Provenience: Site No. / Structure / Vertical subdivision	Feature No.	Feature Type	Sample Type	Sample No.	Dating results*	Tree-ring common name	DAR No.
5MT23							
Pitstructure 27 (continued)							
Stratum 3			DD	3063		Douglas-fir	
Stratum 3			DD	3023		Douglas-fir	
Stratum 3			DD	3043		Douglas-fir	
Stratum 3			DD	3071		Ponderosa pine	
Stratum 3			DD	3067		Douglas-fir	
Stratum 3			DD	3092		Ponderosa pine	
Stratum 3			DD	3105		Ponderosa pine	
Stratum 3			DD	3077		Douglas-fir	
Stratum 3			DD	3051		Douglas-fir	
Stratum 3			DD	3101		Ponderosa pine	
Stratum 3			DD	3087		Ponderosa pine	
Stratum 3			DD	3072		Populus	
Surface 1	900	Hearth	DD	3119		Ponderosa pine	
Surface 1	900	Hearth	DD	3118		Pinyon pine	
Surface 1	900	Hearth	AM	59	Poor results		
Surface 1	900	Hearth	AM	47	Poor results		
Surface 1	900	Hearth	DD	3120		Ponderosa pine	
Surface 1	904	Posthole	DD	3018		Ponderosa pine	
Surface 1	905	Posthole	DD	3020		Ponderosa pine	
Pitstructure 28							
Level 1			DD	3122		Pinyon pine	
Level 1			DD	3123		Ponderosa pine	
Surface 1			AM	56	700-775; 865-940		
Pitstructure 32							
			AM	73	885-900		
			AM	29	880-915		
	1721	Posthole	DD	3172	595 / 682vv	Ponderosa pine	426
	1722	Posthole	DD	3171		Juniper	
Level 2			DD	3158	636p / 724+vv	Ponderosa pine	421
Level 2			DD	3151		Douglas-fir	
Level 2			DD	3159		Ponderosa pine	
Level 2			DD	3152		Ponderosa pine	
Level 2			DD	3160		Ponderosa pine	
Level 2			DD	3155		Ponderosa pine	
Level 2			DD	3161		Ponderosa pine	
Level 2			DD	3153		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 14 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT23							
Pitstructure 32 (continued)							
Level 2			DD	3156		Ponderosa pine	
Level 2			DD	3154	804 / 877vv	Pinyon pine	420
Level 2			DD	3157		Ponderosa pine	
Surface 1			DD	3163		Ponderosa pine	
Surface 1			DD	3162		Ponderosa pine	
Surface 1			DD	3164		Ponderosa pine	
Surface 1	1657	Hearth	AM	69	pre-700-725		
Surface 1	987	Posthole	DD	2053		Juniper	
Surface 1	1658	Posthole	DD	3167	720 / 836+vv	Juniper	422
Surface 1	1659	Posthole	DD	3168	596±p / 836+vv	Juniper	423
Surface 1	1660	Posthole	DD	3166		Juniper	
Surface 1	1672	Posthole	DD	3169		Juniper	
Pitstructure 33							
Surface 2	1750	Hearth	AM	72	765-790; 845-865; 890-915		
Surface 2	669	Posthole	DD	2050		Populus	
Pitstructure 39							
Stratum 4			DD	3006	690 / 734vv	Juniper	396
Surface 1			AM	61	Not near curve		
Pitstructure 41							
			AM	58	Poor results		
Surface 1	789	Hearth	AM	57	Poor results		
Pitstructure 42							
	816	Wall cist	DD	3007		Ponderosa pine	
	816	Wall cist	DD	3008		Ponderosa pine	
Pitstructure 43							
	1277	Posthole	DD	3124		Juniper	
	1278	Posthole	DD	3125		Juniper	
	1279	Posthole	DD	3126		Juniper	
Level 1			DD	3132		Douglas-fir	
Level 1			DD	3148		Ponderosa pine	
Level 1			DD	3145		Ponderosa pine	
Level 1			DD	3134		Douglas-fir	
Level 1			DD	3143		Ponderosa pine	
Level 1			DD	3139		Ponderosa pine	
Level 1			DD	3142		Ponderosa pine	
Level 1			DD	3140		Ponderosa pine	
Level 1			DD	3137		Ponderosa pine	
Level 1			DD	3141		Ponderosa pine	
Level 1			DD	3138		Ponderosa pine	
Level 1			DD	3129	654±p / 856r	Juniper	408
Level 1			DD	3133		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 15 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT23							
Pitstructure 43 (continued)							
Level 1			DD	3128		Ponderosa pine	
Level 1			DD	3135		Ponderosa pine	
Level 1			DD	3131		Douglas-fir	
Level 1			DD	3147		Ponderosa pine	
Level 1			DD	3130		Ponderosa pine	
Level 1			DD	3136		Ponderosa pine	
Level 1			DD	3146	773 / 872v	Ponderosa pine	409
Level 1			DD	3144		Ponderosa pine	
Level 1			DD	3127	664p / 809++vv	Ponderosa pine	407
Pitstructure 44							
Surface 1			AM	t27	700-760; 925-1000		
Surface 1	843	Hearth	AM	28	935-975		
Pitstructure 45							
Level 1			DD	3015	675p / 736vv	Ponderosa pine	399
Surface 1	922	Hearth	AM	40	700-750; 925-1010		
Surface 1	839	Posthole	DD	3009		Ponderosa pine	
Surface 1	1248	Posthole	DD	3121	609 / 652vv	Ponderosa pine	405
Pitstructure 46							
Surface 1	861	Hearth	AM	26	700-760; 860-885		
Pitstructure 47							
Surface 1	484	Posthole	DD	1019		Ponderosa pine	
Pitstructure 48							
Surface 1	923	Hearth	AM	41	Poor results		
Pitstructure 49							
Surface 1	998	Hearth	AM	34	750-790; 850-920		
Pitstructure 50							
Surface 1	1160	Hearth	AM	55	775-790; 845-865		
Surface 1	1160	Hearth	DD	2102		Pinyon pine	
Surface 1	443	Posthole	DD	342		Juniper	
Surface 1	1029	Posthole	DD	2057		Ponderosa pine	
Pitstructure 51							
			AM	37	Poor results		
Stratum 5			DD	2084		Ponderosa pine	
Stratum 5			DD	2063		Ponderosa pine	
Stratum 5			DD	2085		Ponderosa pine	
Stratum 5			DD	2058		Ponderosa pine	
Stratum 5			DD	2074		Ponderosa pine	
Stratum 5			DD	2061		Ponderosa pine	
Stratum 5			DD	2079		Ponderosa pine	
Stratum 5			DD	2077		Ponderosa pine	
Stratum 5			DD	2082		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 16 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT23							
Pitstructure 51 (continued)							
Stratum 5			DD	2059	820 / 870vv	Ponderosa pine	389
Stratum 5			DD	2083		Ponderosa pine	
Stratum 5			DD	2070		Ponderosa pine	
Stratum 5			DD	2066		Ponderosa pine	
Stratum 5			DD	2065		Ponderosa pine	
Stratum 5			DD	2075		Ponderosa pine	
Stratum 5			DD	2069	799p / 865+r	Ponderosa pine	390
Stratum 5			DD	2080	733p / 811+vv	Ponderosa pine	392
Stratum 5			DD	2060		Ponderosa pine	
Stratum 5			DD	2081		Ponderosa pine	
Stratum 5			DD	2071		Ponderosa pine	
Stratum 5			DD	2076	725p / 864+vv	Pinyon pine	391
Stratum 5			DD	2067		Pinyon pine	
Stratum 5			DD	2073		Ponderosa pine	
Stratum 5			DD	2064		Ponderosa pine	
Stratum 5			DD	2062		Ponderosa pine	
Stratum 5			DD	2068		Ponderosa pine	
Stratum 5			DD	2078		Ponderosa pine	
Stratum 5			DD	2072		Ponderosa pine	
Surface 1			DD	2090		Ponderosa pine	
Surface 1			DD	2087		Juniper	
Surface 1			DD	2089		Ponderosa pine	
Surface 1			DD	2088		Ponderosa pine	
Surface 1			DD	2086		Ponderosa pine	
Surface 1	1066	Hearth	AM	36	pre-700-755; 865-940		
Pitstructure 52							
Level 1			DD	2096		Juniper	
Level 1			DD	2097		Juniper	
Surface 1	1173	Hearth	AM	49	Poor results		
Surface 1	1140	Posthole	DD	2098		Juniper	
Surface 1	1180	Posthole	DD	2103		Juniper	
Pitstructure 53							
Surface 1			DD	3016		Douglas-fir	
Surface 1			DD	3019		Ponderosa pine	
Surface 1	924	Hearth	AM	42	700-760; 860-885; 915-950		
Pitstructure 54							
Surface 1	1531	Hearth	AM	62	770-795; 835-865		
Pitstructure 55							
			AM	48	Poor results		
Level 1			DD	2104		Ponderosa pine	
Level 1			DD	2100		Douglas-fir	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 17 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23 (continued)							
Pitstructure 56							
Surface 1			DD	2106		Douglas-fir	
Surface 1	1522	Hearth	AM	54	Poor results		
Pitstructure 59							
	996	Posthole	DD	345		Juniper	
	204	Ventilation system	DD	212	730p / 804vv	Juniper	261
	204	Ventilation system	DD	211		Juniper	
	204	Ventilation system	DD	196	698fp / 834vv	Juniper	255
	204	Ventilation system	DD	341		Ponderosa pine	
	204	Ventilation system	DD	314		Juniper	
	204	Ventilation system	DD	210		Juniper	
	204	Ventilation system	DD	204		Juniper	
	204	Ventilation system	DD	213		Juniper	
	204	Ventilation system	DD	197	548p / 759vv	Juniper	256
	204	Ventilation system	DD	200		Pinyon pine	
Surface 1	995	Posthole	DD	2054		Juniper	
Surface 1	995	Posthole	DD	344		Juniper	
Surface 1	996	Posthole	DD	2055		Juniper	
Surface 1	1001	Posthole	DD	2056		Ponderosa pine	
Surface 1	1512	Posthole	DD	2107		Juniper	
Surface 1	1513	Posthole	DD	2108		Juniper	
Pitstructure 60							
Surface 1	1485	Hearth	AM	60	pre-700-750; 865-890; 915-950		
Pitstructure 61							
			AM	†103	940-1015		
Surface 1	2035	Hearth	AM	100	700-750; 865-885; 920-950		
Pitstructure 62							
Surface 1	2046	Hearth	AM	105	700-775; 860-925		
Pitstructure 64							
Surface 1	1840	Hearth	AM	74	850-865; 890-910		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 18 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT23 (continued)							
Pitstructure 65							
Surface 1	1772	Hearth	AM	79	700-750; 880-895		
Surface 1	1752	Posthole	DD	3176		Juniper	
Surface 1	1754	Posthole	DD	3177	720 / 791vv	Juniper	427
Surface 1	1784	Posthole	DD	3179		Juniper	
Pitstructure 66							
Surface 1	1948	Hearth	AM	89	pre-700-750; 865-885; 925-950		
Surface 1	1747	Posthole	DD	3174		Ponderosa pine	
Pitstructure 69							
Surface 1	1830	Hearth	AM	75	890-905		
Pitstructure 70							
	1871	Posthole	DD	3185		Juniper	
	1881	Posthole	DD	3186		Pinyon pine	
	1881	Posthole	DD	3187		Pinyon pine	
Stratum 6			DD	3190		Juniper	
Stratum 6			DD	3189		Juniper	
Stratum 6			DD	3198		Ponderosa pine	
Stratum 6			DD	3188		Juniper	
Stratum 6			DD	3192		Ponderosa pine	
Stratum 6			DD	3191		Ponderosa pine	
Stratum 6			DD	3194		Ponderosa pine	
Stratum 6			DD	3193		Ponderosa pine	
Stratum 6			DD	3200		Ponderosa pine	
Stratum 6			DD	3196		Juniper	
Stratum 6			DD	3195		Ponderosa pine	
Stratum 6			DD	3197	813 / 856v	Ponderosa pine	432
Surface 1			DD	3181		Ponderosa pine	
Surface 1			DD	3199		Ponderosa pine	
Surface 1			DD	3180		Ponderosa pine	
Surface 1			DD	3182		Juniper	
Surface 1			DD	3183		Ponderosa pine	
Surface 1	1884	Hearth	AM	90	855-910		
Surface 1	1869	Posthole	DD	3184		Juniper	
Surface 1	1898	Posthole	DD	3201		Ponderosa pine	
Surface 1	1903	Posthole	DD	3203		Ponderosa pine	
Surface 1	1903	Posthole	DD	3202		Ponderosa pine	
Pitstructure 71							
Surface 1	1847	Hearth	AM	76	725-775; 855-925		
Pitstructure 72							
Surface 1	1854	Hearth	AM	80	855-865; 890-915		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 19 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23 (continued)							
Pitstructure 74							
			AM	87	880-895		
Surface 1	1917	Hearth	AM	85	poss. pre-700		
Surface 1	1930	Hearth	AM	86	750-775; 855-870; 905-925		
Pitstructure 75							
			AM	†83	700-750; 865-910		
Surface 1	1895	Hearth	AM	84	700-750; 870-880; 930-950		
Pitstructure 76							
Surface 1	1935	Hearth	AM	88	780-790; 850-860		
Pitstructure 77							
Surface 1	1916	Hearth	AM	82	885-900		
Pitstructure 79							
Surface 1	1915	Hearth	AM	81	pre-700-750; 870-890		
Pitstructure 80							
	1966	Posthole	DD	3205		Ponderosa pine	
Surface 1	1978	Hearth	AM	93	Poor results		
Pitstructure 82							
Level 1			DD	3218		Ponderosa pine	
Level 1			DD	3211		Ponderosa pine	
Level 1			DD	3221		Ponderosa pine	
Level 1			DD	3215	720p / 768v	Pinyon pine	436
Level 1			DD	3206		Ponderosa pine	
Level 1			DD	3214		Ponderosa pine	
Level 1			DD	3213		Ponderosa pine	
Level 1			DD	3207		Ponderosa pine	
Level 1			DD	3209		Ponderosa pine	
Level 1			DD	3212	516±p / 767v	Juniper	435
Level 1			DD	3216		Ponderosa pine	
Level 1			DD	3219	734±p / 861vv	Juniper	437
Level 1			DD	3208		Ponderosa pine	
Level 1			DD	3210		Ponderosa pine	
Level 1			DD	3217		Ponderosa pine	
Surface 1	1986	Hearth	AM	92	700-775; 865-945		
Pitstructure 83							
Surface 1	2001	Hearth	AM	94	775-790; 850-860; 895-910		
Pitstructure 84							
Surface 1	2013	Hearth	AM	91	760-785; 850-865; 890-910		
Pitstructure 87							
Surface 1	2025	Fireplace	AM	99	730-765; 860-885; 910-935		
Pitstructure 90							
Surface 1	2043	Hearth	AM	102	765-785; 850-865; 895-925		
Surface 1	2018	Posthole	DD	3224	591±p / 754vv	Juniper	438

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 20 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23 (continued)							
Pitstructure 91							
			AM	†98	765-790; 850-870; 890-915		
Pitstructure 94							
			AM	†104	885-900		
Pitstructure 98							
Surface 1	2069	Posthole	DD	3225		Ponderosa pine	
Surface 1	2070	Posthole	DD	3226		Ponderosa pine	
Pitstructure 100							
Surface 1	2097	Posthole	DD	3228	619 / 689vv	Ponderosa pine	439
Pitstructure 106							
Surface 1	2123	Posthole	DD	3240		Juniper	
Pitstructure 110							
Surface 1	2023	Hearth	AM	95	700-750; 880-895		
Nonstructural Unit 2							
Stratum 6			DD	34		Ponderosa pine	
Nonstructural Unit 17							
Surface 1			DD	332		Pinyon pine	
Surface 1			DD	331		Juniper	
Surface 1	346	Posthole	DD	329		Juniper	
Nonstructural Unit 18							
Stratum 1			DD	186		Juniper	
Stratum 2			DD	193		Juniper	
Nonstructural Unit 19							
Surface 1	358	Posthole	DD	333		Pinyon pine	
Nonstructural Unit 26							
Surface 1	458	Pit feature	DD	1004		Pinyon pine	
Surface 1	458	Pit feature	DD	1003		Pinyon pine	
Nonstructural Unit 37							
Level 1			DD	3165		Ponderosa pine	
Excavation unit 2							
Level 4	3	Hearth	AM	1	Poor results		
Excavation unit 5							
Level 8			DD	46		Juniper	
Level 8			DD	47		Juniper/ *Populus*	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 21 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT23 (continued)							
Excavation unit 7							
Level 2			DD	42		Ponderosa pine	
Level 2			DD	41		Pinyon pine	
Level 4			DD	33		Juniper	
Level 5			DD	20		Ponderosa pine	
Level 5			DD	36		Pinyon pine	
Level 5			DD	38		Pinyon pine	
Level 5			DD	37		Pinyon pine	
Level 6			DD	71		Juniper	
Full cut			DD	1001		Ponderosa pine	
Excavation unit 9							
Stratum 11			DD	26		Ponderosa pine	
Level 1			DD	137		Ponderosa pine	
Excavation unit 12							
Stratum 1			DD	107		Ponderosa pine	
RDA 40							
Level 1			DD	87		Ponderosa pine	
Level 1			DD	91		Ponderosa pine	
Level 1			DD	89		Ponderosa pine	
Level 1			DD	92		Ponderosa pine	
Level 1			DD	88		Ponderosa pine	
Level 1			DD	90		Ponderosa pine	
Full cut			DD	44		Ponderosa pine	
RDA 41							
Full cut			DD	68		Juniper	
Grid square 274S/308E							
Stratum 3			DD	145		Ponderosa pine	
Grid square 276S/310E							
Stratum 3			DD	154		Pinyon pine	
Stratum 3			DD	132		Ponderosa pine	
Stratum 3			DD	156		Ponderosa pine	
Stratum 3			DD	152		Pinyon pine	
Stratum 3			DD	153		Ponderosa pine	
Stratum 3			DD	131		Ponderosa pine	
Grid square 278S/352E							
Stratum 2			DD	1		Juniper	
Grid square 284S/398E							
Stratum 5			DD	4		Ponderosa pine	
Stratum 5			DD	5		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 22 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT23							
Grid square 284S/398E (continued)							
Stratum 5			DD	3		Ponderosa pine	
Stratum 5			DD	6		Ponderosa pine	
Grid square 284S/400E							
Stratum 5			DD	7		Ponderosa pine	
Grid square 286S/284E							
Stratum 7	53	Posthole	DD	45		Juniper	
Stratum 3			DD	100		Ponderosa pine	
Stratum 3			DD	99		Pinyon pine	
Grid square 288S/394E							
Stratum 2			DD	140		Ponderosa pine	
Grid square 289S/398E							
Stratum 4	46	Posthole	DD	49		Ponderosa pine	
Grid square 297S/389E							
Stratum 5			DD	48		Ponderosa pine	
Grid square 300S/246E							
Stratum 3			DD	16		Pinyon pine	
Grid square 304S/324E							
Stratum 4			DD	133		Pinyon pine	
5MT2151							
Room 1							
Surface 1			AM	9	925-1010		
Room 3							
Stratum 1			DD	3		Ponderosa pine	
Room 10							
Surface 1			AM	2	Poor results		
Room 11			AM	12	925-1010		
Surface 2	78	Hearth	AM	11	Poor results		
Room 12							
Stratum 3			DD	26	557 / 702vv	Juniper	147
Stratum 3			DD	18		Pinyon pine	
Stratum 3			DD	19		Ponderosa pine	
Stratum 3			DD	20		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 23 of 82)

Provenience: Site No. / Structure / Vertical subdivision	Feature No.	Feature Type	Sample Type	Sample No.	Dating results*	Tree-ring common name	DAR No.
5MT2151 (continued)							
Pitstructure 1							
Stratum 3			DD	6		Pinyon pine	
Stratum 3			DD	13		Populus	
Stratum 3			DD	8		Populus/ nonconiferous	
Stratum 3			DD	14		Pinyon pine	
Stratum 3			DD	12		Populus	
Stratum 3			DD	11		Populus	
Stratum 3			DD	4		Populus	
Stratum 3			DD	10	609fp / 803+vv	Juniper	52
Stratum 7			DD	9		Pinyon pine	
Stratum 7			DD	5		Populus	
Stratum 8	38	Fireplace	AM	8	Poor results		
Stratum 12	34	Fireplace	AM	1	Poor results		
Stratum 12	34	Fireplace	AM	7	Poor results		
Surface 1	46	Hearth	AM	10	Poor results		
Surface 1	55	Posthole	DD	16		Nonconiferous	
Surface 1	64	Posthole	DD	17		Ponderosa pine	
Pitstructure 2							
Stratum 1			DD	22		Ponderosa pine	
Stratum 16			DD	21		Pinyon pine	
Surface 1			DD	25	562fp / 700++v	Pinyon pine	146
Surface 1			DD	24		Pinyon pine	
Surface 1			DD	23	407fp / 482vv	Pinyon pine	144
Surface 1	88	Hearth	AM	13	Used in Dolores Modification		
Nonstructural Unit 1							
Surface 1	25	Unburned pit	AM	5	Poor results		
Nonstructural Unit 3							
			AM	6	Poor results		
			AM	4	Poor results		
Surface 1			AM	3	Poor results		
Excavation unit 3							
Stratum 14			DD	2		Pinyon pine	
Stratum 2			DD	1		Ponderosa pine	
Full cut			DD	15		Ponderosa pine	
5MT2161							
Room 9							
Full cut			DD	20		Ponderosa pine	
Full cut			DD	21		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 24 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2161 (continued)							
Pitstructure 1							
Level 3			DD	23		Ponderosa pine	
Level 3			DD	26		Ponderosa pine	
Level 3			DD	19		Ponderosa pine	
Level 3			DD	22		Ponderosa pine	
Level 3			DD	18	821fp / 862vv	Ponderosa pine	166
Level 4			DD	27		Ponderosa pine	
Level 4			DD	30		Ponderosa pine	
Level 4			DD	29		Ponderosa pine	
Level 9			DD	2		Pinyon pine	
Surface 1	19	Hearth	AM	2	Poor results		
Surface 1	38	Wingwall	AM	4	Poor results		
Surface 1	38	Wingwall	DD	3		Ponderosa pine	
Pitstructure 2							
Stratum 8			DD	6		Ponderosa pine	
Level 2			DD	7		Ponderosa pine	
Level 3			DD	12		Ponderosa pine	
Level 3			DD	11		Ponderosa pine	
Level 3			DD	8		Ponderosa pine	
Level 3			DD	9		Ponderosa pine	
Level 3			DD	10		Ponderosa pine	
Level 7			DD	4			
Level 7			DD	5		Juniper	
Surface 1			DD	24		Ponderosa pine	
Surface 1			DD	16		Ponderosa pine	
Surface 1			DD	25		Ponderosa pine	
Surface 1			DD	14		Ponderosa pine	
Surface 1			DD	15		Ponderosa pine	
Surface 1	18	Hearth	AM	1	Poor results		
Surface 1	34	Wingwall	AM	3	Poor results		
Surface 1	20	Bin	DD	28		Ponderosa pine	
Excavation unit 2							
Stratum 3	1	Post	DD	1		Pinyon pine	
5MT2162							
Pitstructure 1							
Level 1			DD	6		Pinyon pine	
Level 1			DD	8		Populus	
Level 1			DD	2	289±p / 634+vv	Juniper	153
Level 1			DD	5		Douglas-fir	
Level 1			DD	7		Douglas-fir	
Level 1			DD	1	628p / 692vv	Douglas-fir	152
Level 1			DD	4	635p / 691vv	Douglas-fir	154
Level 1			DD	3		Douglas-fir	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 25 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2174							
Room 1							
Full cut			DD	1		Ponderosa pine	
5MT2181							
Pitstructure 1							
Stratum 1			DD	5		Ponderosa pine	
Stratum 1			DD	8		Ponderosa pine	
Stratum 1			DD	2		Ponderosa pine	
Stratum 1			DD	6		Ponderosa pine	
Stratum 1			DD	10		Ponderosa pine	
Stratum 1			DD	3	713p / 780v	Ponderosa pine	206
Stratum 1			DD	9		Ponderosa pine	
Stratum 1			DD	4		Ponderosa pine	
Stratum 1			DD	1	726p / 779vv	Ponderosa pine	205
Stratum 1			DD	7		Juniper	
Surface 1	5	Hearth	AM	1	Used in Dolores Modification		
Surface 1	11	Posthole	DD	11		Juniper	
5MT2182							
Room 3							
Surface 1			DD	40		Ponderosa pine	
Surface 1			DD	45		Ponderosa pine	
Surface 1			DD	46		Douglas-fir	
Surface 1			DD	47		White fir	
Surface 1			DD	48		Nonconiferous	
Surface 1	16	Hearth	AM	1	750-790; 840-870; 890-920		
Surface 2	39	Hearth	AM	2	850-930		
Room 6							
Surface 1	49	Posthole	DD	62		Ponderosa pine	
Room 202							
Surface 1	2043	Fireplace	AM	2003	pre-700-750; 865-890		
Room 205							
Level 1			DD	2003		Ponderosa pine	
Level 2			DD	2001		Ponderosa pine	
Surface 1			DD	2005		Ponderosa pine	
Surface 1			DD	2006		Ponderosa pine	
Surface 1			DD	2004		Ponderosa pine	
Surface 1			DD	2002		Ponderosa pine	
Surface 1	2012	Hearth	AM	2002	Poor results		
Surface 1	2011	Fireplace	AM	2001	Poor results		
Surface 1	2034	Posthole	DD	2008		Ponderosa pine	
			AM	3	Used in Dolores Modification		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 26 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2182 (continued)							
Pitstructure 1							
	7	Ventilation system	DD	53		Pinyon pine	
	7	Ventilation system	DD	54	734p / 793v	Pinyon pine	246
	7	Ventilation system	DD	60		Pinyon pine	
	7	Ventilation system	DD	61	724p / 793r	Pinyon pine	249
	7	Ventilation system	DD	52		Juniper	
	7	Ventilation system	DD	55		Juniper	
	7	Ventilation system	DD	51		Pinyon pine	
Stratum 3			DD	22		Ponderosa pine	
Stratum 3			DD	19		Ponderosa pine	
Stratum 7			DD	11	743p / 780r	Ponderosa pine	232
Stratum 7			DD	7	737p / 790r	Ponderosa pine	229
Stratum 7			DD	13		Ponderosa pine	
Stratum 7			DD	8	697p / 789vv	Ponderosa pine	230
Stratum 7			DD	16	694p / 790r	Ponderosa pine	234
Stratum 7			DD	5		Ponderosa pine	
Stratum 7			DD	14		Ponderosa pine	
Stratum 7			DD	6		Juniper	
Stratum 7			DD	17		Ponderosa pine	
Stratum 7			DD	12		Ponderosa pine	
Stratum 7			DD	15		Ponderosa pine	
Stratum 8			DD	33		Ponderosa pine	
Stratum 8			DD	25		Ponderosa pine	
Stratum 8			DD	59		Ponderosa pine	
Stratum 8			DD	31		Ponderosa pine	
Stratum 8			DD	26		Ponderosa pine	
Stratum 8			DD	29		Ponderosa pine	
Stratum 8			DD	32	736p / 790r	Ponderosa pine	238
Stratum 8			DD	30		Ponderosa pine	
Stratum 8			DD	49		Pinyon pine	
Stratum 8			DD	43		Ponderosa pine	
Stratum 8			DD	56		Ponderosa pine	
Stratum 8			DD	28		Ponderosa pine	
Stratum 8			DD	27		Ponderosa pine	
Stratum 8			DD	34		Ponderosa pine	
Stratum 8			DD	58		Ponderosa pine	
Stratum 8			DD	35		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 27 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2182							
Pitstructure 1 (continued)							
Stratum 8			DD	50		Ponderosa pine	
Stratum 8			DD	57		Ponderosa pine	
Level 2			DD	4		Ponderosa pine	
Level 2			DD	9		Pinyon pine	
Level 2			DD	24		Ponderosa pine	
Level 2			DD	23	734p / 780r	Ponderosa pine	237
Level 2			DD	20		Ponderosa pine	
Level 2			DD	10		Ponderosa pine	
Level 2			DD	21		Ponderosa pine	
Level 2			DD	18		Ponderosa pine	
Level 6			DD	2		Ponderosa pine	
Level 6			DD	3		Populus	
Level 6			DD	1	722p / 793vv	Pinyon pine	225
Surface 1			DD	44	740fp / 790r	Ponderosa pine	242
Surface 1			DD	42	716p / 790r	Ponderosa pine	241
Surface 1			DD	37		Ponderosa pine	
Surface 1			DD	38	735p / 781v	Ponderosa pine	239
Surface 1			DD	39		Ponderosa pine	
Surface 1			DD	41		Ponderosa pine	
Surface 1			DD	36		Ponderosa pine	
Surface 1	46	Posthole	DD	66		Ponderosa pine	
Surface 1	47	Posthole	DD	63		Juniper	
Surface 1	56	Posthole	DD	65		Juniper	
Surface 1	66	Posthole	DD	64		Ponderosa pine	
Pitstructure 2							
Surface 1	85	Hearth	AM	4	880-920		
Surface 1	103	Posthole	DD	67			
Pitstructure 102							
	1015	Posthole	DD	1000	714p / 760vv	Ponderosa pine	251
Level 3			DD	1001	503p / 593vv	Ponderosa pine	252
Level 3			DD	1002	706p / 776vv	Ponderosa pine	253
Pitstructure 106							
Level 11			DD	1008		Populus	
Level 11			DD	1011		Populus	
Level 11			DD	1010		Populus	
Pitstructure 107							
Surface 1	1039	Hearth	AM	1001	Poor results		
Pitstructure 201							
			AM	2004	Not near curve		
Stratum 1			DD	2013		Ponderosa pine	
Stratum 1			DD	2017		Ponderosa pine	
Stratum 1			DD	2043		Ponderosa pine	
Stratum 1			DD	2028		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 28 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2182							
Pitstructure 201 (continued)							
Stratum 1			DD	2046		Ponderosa pine	
Stratum 1			DD	2027		Ponderosa pine	
Stratum 1			DD	2022		Populus	
Stratum 1			DD	2014		Ponderosa pine	
Stratum 1			DD	2038		Pinyon pine	
Stratum 1			DD	2050		Ponderosa pine	
Stratum 1			DD	2015		Populus	
Stratum 1			DD	2040		Ponderosa pine	
Stratum 1			DD	2019		Ponderosa pine	
Stratum 1			DD	2009		Ponderosa pine	
Stratum 1			DD	2020		Ponderosa pine	
Stratum 1			DD	2036		Populus	
Stratum 1			DD	2031		Populus	
Surface 1			DD	2051	814p / 866rG	Ponderosa pine	415
Surface 1			DD	2054		Populus	
Surface 1	2086	Hearth	AM	2005	855-910		
Pitstructure 202							
Level 6			DD	2059		Populus	
Level 6			DD	2056		Populus	
Level 6			DD	2058		Populus	
Level 6			DD	2060		Populus	
Level 6			DD	2057		Populus	
Surface 1			DD	2061		Populus	
Nonstructural Unit 202							
Surface 1	2024	Posthole	DD	2007		Juniper	
5MT2191							
Room 1							
Surface 1	6	Hearth	AM	2	Poor results		
Grid square 140S/12E							
Surface 1	11	Fireplace	AM	1	1015-1075		
Grid square 160S/12E							
Surface 1	12	Slab lined pit	CF	3	1310 B.P. ± 70		
5MT2192							
Room 1							
Surface 1	33	Hearth	AM	4	pre-700		
Pitstructure 1							
Stratum 4			CF	1	1990 B.P. ± 160		
Surface 1			CF	3	1510 B.P ± 70		
Surface 1	13	Hearth	AM	1	Poor results		
Nonstructural Unit 2							
Surface 1	26	Hearth	AM	2	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 29 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2192 (continued)							
Nonstructural							
Unit 5							
Surface 1	7	Hearth	AM	3	Poor results		
5MT2193							
Room 1							
Surface 1			AM	2	Used in Dolores Modification		
Surface 1			AM	5	Poor results		
Room 2							
Surface 2	16	Fireplace	AM	1	pre-700-760; 920-1020		
Room 3							
Stratum 3			DD	13		Ponderosa pine	
Stratum 3			DD	12		Populus	
Surface 2			AM	3	Poor results		
Surface 3	131	Posthole	DD	16		Ponderosa pine	
Room 4							
Surface 3	129	Posthole	DD	14		Juniper	
Surface 3	129	Posthole	DD	17		Juniper	
Surface 3	129	Posthole	DD	15		Juniper	
Surface 3	129	Posthole	DD	18		Juniper	
Room 5							
Stratum 2			DD	6		Ponderosa pine	
Surface 1	11	Fireplace	AM	4	Poor results		
Surface 1	11	Fireplace	DD	177		Ponderosa pine	
Room 7							
Surface 1			DD	11		Juniper	
Surface 1			DD	8		Ponderosa pine	
Surface 1			DD	7		Ponderosa pine	
Pitstructure 1							
			AM	18	pre-700-775; 860-925		
Stratum 2			DD	140		Populus	
Stratum 2			DD	136		Populus	
Stratum 2			DD	36		Populus	
Stratum 2			DD	148		Ponderosa pine	
Stratum 2			DD	96		Populus	
Stratum 2			DD	132		Populus	
Stratum 2			DD	81		Populus	
Stratum 2			DD	105		Populus	
Stratum 2			DD	153		Ponderosa pine	
Stratum 2			DD	69		Populus	
Stratum 2			DD	145		Ponderosa pine	
Stratum 2			DD	50		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 30 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT2193							
Pitstructure 1 (continued)							
Stratum 2			DD	143		Populus	
Stratum 2			DD	41		Ponderosa pine	
Stratum 2			DD	110		Populus	
Stratum 2			DD	35		Populus	
Stratum 2			DD	131		Populus	
Stratum 2			DD	39		Populus	
Stratum 2			DD	101		Ponderosa pine	
Stratum 2			DD	22		Populus	
Stratum 2			DD	56		Populus	
Stratum 2			DD	33		Populus	
Stratum 2			DD	146		Ponderosa pine	
Stratum 2			DD	32		Ponderosa pine	
Stratum 2			DD	98		Ponderosa pine	
Stratum 2			DD	138		Ponderosa pine	
Stratum 2			DD	102		Ponderosa pine	
Stratum 2			DD	34		Populus	
Stratum 2			DD	40		Populus	
Stratum 2			DD	113		Ponderosa pine	
Stratum 2			DD	38		Ponderosa pine	
Stratum 2			DD	150		Ponderosa pine	
Stratum 2			DD	63		Ponderosa pine	
Stratum 2			DD	91		Ponderosa pine	
Stratum 2			DD	73		Populus	
Stratum 2			DD	139		Ponderosa pine	
Stratum 2			DD	43		Ponderosa pine	
Stratum 2			DD	97		Populus	
Stratum 2			DD	134		Ponderosa pine	
Stratum 2			DD	112		Ponderosa pine	
Stratum 2			DD	135		Ponderosa pine	
Stratum 2			DD	127		Populus	
Stratum 2			DD	128		Populus	
Stratum 2			DD	129		Populus	
Stratum 2			DD	51		Populus	
Stratum 2			DD	71		Ponderosa pine	
Stratum 2			DD	111		Populus	
Stratum 2			DD	72		Ponderosa pine	
Stratum 2			DD	107		Populus	
Stratum 2			DD	70		Ponderosa pine	
Stratum 2			DD	64		Populus	
Stratum 2			DD	158		Populus	
Stratum 2			DD	147		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 31 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2193							
Pitstructure 1 (continued)							
Stratum 2			DD	142		Ponderosa pine	
Stratum 2			DD	54		Ponderosa pine	
Stratum 2			DD	133		Populus	
Stratum 2			DD	108		Populus	
Stratum 2			DD	137		Ponderosa pine	
Stratum 2			DD	152		Populus	
Stratum 2			DD	55		Populus	
Stratum 2			DD	114		Ponderosa pine	
Stratum 2			DD	109		Populus	
Stratum 2			DD	90		Ponderosa pine	
Surface 1			DD	117		Ponderosa pine	
Surface 1			DD	116		Ponderosa pine	
Surface 1			DD	87		Ponderosa pine	
Surface 1			DD	125		Ponderosa pine	
Surface 1			DD	124		Ponderosa pine	
Surface 1			DD	99		Populus	
Surface 1			DD	84		Populus	
Surface 1			DD	66		Populus	
Surface 1			DD	100		Populus	
Surface 1			DD	95		Populus	
Surface 1			DD	79		Populus	
Surface 1			DD	65		Ponderosa pine	
Surface 1			DD	106		Ponderosa pine	
Surface 1			DD	149		Ponderosa pine	
Surface 1			DD	123		Ponderosa pine	
Surface 1			DD	122		Ponderosa pine	
Surface 1			DD	89		Ponderosa pine	
Surface 1			DD	103		Populus	
Surface 1			DD	68		Populus	
Surface 1			DD	37	641p / 737vv	Juniper	4
Surface 1			DD	67		Ponderosa pine	
Surface 1			DD	92		Populus	
Surface 1			DD	160	587p / 759vv	Juniper	17
Surface 1			DD	121		Ponderosa pine	
Surface 1			DD	141		Populus	
Surface 1			DD	88		Pinyon pine	
Surface 1			DD	86		Ponderosa pine	
Surface 1			DD	94		Populus	
Surface 1			DD	82		Ponderosa pine	
Surface 1	26	Hearth	AM	15	Poor results		
Surface 1	26	Hearth	AM	17	Poor results		
Surface 1	26	Hearth	AM	16	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 32 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2193 (continued)							
Pitstructure 2							
	58	Posthole	DD	226	676p / 770vv	Juniper	133
	59	Posthole	DD	217		Juniper	
	67	Posthole	DD	227		Juniper	
	68	Posthole	DD	228		Juniper	
	97	Posthole	DD	225		Juniper	
	74	Bench	AM	21	Poor results		
	75	Ventilation system	DD	188		Populus	
	75	Ventilation system	DD	187		Populus	
	75	Ventilation system	DD	202		Populus	
	75	Ventilation system	DD	207		Populus	
	75	Ventilation system	DD	206		Populus	
	75	Ventilation system	DD	198		Populus	
	75	Ventilation system	DD	199		Populus	
	75	Ventilation system	DD	205		Populus	
Stratum 1			DD	28		Ponderosa pine	
Stratum 1			DD	31		Juniper	
Stratum 1			DD	26		Ponderosa pine	
Stratum 1			DD	130	660p / 732vv	Juniper	36
Stratum 1			DD	29		Ponderosa pine	
Stratum 1			DD	23		Ponderosa pine	
Stratum 1			DD	24		Ponderosa pine	
Stratum 1			DD	27		Ponderosa pine	
Stratum 1			DD	44		Ponderosa pine	
Stratum 1			DD	30		Ponderosa pine	
Stratum 1			DD	25		Ponderosa pine	
Stratum 1			DD	52	676±p / 764vv	Juniper	19
Stratum 1			DD	45		Ponderosa pine	
Stratum 2			DD	119	721fp / 768vv	Ponderosa pine	39
Stratum 2			DD	167		Populus	
Stratum 2			DD	120	714p / 766vv	Ponderosa pine	3
Stratum 2			DD	204	714p / 767vv	Ponderosa pine	126
Stratum 2			DD	203		Ponderosa pine	
Stratum 2			DD	201		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 33 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT2193							
Pitstructure 2 (continued)							
Stratum 2			DD	126		Ponderosa pine	
Stratum 2			DD	197		Ponderosa pine	
Stratum 2			DD	219		Ponderosa pine	
Stratum 2			DD	42		Ponderosa pine	
Stratum 2			DD	118		Juniper	
Stratum 2			DD	218		Ponderosa pine	
Stratum 2			DD	104	641±p / 769vv	Juniper	35
Stratum 2			DD	163		Ponderosa pine	
Stratum 2			DD	200		Ponderosa pine	
Stratum 2			DD	170		Ponderosa pine	
Level 3			DD	181		Ponderosa pine	
Level 3			DD	49	730fp / 769v	Ponderosa pine	28
Level 3			DD	62		Juniper	
Level 3			DD	20		Ponderosa pine	
Level 3			DD	164		Ponderosa pine	
Level 3			DD	85		Ponderosa pine	
Level 3			DD	151		Ponderosa pine	
Level 3			DD	183		Ponderosa pine	
Level 3			DD	179		Juniper	
Level 3			DD	78	702±p / 766vv	Juniper	32
Level 3			DD	77		Ponderosa pine	
Level 3			DD	173		Ponderosa pine	
Level 3			DD	83	720p / 769vv	Ponderosa pine	30
Level 3			DD	166	724p / 768vv	Ponderosa pine	18
Level 3			DD	184		Ponderosa pine	
Level 3			DD	74		Ponderosa pine	
Level 3			DD	180		Ponderosa pine	
Level 3			DD	47	670p / 759vv	Juniper	31
Level 3			DD	182		Juniper	
Level 3			DD	178		Ponderosa pine	
Level 3			DD	46		Ponderosa pine	
Level 3			DD	162		Ponderosa pine	
Level 3			DD	165		Ponderosa pine	
Level 3			DD	169		Ponderosa pine	
Level 3			DD	53		Juniper	
Level 3			DD	185		Nonconiferous	
Level 3			DD	175		Ponderosa pine	
Level 3			DD	171	731p / 763vv	Ponderosa pine	20
Level 3			DD	75		Ponderosa pine	
Level 3			DD	21		Ponderosa pine	
Level 3			DD	156		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 34 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2193							
Pitstructure 2 (continued)							
Level 3			DD	58		Juniper	
Level 3			DD	144		Ponderosa pine	
Level 3			DD	155		Ponderosa pine	
Level 3			DD	176		Ponderosa pine	
Level 3			DD	48	721p / 769vv	Ponderosa pine	25
Level 3			DD	154		Ponderosa pine	
Level 3			DD	19		Populus	
Level 3			DD	186		Ponderosa pine	
Level 3			DD	159		Ponderosa pine	
Level 3			DD	60	707±p / 765vv	Juniper	34
Level 3			DD	61	711p / 765vv	Juniper	33
Level 3			DD	76	705p / 769vv	Ponderosa pine	22
Level 3			DD	157		Ponderosa pine	
Level 3			DD	174		Ponderosa pine	
Level 3			DD	172		Ponderosa pine	
Level 3			DD	191		Populus	
Level 3			DD	161	706p / 742vv	Ponderosa pine	29
Level 3			DD	80		Ponderosa pine	
Level 3			DD	168	718p / 765vv	Ponderosa pine	24
Surface 1			DD	214		Ponderosa pine	
Surface 1			DD	209		Ponderosa pine	
Surface 1			DD	189		Populus	
Surface 1			DD	213	724p / 769v	Ponderosa pine	130
Surface 1			DD	211		Ponderosa pine	
Surface 1			DD	212	732fp / 769v	Ponderosa pine	129
Surface 1			DD	59		Populus	
Surface 1			DD	190		Ponderosa pine	
Surface 1			DD	220		Ponderosa pine	
Surface 1			DD	221		Ponderosa pine	
Surface 1			DD	208	724p / 769vv	Ponderosa pine	127
Surface 1			DD	210	735p / 765vv	Ponderosa pine	128
Surface 1			AM	22	Poor results		
Surface 1			DD	192		Ponderosa pine	
Surface 1			DD	194		Ponderosa pine	
Surface 1			DD	193		Juniper	
Surface 1			DD	216		Ponderosa pine	
Surface 1			DD	57		Populus	
Surface 1			DD	196		Ponderosa pine	
Surface 1			DD	195		Ponderosa pine	
Surface 1			DD	215		Ponderosa pine	
Surface 1	84	Hearth	AM	20	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 35 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2193							
Pitstructure 2 (continued)							
Surface 1	89	Posthole	DD	223		Juniper	
Surface 1	89	Posthole	DD	224		Juniper	
Surface 1	89	Posthole	DD	222		Juniper	
Nonstructural Unit 5							
Surface 1			DD	5		Populus	
Surface 1	132	Posthole	DD	10		Juniper	
Surface 1	132	Posthole	DD	9		Juniper	
Nonstructural Unit 8							
Surface 1	7	Fireplace	AM	6	Poor results		
Nonstructural Unit 12							
Surface 1	83	Fireplace	AM	19	Poor results		
Grid square 122S/164E							
Level 1			DD	1		Ponderosa pine	
Level 1			DD	2		Ponderosa pine	
Level 1			DD	3		Ponderosa pine	
Level 1			DD	4		Ponderosa pine	
5MT2194							
Pitstructure 1							
Surface 1	24	Hearth	AM	1	Poor results		
5MT2198							
Pitstructure 1							
Stratum 1			DD	12		Juniper	
Stratum 1			DD	9	496fp / 550vv	Juniper	57
Stratum 1			DD	10		Juniper	
Stratum 1			DD	11		Juniper	
Stratum 1			DD	13		Juniper	
Stratum 2			DD	16		Nonconiferous	
Surface 1			DD	14		Nonconiferous	
Surface 1			DD	15		Nonconiferous	
Surface 1	8	Hearth	AM	2	925-1015; 1250-post-1425		
Pitstructure 2							
Full cut			DD	4		Pinyon pine	
Full cut			DD	7		Populus	
Full cut			DD	6		Juniper	
Full cut			DD	1		Juniper	
Full cut			DD	8	528p / 634vv	Juniper	58
Full cut			DD	3	581fp / 655vv	Juniper	56

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 36 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2198							
Pitstructure 2 (continued)							
Full cut			DD	2		Juniper	
Full cut			DD	5		Juniper	
Nonstructural Unit 2							
Surface 1	2	Fireplace	AM	1	pre-700		
5MT2199							
Grid square 80S/58E							
Surface 1	3	Hearth	AM	1	Poor results		
Grid square 300S/42E							
Surface 1	2	Burned pit	CF	1	5680 B.P. ± 2350		
5MT2203							
Nonstructural Unit 2							
Surface 1	3	Burned pit	AM	1	Poor results		
5MT2215							
Room 1							
Surface 1	1	Burned pit	AM	1	Poor results		
5MT2226							
Room 1							
Surface 1	1	Posthole	DD	1		Ponderosa pine	
Pitstructure 1							
Surface 1	28	Hearth	AM	1	Poor results		
Surface 1	14	Posthole	DD	3		Pinyon pine	
Surface 1	17	Posthole	DD	2		Ponderosa pine	
5MT2235							
Pitstructure 1							
Stratum 1			CF	2	1545 B.P. ± 170		
Stratum 2			DD	1	912fp / 1102vv	Juniper	60
Stratum 3	10	Hearth	AM	3	1000-1350		
Surface 2	11	Hearth	DD	5	909fp/ 988+vv	Juniper	59
Surface 2	11	Hearth	AM	4	1010-1050		
Surface 2	11	Hearth	CF	6	1065 B.P ± 100		
Surface 2	11	Hearth	DD	6		Juniper	
Surface 2	28	Human burial	DD	3		Juniper	
Full cut			DD	4		Juniper	
Full cut			DD	2		Pinyon pine	
Excavation unit 6							
Full cut	8	Hearth	AM	1	1000-1025; 1300-post-1425		
Grid square 140S/02E							
Level 2	5	Hearth	CF	1	1145 B.P. ± 65		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 37 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2235 (continued)							
Grid square 140S/16E							
Level 2	7	Hearth	AM	2	Poor results		
5MT2236							
Pitstructure 1							
Surface 1			DD	14	718 / 762vv	Ponderosa pine	138
Surface 1			DD	5		Ponderosa pine	
Surface 1			DD	13		Ponderosa pine	
Surface 1			DD	15	720p / 762v	Ponderosa pine	139
Surface 1			DD	3		Ponderosa pine	
Surface 1			DD	7		Ponderosa pine	
Surface 1			DD	2		Ponderosa pine	
Surface 1			DD	12		Ponderosa pine	
Surface 1			DD	16		Ponderosa pine	
Surface 1			DD	9	725 / 760vv	Ponderosa pine	137
Surface 1			DD	17	729p / 765vv	Ponderosa pine	140
Surface 1			DD	6	722p / 765r	Ponderosa pine	135
Surface 1			DD	4		Ponderosa pine	
Surface 1			DD	11		Ponderosa pine	
Surface 1			DD	19	728p / 758vv	Ponderosa pine	142
Surface 1			DD	8		Ponderosa pine	
Surface 1			DD	1	727p / 765vv	Ponderosa pine	134
Surface 1			DD	10		Ponderosa pine	
Surface 1			DD	18	728p / 761vv	Ponderosa pine	141
Surface 1	5	Hearth	AM	2	Used in Dolores Modification		
Grid square 160S/74E							
Surface 1	4	Fireplace	AM	1	1010-1050		
5MT2241							
Nonstructural							
Unit 2							
Surface 1	1	Hearth	CF	1	690 B.P. ± 50		
5MT2242							
Grid square 140S/34E							
Surface 1	3	Hearth	CF	1	3710 B.P. ± 90		
5MT2320							
Room 8							
Surface 1	31	Hearth	AM	5	Poor results		
Pitstructure 1							
Surface 1	3	Hearth	AM	1	Used in Dolores Modification		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 38 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2320 (continued)							
Pitstructure 2							
			AM	3	790-850		
Surface 1	50	Hearth	AM	4	880-915		
Surface 1	50	Hearth	AM	2	Poor results		
Pitstructure 3							
			AM	6	770-790; 830-860		
Surface 1	58	Posthole	DD	1		Ponderosa pine	
Pitstructure 4							
Stratum 3			DD	12		Ponderosa pine	
Stratum 3			DD	3		Ponderosa pine	
Stratum 3			DD	7		Ponderosa pine	
Stratum 3			DD	8		Ponderosa pine	
Stratum 3			DD	2		Ponderosa pine	
Stratum 3			DD	9		Ponderosa pine	
Stratum 3			DD	10		Ponderosa pine	
Stratum 3			DD	11		Ponderosa pine	
Surface 1	113	Hearth	AM	7	780-790; 890-910; 850-860		
5MT2336							
Room 2							
Surface 1	23	Posthole	DD	3		Pinyon pine	
Room 5							
Surface 1	26	Posthole	DD	4		Ponderosa pine	
Room 9							
Surface 1	46	Posthole	DD	5		Ponderosa pine	
Pitstructure 1							
Surface 1			DD	1		Ponderosa pine	
Surface 1			DD	2		Ponderosa pine	
Surface 1	65	Unburned pit	AM	1	860-950		
Pitstructure 2							
Surface 1	99	Small floor cist	DD	6		Ponderosa pine	
Surface 1	99	Small floor cist	DD	7		Ponderosa pine	
Surface 1	99	Small floor cist	DD	8		Ponderosa pine	
Pitstructure 5							
Surface 1			DD	9		Pinyon pine	
Surface 1			DD	10		Pinyon pine	
Nonstructural Unit 5							
Surface 1	42	Hearth	AM	2	Poor results		
5MT2378							
Pitstructure 1							
Surface 1	9	Hearth	AM	1	pre-700-735		
Pitstructure 2							
Surface 1	6	Hearth	AM	2	pre-700		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 39 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2378 (continued)							
Nonstructural							
Unit 1							
Surface 1	44	Posthole	DD	1		Juniper	
5MT2729							
Pitstructure 1							
Surface 1	7	Hearth	AM	1	1005-1030; 1250-1350		
Surface 1	9	Warming pit	AM	2	1000-1030; 1275-1350		
5MT2731							
Room 1							
Surface 1	7	Fireplace	CF	11	2650 B.P. ± 70		
Full cut			CF	10	2830 B.P. ± 50		
Nonstructural							
Unit 1							
Level 1	2	Fireplace	AM	2	Poor results		
Level 1	2	Fireplace	CF	3	1250 B.P. ± 60		
Level 1	1	Slab lined pit	CF	1	1630 B.P. ± 70		
Level 1	1	Slab lined pit	AM	1	Poor results		
Grid square 300S/300E							
Surface 1			CF	2	3340 B.P. ± 180		
5MT2848							
Pitstructure 1							
Level 2			DD	8		Juniper	
Level 2			DD	5		Juniper	
Level 2			DD	2		Ponderosa pine	
Level 2			DD	7	693p / 784r	Juniper	156
Level 2			DD	4		Ponderosa pine	
Level 2			DD	1		Ponderosa pine	
Level 2			DD	6		Ponderosa pine	
Level 2			DD	3		Ponderosa pine	
Level 2			DD	36		Populus	
Level 2			DD	37		Ponderosa pine	
Level 2			DD	34	717p / 783vv	Ponderosa pine	172
Level 2			DD	35		Populus	
Level 2			DD	38		Ponderosa pine	
Level 2			DD	33		Ponderosa pine	
Level 2			DD	39		Ponderosa pine	
Surface 1			AM	2	Used in Dolores Modification		
Surface 1	9	Hearth	AM	3	760-790; 840-870; 885-915		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 40 of 82)

Provenience: Site No. / Structure / Vertical subdivision	Feature No.	Feature Type	Sample Type	Sample No.	Dating results*	Tree-ring common name	DAR No.
5MT2848 (continued)							
Pitstructure 2							
	26	Bench	DD	47	622p / 685v	Ponderosa pine	312
Level 1			DD	41		Juniper	
Level 1			DD	40	468±p / 635vv	Juniper	173
Level 1			DD	43		Juniper	
Level 1			DD	42		Juniper	
Level 1			DD	44		Juniper	
Surface 1			DD	23		Ponderosa pine	
Surface 1			DD	19		Populus	
Surface 1			DD	25		Ponderosa pine	
Surface 1			DD	21		Populus	
Surface 1			DD	27		Populus	
Surface 1			DD	24		Ponderosa pine	
Surface 1			DD	29		Populus	
Surface 1			DD	22		Populus	
Surface 1			DD	31		Populus	
Surface 1			DD	9		Populus	
Surface 1			DD	45		Ponderosa pine	
Surface 1			DD	26		Ponderosa pine	
Surface 1			DD	16		Populus	
Surface 1			DD	28		Populus	
Surface 1			DD	50		Populus	
Surface 1			DD	30		Populus	
Surface 1			DD	48		Populus	
Surface 1			DD	46		Ponderosa pine	
Surface 1			DD	14		Populus	
Surface 1			DD	32	370 617vv	Juniper	158
Surface 1			DD	10		Ponderosa pine	
Surface 1			DD	13		Populus	
Surface 1			DD	12		Populus	
Surface 1			DD	49		Populus	
Surface 1			DD	11		Ponderosa pine	
Surface 1			DD	15		Ponderosa pine	
Surface 1			DD	20		Ponderosa pine	
Surface 1			DD	17	632p / 684v	Ponderosa pine	157
Surface 1			DD	18		Populus	
Grid square 260S/28E							
Surface 1	3	Hearth	AM	1	pre-700-750; 920-1010		
5MT2853							
Pitstructure 2							
Surface 1	5	Hearth	AM	1	775-790; 840-860		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 41 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT2854							
Pitstructure 1							
Stratum 7			CF	3	1620 B.P. ± 60		
Pitstructure 2							
	79	Ventilation system	DD	4		Ponderosa pine	
Surface 2	17	Hearth	AM	2	pre-700-750; 870-890		
Surface 2	44	Posthole	DD	2		Ponderosa pine	
Pitstructure 3							
Surface 3	12	Posthole	DD	1		Pinyon pine	
Surface 3	65	Posthole	CF	7	1680 B.P. ± 60		
Surface 3	65	Posthole	DD	3		Pinyon pine	
Nonstructural Unit 1							
Surface 1	2	Hearth	AM	1	950-1020; 1325-post-1425		
Surface 1	92	Burned pit	AM	3	Poor results		
Surface 1	93	Burned pit	AM	4	Poor results		
5MT2858							
Pitstructure 1							
Surface 1			AM	3	Poor results		
Surface 1			CF	5	1661 B.P. ± 60		
Surface 1	2	Hearth	AM	2	pre-700-750; 865-890		
Pitstructure 2							
Surface 1	33	Hearth	AM	4	Poor results		
Full cut			CF	6	2000 B.P. ± 60		
Nonstructural Unit 1							
Surface 1	1	Hearth	AM	1	pre-700-750; 865-890; 910-950		
5MT4475							
Room 1							
Surface 3	17	Hearth	AM	6	Poor results		
Room 7							
Surface 1	9	Fireplace	AM	11	950-1050; 1125-post-1425		
Surface 1	15	Fireplace	AM	12	Poor results		
Room 10							
Stratum 3			DD	319		Ponderosa pine	
Stratum 3			DD	315		Ponderosa pine	
Stratum 3			DD	317		Ponderosa pine	
Stratum 3			DD	320		Ponderosa pine	
Stratum 3			DD	314		Ponderosa pine	
Stratum 3			DD	318		Ponderosa pine	
Stratum 3			DD	316		Ponderosa pine	
Surface 1	14	Fireplace	AM	10	pre-700-775; 865-930		
Surface 1	13	Bin	DD	64		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 42 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Room 10 (continued)							
Surface 1	10	Storage Bin	DD	65	822p / 862v	Ponderosa pine	45
Surface 3	508	Bin	DD	301		Ponderosa pine	
Surface 3	508	Bin	DD	300	832 / 875+vv	Ponderosa pine	348
Surface 3	508	Bin	DD	299		Ponderosa pine	
Surface 3	508	Bin	DD	295		Populus	
Full cut			DD	43		Ponderosa pine	
Full cut			DD	46		Populus	
Full cut			DD	49		Ponderosa pine	
Full cut			DD	44			
Full cut			DD	45		Ponderosa pine	
Full cut			DD	42		Ponderosa pine	
Room 59							
Stratum 3			DD	242		Ponderosa pine	
Stratum 3			DD	243		Ponderosa pine	
Stratum 3			DD	240		Ponderosa pine	
Stratum 3			DD	241		Ponderosa pine	
Stratum 3			DD	244		Ponderosa pine	
Surface 1			DD	245		Ponderosa pine	
Room 61							
Level 1			DD	24		Ponderosa pine	
Level 1			DD	4		Ponderosa pine	
Level 1			DD	22		Ponderosa pine	
Level 1			DD	23		Ponderosa pine	
Level 1			DD	6		Ponderosa pine	
Level 1			DD	21	812p / 879v	Ponderosa pine	43
Level 1			DD	3		Ponderosa pine	
Level 1			DD	5	837p / 877v	Ponderosa pine	42
Level 1			DD	25		Ponderosa pine	
Surface 1			DD	247		Ponderosa pine	
Room 63							
Level 1	16	Hearth	AM	7	Poor results		
Room 66							
Surface 1			DD	30		Ponderosa pine	
Surface 1			DD	31		Ponderosa pine	
Surface 1			DD	20		Ponderosa pine	
Surface 1			DD	29		Pinyon pine	
Room 67							
Level 2			DD	69		Ponderosa pine	
Level 3			DD	74		Ponderosa pine	
Level 3			DD	73		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 43 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Room 74							
Surface 1	601	Bin	AM	22	Not near curve		
Room 77							
Stratum 2			DD	555		Douglas-fir	
Room 79							
Stratum 1			DD	554		Ponderosa pine	
Stratum 1			DD	569		Ponderosa pine	
Stratum 1			DD	564		Ponderosa pine	
Stratum 1			DD	565		Ponderosa pine	
Stratum 1			DD	566		Ponderosa pine	
Stratum 1			DD	563		Ponderosa pine	
Room 81							
Stratum 1			DD	539	830 / 875+vv	Ponderosa pine	361
Stratum 1			DD	552	819 / 874r	Ponderosa pine	363
Stratum 1			DD	535		Ponderosa pine	
Stratum 1			DD	536		Ponderosa pine	
Stratum 1			DD	559		Ponderosa pine	
Stratum 1			DD	560		Ponderosa pine	
Stratum 1			DD	557		Ponderosa pine	
Stratum 1			DD	558		Ponderosa pine	
Stratum 1			DD	561	820p / 861vv	Ponderosa pine	364
Surface 1			DD	553		Populus	
Surface 1			DD	562		Ponderosa pine	
Room 83							
Stratum 1			DD	567		Ponderosa pine	
Pitstructure 1							
			AM	4	1000-1060; 1100-1425		
	39	Bench	DD	101		Juniper	
Stratum 3			DD	54		Populus	
Stratum 3			DD	34		Populus	
Stratum 3			DD	63		Populus	
Stratum 3			DD	12		Populus	
Stratum 3			DD	7		Populus	
Stratum 3			DD	16		Populus	
Stratum 3			DD	59		Populus	
Stratum 3			DD	10		Populus	
Stratum 3			DD	50		Populus	
Stratum 3			DD	62		Populus	
Stratum 3			DD	9		Populus	
Stratum 3			DD	41		Populus	
Stratum 3			DD	60		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 44 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 1 (continued)							
Stratum 3			DD	39		Populus	
Stratum 3			DD	2		Populus	
Stratum 3			DD	18		Populus	
Stratum 3			DD	33		Populus	
Stratum 3			DD	36		Populus	
Stratum 3			DD	40		Populus	
Stratum 3			DD	14		Populus	
Stratum 3			DD	11		Populus	
Stratum 3			DD	57		Populus	
Stratum 3			DD	28		Populus	
Stratum 3			DD	8		Populus	
Stratum 3			DD	17		Populus	
Stratum 3			DD	35		Populus	
Stratum 3			DD	15		Populus	
Stratum 3			DD	19		Populus	
Stratum 3			DD	37		Populus	
Stratum 3			DD	51		Populus	
Stratum 3			DD	27		Populus	
Stratum 3			DD	53		Populus	
Stratum 3			DD	56		Populus	
Stratum 3			DD	55		Populus	
Stratum 3			DD	58		Populus	
Stratum 3			DD	13		Populus	
Stratum 3			DD	52		Ponderosa pine	
Stratum 3			DD	26		Populus	
Stratum 3			DD	61		Populus	
Stratum 3			DD	32		Populus	
Level 2			DD	48		Populus	
Level 2			DD	38		Juniper	
Level 2			DD	47		Populus	
Surface 1	24	Hearth	AM	1	1000-1050		
Pitstructure 2							
			AM	5	775-800; 835-865; 885-915		
Pitstructure 3							
			AM	3	700-770; 860-925		
			AM	2	Poor results		
	154	Bench	AM	18	Used in Dolores Modification		
	154	Bench	DD	213		Ponderosa pine	
	155	Ventilation system	DD	237		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 45 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 3 (continued)							
	155	Ventilation system	DD	238		Ponderosa pine	
Stratum 3			DD	113		Ponderosa pine	
Stratum 3			DD	135		Ponderosa pine	
Stratum 3			DD	174		Ponderosa pine	
Stratum 3			DD	120		Ponderosa pine	
Stratum 3			DD	194		Ponderosa pine	
Stratum 3			DD	127		Ponderosa pine	
Stratum 3			DD	152			
Stratum 3			DD	119		Ponderosa pine	
Stratum 3			DD	203		Ponderosa pine	
Stratum 3			DD	134	786 / 875v	Douglas-fir	186
Stratum 3			DD	192		Ponderosa pine	
Stratum 3			DD	130		Ponderosa pine	
Stratum 3			DD	180		Ponderosa pine	
Stratum 3			DD	110		Ponderosa pine	
Stratum 3			DD	163		Ponderosa pine	
Stratum 3			DD	177		Douglas-fir	
Stratum 3			DD	176	564p / 685vv	Ponderosa pine	190
Stratum 3			DD	124		Ponderosa pine	
Stratum 3			DD	181		Ponderosa pine	
Stratum 3			DD	164	836fp / 874vv	Ponderosa pine	189
Stratum 3			DD	139		Ponderosa pine	
Stratum 3			DD	118		Ponderosa pine	
Stratum 3			DD	148		Ponderosa pine	
Stratum 3			DD	173		Ponderosa pine	
Stratum 3			DD	132		Ponderosa pine	
Stratum 3			DD	143		Ponderosa pine	
Stratum 3			DD	117		Ponderosa pine	
Stratum 3			DD	183		Ponderosa pine	
Stratum 3			DD	186		Ponderosa pine	
Stratum 3			DD	202		Ponderosa pine	
Stratum 3			DD	188		Ponderosa pine	
Stratum 3			DD	179		Ponderosa pine	
Stratum 3			DD	137		Ponderosa pine	
Stratum 3			DD	168		Ponderosa pine	
Stratum 3			DD	204		Ponderosa pine	
Stratum 3			DD	125		Ponderosa pine	
Stratum 3			DD	153		Ponderosa pine	
Stratum 3			DD	208		Ponderosa pine	
Stratum 3			DD	146	806fp / 874r	Ponderosa pine	187

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 46 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4475							
Pitstructure 3 (continued)							
Stratum 3			DD	205		Ponderosa pine	
Stratum 3			DD	151		Ponderosa pine	
Stratum 3			DD	122		Ponderosa pine	
Stratum 3			DD	182		Ponderosa pine	
Stratum 3			DD	161		Ponderosa pine	
Stratum 3			DD	162		Ponderosa pine	
Stratum 3			DD	217		Ponderosa pine	
Stratum 3			DD	149		Ponderosa pine	
Stratum 3			DD	195		Douglas-fir	
Stratum 3			DD	169		Ponderosa pine	
Stratum 3			DD	142		Ponderosa pine	
Stratum 3			DD	158		Ponderosa pine	
Stratum 3			DD	121		Ponderosa pine	
Stratum 3			DD	190	766p / 874v	Douglas-fir	191
Stratum 3			DD	114		Ponderosa pine	
Stratum 3			DD	155		Ponderosa pine	
Stratum 3			DD	189		Ponderosa pine	
Stratum 3			DD	144		Ponderosa pine	
Stratum 3			DD	170		Ponderosa pine	
Stratum 3			DD	111		Ponderosa pine	
Stratum 3			DD	199		Ponderosa pine	
Stratum 3			DD	184		Ponderosa pine	
Stratum 3			DD	197		Douglas-fir	
Stratum 3			DD	198		Douglas-fir	
Stratum 3			DD	185		Ponderosa pine	
Stratum 3			DD	175		Ponderosa pine	
Stratum 3			DD	207		Ponderosa pine	
Stratum 3			DD	129		Ponderosa pine	
Stratum 3			DD	172		Ponderosa pine	
Stratum 3			DD	150		Ponderosa pine	
Stratum 3			DD	126		Ponderosa pine	
Stratum 3			DD	138		Ponderosa pine	
Stratum 3			DD	165		Ponderosa pine	
Stratum 3			DD	196	744fp / 805vv	Douglas-fir	188
Stratum 3			DD	206		Ponderosa pine	
Stratum 3			DD	167		Ponderosa pine	
Stratum 3			DD	145		Ponderosa pine	
Stratum 3			DD	201		Douglas-fir	
Stratum 3			DD	131		Ponderosa pine	
Stratum 3			DD	115		Ponderosa pine	
Stratum 3			DD	141		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 47 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 3 (continued)							
Stratum 3			DD	209		Ponderosa pine	
Stratum 3			DD	123		Ponderosa pine	
Stratum 3			DD	156			
Stratum 3			DD	200			
Stratum 3			DD	147		Ponderosa pine	
Stratum 3			DD	133		Ponderosa pine	
Stratum 3			DD	187		Ponderosa pine	
Stratum 3			DD	191		Ponderosa pine	
Stratum 3			DD	166		Ponderosa pine	
Stratum 3			DD	140		Ponderosa pine	
Stratum 3			DD	112		Ponderosa pine	
Stratum 3			DD	116		Ponderosa pine	
Stratum 3			DD	136		Ponderosa pine	
Stratum 3	156	Unburned pit	DD	216		Ponderosa pine	
Level 1			DD	104	752p / 874+r	Douglas-fir	50
Level 1			DD	106		Ponderosa pine	
Level 1			DD	107		Ponderosa pine	
Surface 1			DD	218		Ponderosa pine	
Surface 1			DD	214		Ponderosa pine	
Surface 1			DD	220		Ponderosa pine	
Surface 1			DD	215		Ponderosa pine	
Surface 1			DD	222		Ponderosa pine	
Surface 1			DD	223		Ponderosa pine	
Surface 1			DD	219		Ponderosa pine	
Surface 1			DD	221		Ponderosa pine	
Surface 1			DD	224		Ponderosa pine	
Surface 1	166	Posthole	AM	15	Used in Dolores Modification		
Surface 1	166	Posthole	AM	14	Used in Dolores Modification		
Surface 1	171	Posthole	DD	210		Ponderosa pine	
Surface 1	171	Posthole	DD	212		Ponderosa pine	
Surface 1	171	Posthole	DD	211		Ponderosa pine	
Surface 1	174	Posthole	DD	227		Ponderosa pine	
Surface 1	174	Posthole	DD	226		Ponderosa pine	
Surface 1	176	Floor vault	DD	231		Ponderosa pine	
Surface 1	176	Floor vault	DD	225		Ponderosa pine	
Surface 1	176	Floor vault	DD	234		Ponderosa pine	
Surface 1	176	Floor vault	DD	235		Ponderosa pine	
Surface 1	176	Floor vault	DD	228		Ponderosa pine	
Surface 1	176	Floor vault	DD	233		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 48 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475 (continued)							
Pitstructure 3 (continued)							
Surface 1	176	Floor vault	DD	229		Ponderosa pine	
Surface 1	176	Floor vault	DD	230		Ponderosa pine	
Surface 1	176	Floor vault	DD	236		Ponderosa pine	
Surface 1	176	Floor vault	DD	232		Ponderosa pine	
Surface 1	159	Wingwall	AM	16	Used in Dolores Modification		
Surface 2	215	Unburned pit	DD	239		Ponderosa pine	
Surface 2	223	Unburned pit	AM	17	Poor results		
Full cut			DD	102		Ponderosa pine	
Pitstructure 4							
	339	Ventilation system	DD	255		Ponderosa pine	
Surface 1	255	Hearth	AM	19	950-1015; 1175-post-1425		
Pitstructure 5							
Level 1			DD	249		Ponderosa pine	
Level 1			DD	254		Ponderosa pine	
Level 1			DD	253	785fp / 825vv	Pinyon pine	196
Level 1			DD	251		Juniper	
Level 1			DD	250		Ponderosa pine	
Level 1			DD	248		Ponderosa pine	
Level 1			DD	252		Pinyon pine	
Surface 1			DD	246		Ponderosa pine	
Surface 1	395	Hearth	AM	20	Used in Dolores Modification		
Pitstructure 6							
Stratum 2			DD	568		Populus	
Pitstructure 7							
			AM	28	855-870; 880-925		
Stratum 2			DD	444		Ponderosa pine	
Stratum 2			DD	372		Ponderosa pine	
Stratum 2			DD	415		Douglas-fir	
Stratum 2			DD	418		Populus	
Stratum 2			DD	420		Ponderosa pine	
Stratum 2			DD	465		Ponderosa pine	
Stratum 2			DD	466		Ponderosa pine	
Stratum 2			DD	447		Ponderosa pine	
Stratum 2			DD	406		Ponderosa pine	
Stratum 2			DD	484		Ponderosa pine	
Stratum 2			DD	392		Ponderosa pine	
Stratum 2			DD	390		Ponderosa pine	
Stratum 2			DD	426	830p / 871r	Ponderosa pine	359

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 49 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4475							
Pitstructure 7 (continued)							
Stratum 2			DD	351		Ponderosa pine	
Stratum 2			DD	449		Ponderosa pine	
Stratum 2			DD	412		Ponderosa pine	
Stratum 2			DD	395		Ponderosa pine	
Stratum 2			DD	365		Ponderosa pine	
Stratum 2			DD	384		Ponderosa pine	
Stratum 2			DD	423		Ponderosa pine	
Stratum 2			DD	439		Ponderosa pine	
Stratum 2			DD	424		Ponderosa pine	
Stratum 2			DD	493		Ponderosa pine	
Stratum 2			DD	417		Douglas-fir	
Stratum 2			DD	391		Ponderosa pine	
Stratum 2			DD	421		Ponderosa pine	
Stratum 2			DD	422		Ponderosa pine	
Stratum 2			DD	383		Ponderosa pine	
Stratum 2			DD	393		Ponderosa pine	
Stratum 2			DD	410		Ponderosa pine	
Stratum 2			DD	481		Ponderosa pine	
Stratum 2			DD	431		Ponderosa pine	
Stratum 2			DD	380		Ponderosa pine	
Stratum 2			DD	416		Ponderosa pine	
Stratum 2			DD	354		Ponderosa pine	
Stratum 2			DD	467		Ponderosa pine	
Stratum 2			DD	459		Ponderosa pine	
Stratum 2			DD	349	779p / 856vv	Ponderosa pine	349
Stratum 2			DD	359	834 / 870v	Ponderosa pine	350
Stratum 2			DD	408		Ponderosa pine	
Stratum 2			DD	409		Ponderosa pine	
Stratum 2			DD	470		Ponderosa pine	
Stratum 2			DD	400		Ponderosa pine	
Stratum 2			DD	486		Ponderosa pine	
Stratum 2			DD	401		Ponderosa pine	
Stratum 2			DD	468		Ponderosa pine	
Stratum 2			DD	350		Ponderosa pine	
Stratum 2			DD	427		Ponderosa pine	
Stratum 2			DD	404		Ponderosa pine	
Stratum 2			DD	434		Ponderosa pine	
Stratum 2			DD	438		Ponderosa pine	
Stratum 2			DD	496		Ponderosa pine	
Stratum 2			DD	441		Ponderosa pine	
Stratum 2			DD	498		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 50 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4475							
Pitstructure 7 (continued)							
Stratum 2			DD	394	833 / 872vv	Ponderosa pine	352
Stratum 2			DD	479		Ponderosa pine	
Stratum 2			DD	483		Ponderosa pine	
Stratum 2			DD	440		Ponderosa pine	
Stratum 2			DD	521		Populus	
Stratum 2			DD	353		Ponderosa pine	
Stratum 2			DD	361		Ponderosa pine	
Stratum 2			DD	385		Ponderosa pine	
Stratum 2			DD	397		Ponderosa pine	
Stratum 2			DD	450		Ponderosa pine	
Stratum 2			DD	399		Ponderosa pine	
Stratum 2			DD	448		Ponderosa pine	
Stratum 2			DD	472		Ponderosa pine	
Stratum 2			DD	405		Ponderosa pine	
Stratum 2			DD	461		Ponderosa pine	
Stratum 2			DD	396		Ponderosa pine	
Stratum 2			DD	428		Ponderosa pine	
Stratum 2			DD	458		Ponderosa pine	
Stratum 2			DD	463		Ponderosa pine	
Stratum 2			DD	403		Ponderosa pine	
Stratum 2			DD	490		Ponderosa pine	
Stratum 2			DD	480		Ponderosa pine	
Stratum 2			DD	544			
Stratum 2			DD	442		Ponderosa pine	
Stratum 2			DD	469		Ponderosa pine	
Stratum 2			DD	474		Ponderosa pine	
Stratum 2			DD	377		Ponderosa pine	
Stratum 2			DD	494		Ponderosa pine	
Stratum 2			DD	541			
Stratum 2			DD	370		Ponderosa pine	
Stratum 2			DD	388		Ponderosa pine	
Stratum 2			DD	533		Populus	
Stratum 2			DD	543			
Stratum 2			DD	478		Ponderosa pine	
Stratum 2			DD	473		Ponderosa pine	
Stratum 2			DD	513			
Stratum 2			DD	477		Ponderosa pine	
Stratum 2			DD	491		Ponderosa pine	
Stratum 2			DD	488		Ponderosa pine	
Stratum 2			DD	437		Ponderosa pine	
Stratum 2			DD	443		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 51 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 7 (continued)							
Stratum 2			DD	462		Ponderosa pine	
Stratum 2			DD	482		Ponderosa pine	
Stratum 2			DD	526		Ponderosa pine	
Stratum 2			DD	518		Populus	
Stratum 2			DD	520		Populus	
Stratum 2			DD	389		Ponderosa pine	
Stratum 2			DD	356		Ponderosa pine	
Stratum 2			DD	487		Ponderosa pine	
Stratum 2			DD	445		Ponderosa pine	
Stratum 2			DD	425	829p / 871r	Ponderosa pine	358
Stratum 2			DD	358		Ponderosa pine	
Stratum 2			DD	371		Ponderosa pine	
Stratum 2			DD	500		Ponderosa pine	
Stratum 2			DD	374		Ponderosa pine	
Stratum 2			DD	524	822 / 865r	Ponderosa pine	360
Stratum 2			DD	464		Ponderosa pine	
Stratum 2			DD	398		Ponderosa pine	
Stratum 2			DD	433		Ponderosa pine	
Stratum 2			DD	362		Ponderosa pine	
Stratum 2			DD	545			
Stratum 2			DD	514			
Stratum 2			DD	547			
Stratum 2			DD	452		Ponderosa pine	
Stratum 2			DD	489		Ponderosa pine	
Stratum 2			DD	525		Populus	
Stratum 2			DD	364		Ponderosa pine	
Stratum 2			DD	367		Ponderosa pine	
Stratum 2			DD	460		Ponderosa pine	
Stratum 2			DD	355		Ponderosa pine	
Stratum 2			DD	369		Ponderosa pine	
Stratum 2			DD	402		Ponderosa pine	
Stratum 2			DD	357		Ponderosa pine	
Stratum 2			DD	436		Ponderosa pine	
Stratum 2			DD	414	829 / 871r	Ponderosa pine	355
Stratum 2			DD	527		Ponderosa pine	
Stratum 2			DD	430		Ponderosa pine	
Stratum 2			DD	551	827p / 871r	Ponderosa pine	362
Stratum 2			DD	476		Ponderosa pine	
Stratum 2			DD	495		Ponderosa pine	
Stratum 2			DD	519		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 52 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 7 (continued)							
Stratum 2			DD	429		Ponderosa pine	
Stratum 2			DD	542			
Stratum 2			DD	529		Populus	
Stratum 2			DD	499		Ponderosa pine	
Stratum 2			DD	497		Ponderosa pine	
Stratum 2			DD	373		Ponderosa pine	
Stratum 2			DD	366		Ponderosa pine	
Stratum 2			DD	492		Ponderosa pine	
Stratum 2			DD	549			
Stratum 2			DD	451		Ponderosa pine	
Stratum 2			DD	360		Ponderosa pine	
Stratum 2			DD	446		Ponderosa pine	
Stratum 2			DD	471		Ponderosa pine	
Stratum 2			DD	528		Ponderosa pine	
Stratum 2			DD	411		Ponderosa pine	
Stratum 2			DD	435		Ponderosa pine	
Stratum 2			DD	368		Ponderosa pine	
Stratum 2			DD	485		Ponderosa pine	
Stratum 2			DD	378		Ponderosa pine	
Stratum 2			DD	550			
Stratum 2			DD	523		Populus	
Stratum 2			DD	352		Ponderosa pine	
Surface 1			DD	454		Ponderosa pine	
Surface 1			DD	505		Ponderosa pine	
Surface 1			DD	510		Ponderosa pine	
Surface 1			DD	511		Ponderosa pine	
Surface 1			DD	432		Juniper	
Surface 1			DD	455		Ponderosa pine	
Surface 1			DD	538		Ponderosa pine	
Surface 1			DD	507		Ponderosa pine	
Surface 1			DD	508		Ponderosa pine	
Surface 1			DD	537		Ponderosa pine	
Surface 1			DD	506		Ponderosa pine	
Surface 1			DD	457		Ponderosa pine	
Surface 1			DD	475		Ponderosa pine	
Surface 1			DD	509		Ponderosa pine	
Surface 1			DD	456		Ponderosa pine	
Surface 1			DD	453		Ponderosa pine	
Surface 1			DD	548			
Surface 1	715	Hearth	AM	26	750-790; 850-870; 890-920		
Surface 2	796	Hearth	AM	27	700-780; 860-915		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 53 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4475 (continued)							
Pitstructure 8							
			AM	25	Poor results		
Stratum 2			DD	257		Juniper	
Stratum 2			DD	282		Populus	
Stratum 2			DD	327		Populus	
Stratum 2			DD	259		Juniper	
Stratum 2			DD	267		Populus	
Stratum 2			DD	291		Populus	
Stratum 2			DD	340		Populus	
Stratum 2			DD	269		Populus	
Stratum 2			DD	279		Populus	
Stratum 2			DD	326		Populus	
Stratum 2			DD	284		Populus	
Stratum 2			DD	292		Populus	
Stratum 2			DD	289		Other	
Stratum 2			DD	342		Populus	
Stratum 2			DD	339		Populus	
Stratum 2			DD	293		Populus	
Stratum 2			DD	288		Populus	
Stratum 2			DD	325		Populus	
Stratum 2			DD	270		Populus	
Stratum 2			DD	263		Populus	
Stratum 2			DD	285		Populus	
Stratum 2			DD	281		Populus	
Stratum 2			DD	274		Populus	
Stratum 2			DD	304		Juniper	
Stratum 2			DD	302		Populus	
Stratum 2			DD	323		Juniper	
Stratum 2			DD	261		Populus	
Stratum 2			DD	294		Populus	
Stratum 2			DD	296		Populus	
Stratum 2			DD	262		Populus	
Stratum 2			DD	297		Populus	
Stratum 2			DD	273		Populus	
Stratum 2			DD	344			
Stratum 2			DD	286		Populus	
Stratum 2			DD	265		Populus	
Stratum 2			DD	280		Populus	
Stratum 2			DD	277		Populus	
Stratum 2			DD	272		Populus	
Stratum 2			DD	271		Other	
Stratum 2			DD	259		Juniper	
Stratum 2			DD	258		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 54 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Pitstructure 8 (continued)							
Stratum 2			DD	343		Populus	
Stratum 2			DD	275		Populus	
Stratum 2			DD	287		Populus	
Stratum 2			DD	264		Populus	
Stratum 2			DD	278		Populus	
Stratum 2			DD	266		Populus	
Stratum 2			DD	268		Populus	
Stratum 2			DD	336		Populus	
Stratum 2			DD	276		Populus	
Stratum 2			DD	338		Populus	
Stratum 2			DD	290		Populus	
Stratum 2			DD	283		Populus	
Stratum 3			DD	348		Ponderosa pine	
Surface 1			DD	310		Populus	
Surface 1			DD	309		Populus	
Surface 1			DD	337		Juniper	
Surface 1			DD	341		Populus	
Surface 1			DD	335		Populus	
Surface 2	534	Fireplace	AM	21	pre-700-750; 925-1000		
Surface 2	535	Posthole	DD	329		Juniper	
Surface 2	538	Posthole	DD	256		Juniper	
Surface 2	604	Posthole	DD	305		Juniper	
Pitstructure 9							
			AM	24	Poor results		
Stratum 1			DD	363		Ponderosa pine	
Stratum 1			DD	379		Ponderosa pine	
Stratum 1			DD	407		Ponderosa pine	
Stratum 1			DD	382		Ponderosa pine	
Stratum 1			DD	387		Ponderosa pine	
Stratum 1			DD	386		Ponderosa pine	
Stratum 1			DD	502		Ponderosa pine	
Stratum 1			DD	381		Ponderosa pine	
Stratum 1			DD	504		Ponderosa pine	
Stratum 1			DD	512		Ponderosa pine	
Stratum 1			DD	501		Ponderosa pine	
Surface 1			DD	413		Ponderosa pine	
Surface 1			DD	503		Ponderosa pine	
Surface 1			DD	376		Ponderosa pine	
Surface 1			DD	375		Ponderosa pine	
Surface 1	573	Hearth	AM	23	Poor results		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 55 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475 (continued)							
Pitstructure 10							
Stratum 2			DD	522		Populus	
Stratum 2			DD	530		Populus	
Stratum 2			DD	516		Populus	
Stratum 2			DD	532		Populus	
Stratum 2			DD	534		Populus	
Stratum 2			DD	540		Populus	
Stratum 2			DD	531		Populus	
Stratum 2			DD	517		Populus	
Nonstructural							
Unit 1							
Stratum 3			DD	97		Ponderosa pine	
Stratum 3			DD	103		Ponderosa pine	
Stratum 3			DD	93		Ponderosa pine	
Stratum 3			DD	94		Ponderosa pine	
Stratum 3			DD	99		Ponderosa pine	
Stratum 3			DD	96		Ponderosa pine	
Stratum 3			DD	95		Ponderosa pine	
Stratum 3			DD	98		Ponderosa pine	
Stratum 3			DD	100		Ponderosa pine	
Surface 2	20	Hearth	AM	9	700-770; 865-885; 910-965		
Surface 2	21	Hearth	AM	8	pre-700		
Surface 2	12	Fireplace	AM	13	Poor results		
Grid square 320S/46E							
Level 4			DD	1		Juniper	
Unknown							
Unknown	800	Unburned pit	DD	66		Ponderosa pine	
Unknown	800	Unburned pit	DD	67		Ponderosa pine	
Unknown	800	Unburned pit	DD	68		Ponderosa pine	
Unknown	800	Unburned pit	DD	69		Ponderosa pine	
Unknown	800	Unburned pit	DD	70		Ponderosa pine	
Unknown	800	Unburned pit	DD	71		Ponderosa pine	
Unknown	800	Unburned pit	DD	72		Ponderosa pine	
Unknown	800	Unburned pit	DD	75		Ponderosa pine	
Unknown	800	Unburned pit	DD	76		Ponderosa pine	
Unknown	800	Unburned pit	DD	77		Ponderosa pine	
Unknown	800	Unburned pit	DD	78		Ponderosa pine	
Unknown	800	Unburned pit	DD	79		Populus	
Unknown	800	Unburned pit	DD	80		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 56 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4475							
Unknown (continued)							
Unknown	800	Unburned pit	DD	81		Ponderosa pine	
Unknown	800	Unburned pit	DD	82		Ponderosa pine	
Unknown	800	Unburned pit	DD	83		Ponderosa pine	
Unknown	800	Unburned pit	DD	84		Ponderosa pine	
Unknown	800	Unburned pit	DD	85		Ponderosa pine	
Unknown	800	Unburned pit	DD	86		Ponderosa pine	
Unknown	800	Unburned pit	DD	87		Ponderosa pine	
Unknown	800	Unburned pit	DD	88		Ponderosa pine	
Unknown	800	Unburned pit	DD	90	802p / 861v	Ponderosa pine	47
Unknown	800	Unburned pit	DD	91	812p / 872r	Ponderosa pine	46
Unknown	800	Unburned pit	DD	92		Ponderosa pine	
5MT4477							
Room 2							
Surface 2	207	Hearth	AM	10	Poor results		
Surface 2	215	Hearth	AM	9	Poor results		
Room 13							
Surface 1			DD	124		Ponderosa pine	
5MT4477							
Room 13 (continued)							
Surface 1			DD	123		Ponderosa pine	
Surface 1			DD	125		Ponderosa pine	
Room 20							
Level 2			DD	163		Ponderosa pine	
Level 2			DD	162		Ponderosa pine	
Level 2			DD	165		Ponderosa pine	
Level 2			DD	164		Ponderosa pine	
Level 2			DD	166		Ponderosa pine	
Surface 1			DD	169		Ponderosa pine	
Surface 1			DD	170	689 / 748+vv	Ponderosa pine	414
Pitstructure 1							
			AM	8	700-765; 860-900		
Stratum 2			DD	153		Douglas-fir	
Stratum 2			DD	146		Populus	
Stratum 2			DD	144		Pinyon pine	
Stratum 2			DD	149		Populus	
Stratum 2			DD	137		Ponderosa pine	
Stratum 2			DD	141		Populus	
Stratum 2			DD	139		Douglas-fir	
Stratum 2			DD	143		Populus	
Stratum 2			DD	142		Populus	
Stratum 2			DD	155		Douglas-fir	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 57 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4477							
Pitstructure 1 (contiued)							
Stratum 2			DD	131		Populus	
Stratum 2			DD	132		Populus	
Stratum 2			DD	150		Populus	
Stratum 2			DD	152		Populus	
Stratum 2			DD	156		Ponderosa pine	
Stratum 2			DD	154		Populus	
Stratum 2			DD	129		Douglas-fir	
Stratum 2			DD	138		Populus	
Stratum 2			DD	145		Populus	
Stratum 2			DD	140		Douglas-fir	
Stratum 2			DD	161		Ponderosa pine	
Stratum 2			DD	130		Ponderosa pine	
Stratum 2			DD	151		Populus	
Stratum 2			DD	128		Populus	
Stratum 2			DD	159		Populus	
Stratum 2			DD	134		Populus	
Stratum 2			DD	157		Populus	
Stratum 2			DD	148		Populus	
Stratum 2			DD	147		Populus	
Stratum 2			DD	158		Populus	
Stratum 2			DD	135		Populus	
Stratum 2			DD	127		Populus	
Stratum 2			DD	133		Ponderosa pine	
Stratum 2			DD	160		Populus	
Stratum 2			DD	136		Populus	
Pitstructure 2							
			AM	2	Used in Dolores Modification		
Stratum 17			DD	45		Ponderosa pine	
Stratum 17			DD	35		Ponderosa pine	
Level 1			DD	3		Ponderosa pine	
Level 1			DD	2		Ponderosa pine	
Level 1			DD	1		Ponderosa pine	
Level 2			DD	18		Ponderosa pine	
Level 2			DD	12		Ponderosa pine	
Level 2			DD	27		Ponderosa pine	
Level 2			DD	37		Ponderosa pine	
Level 2			DD	9		Ponderosa pine	
Level 2			DD	10		Ponderosa pine	
Level 2			DD	32		Ponderosa pine	
Level 2			DD	31		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 58 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4477							
Pitstructure 2 (continued)							
Level 2			DD	13		Ponderosa pine	
Level 2			DD	47		Ponderosa pine	
Level 2			DD	46		Ponderosa pine	
Level 2			DD	41		Ponderosa pine	
Level 2			DD	30		Ponderosa pine	
Level 2			DD	28		Ponderosa pine	
Level 2			DD	11	815p / 871v	Ponderosa pine	209
Level 2			DD	44		Ponderosa pine	
Level 2			DD	52		Ponderosa pine	
Level 2			DD	33		Ponderosa pine	
Level 2			DD	50		Ponderosa pine	
Level 2			DD	14		Ponderosa pine	
Level 2			DD	34		Ponderosa pine	
Level 2			DD	53		Ponderosa pine	
Level 2			DD	15	831 / 871r	Ponderosa pine	210
Level 2			DD	21		Ponderosa pine	
Level 2			DD	24		Ponderosa pine	
Level 2			DD	42		Ponderosa pine	
Level 2			DD	20		Ponderosa pine	
Level 2			DD	19		Ponderosa pine	
Level 2			DD	16		Ponderosa pine	
Level 2			DD	36		Ponderosa pine	
Level 2			DD	49		Ponderosa pine	
Level 2			DD	4		Ponderosa pine	
Level 2			DD	43		Ponderosa pine	
Level 2			DD	8		Ponderosa pine	
Level 2			DD	5		Ponderosa pine	
Level 2			DD	17		Ponderosa pine	
Level 2			DD	23		Ponderosa pine	
Level 2			DD	6		Ponderosa pine	
Level 2			DD	26		Juniper	
Level 2			DD	55		Ponderosa pine	
Level 2			DD	54		Ponderosa pine	
Level 2			DD	51		Ponderosa pine	
Level 2			DD	22		Ponderosa pine	
Level 2			DD	7		Ponderosa pine	
Level 2			DD	25		Ponderosa pine	
Level 2			DD	39		Ponderosa pine	
Level 2			DD	29		Ponderosa pine	
Level 2			DD	48		Ponderosa pine	
Level 2			DD	40		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 59 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4477							
Pitstructure 2 (continued)							
Level 3			DD	56		Ponderosa pine	
Level 3			DD	68		Ponderosa pine	
Level 3			DD	64		Ponderosa pine	
Level 3			DD	65		Ponderosa pine	
Level 3			DD	59		Ponderosa pine	
Level 3			DD	66		Ponderosa pine	
Level 3			DD	62		Ponderosa pine	
Level 3			DD	67		Ponderosa pine	
Level 3			DD	63		Ponderosa pine	
Level 3			DD	104		Ponderosa pine	
Level 3			DD	57		Ponderosa pine	
Level 3			DD	60		Ponderosa pine	
Level 3			DD	71	807 / 845vv	Ponderosa pine	215
Level 3			DD	70		Ponderosa pine	
Surface 2			DD	126		Ponderosa pine	
Surface 2			DD	78		Ponderosa pine	
Surface 2			DD	92		Ponderosa pine	
Surface 2			DD	83		Ponderosa pine	
Surface 2			DD	90		Ponderosa pine	
Surface 2			DD	97		Ponderosa pine	
Surface 2			DD	96		Ponderosa pine	
Surface 2			DD	74		Ponderosa pine	
Surface 2			DD	94		Ponderosa pine	
Surface 2			DD	93		Ponderosa pine	
Surface 2			DD	100		Ponderosa pine	
Surface 2			DD	79	810p / 871B	Ponderosa pine	216
Surface 2			DD	77		Ponderosa pine	
Surface 2			DD	73		Ponderosa pine	
Surface 2			DD	110		Ponderosa pine	
Surface 2			DD	84	818fp / 871r	Ponderosa pine	218
Surface 2			DD	75		Ponderosa pine	
Surface 2			DD	107		Ponderosa pine	
Surface 2			DD	108		Ponderosa pine	
Surface 2			DD	82		White fir	
Surface 2			DD	76		Ponderosa pine	
Surface 2			DD	103		Ponderosa pine	
Surface 2			DD	98		Ponderosa pine	
Surface 2			DD	81		Ponderosa pine	
Surface 2			DD	88		Ponderosa pine	
Surface 2			DD	69		Ponderosa pine	
Surface 2			DD	89		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 60 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4477							
Pitstructure 2 (continued)							
Surface 2			DD	101		Ponderosa pine	
Surface 2			DD	112	786 / 848vv	Ponderosa pine	223
Surface 2			DD	95		Ponderosa pine	
Surface 2			DD	105		Ponderosa pine	
Surface 2			DD	85		Ponderosa pine	
Surface 2			DD	102		Ponderosa pine	
Surface 2			DD	80	805p / 870+v	Ponderosa pine	217
Surface 2			DD	72		Ponderosa pine	
Surface 2			DD	109	788p / 856vv	Ponderosa pine	221
Surface 2			DD	91		Ponderosa pine	
Surface 2			DD	58		Ponderosa pine	
Surface 2			DD	106	572p / 659vv	Ponderosa pine	220
Surface 2			DD	86		Ponderosa pine	
Surface 2			DD	99		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	116		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	120		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	118		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	119		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	121		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	117		Ponderosa pine	
Surface 2	40	Rectangular central pit	DD	122		Ponderosa pine	
Surface 2	16	Hearth	AM	1	700-780, 860-950		
Surface 2	16	Hearth	DD	115		Ponderosa pine	
Surface 2	16	Hearth	DD	111	832p / 871v	Ponderosa pine	222
Surface 2	14	Posthole	DD	61	728p / 841+vv	Juniper	214
Surface 2	15	Posthole	DD	87	690p / 791vv	Juniper	219
Surface 2	29	Posthole	DD	113	651±p / 870+vv	Juniper	224
Surface 2	29	Posthole	DD	114		Juniper	
Pitstructure 5							
Surface 1	216	Hearth	AM	7	945-1010; 1275-1425		
Surface 1	234	Fireplace	AM	6	Poor results		
5MT4479							
Room 5							
Surface 1	105	Posthole	DD	3		Pinyon pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 61 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4479 (continued)							
Room 7							
Surface 1	146	Hearth	AM	3	pre-700-735; 870-895		
Surface 1	147	Posthole	DD	4		Juniper	
Surface 1	151	Posthole	DD	5		Ponderosa pine	
Pitstructure 1							
Level 1			DD	1		Ponderosa pine	
Surface 1	4	Hearth	AM	1	pre-700-735; 870-890		
Surface 1	65	Posthole	DD	2		Ponderosa pine	
Pitstructure 2							
Surface 1	110	Hearth	AM	2	715-775; 860-915		
5MT4480							
Room 1							
Surface 1	23	Hearth	AM	3	pre-700-765; 865-890; 915-950		
Room 4							
Stratum 1			DD	32		Ponderosa pine	
Stratum 1			DD	31		Ponderosa pine	
Stratum 1			DD	28		Ponderosa pine	
Stratum 1			DD	37		Ponderosa pine	
Stratum 1			DD	26		Ponderosa pine	
Stratum 1			DD	25		Ponderosa pine	
Stratum 1			DD	34		Ponderosa pine	
Stratum 1			DD	27		Ponderosa pine	
Stratum 1			DD	36		Ponderosa pine	
Stratum 1			DD	33		Ponderosa pine	
Stratum 1			DD	35		Ponderosa pine	
Surface 1	18	Posthole	DD	38	637 / 702vv	Ponderosa pine	410
Room 5							
Stratum 1			DD	30		Ponderosa pine	
Stratum 1			DD	29		Ponderosa pine	
Room 8							
Surface 1	59	Fireplace	AM	4	750-780; 855-870; 880-920		
Surface 1	53	Posthole	DD	42		Ponderosa pine	
Surface 1	53	Posthole	DD	40	611 / 659vv	Ponderosa pine	411
Full cut			DD	39		Ponderosa pine	
Full cut			DD	41		Ponderosa pine	
Pitstructure 1							
Level 1			DD	9		Ponderosa pine	
Level 1			DD	13		Ponderosa pine	
Level 1			DD	14		Ponderosa pine	
Level 1			DD	15	812p / 874vv	Ponderosa pine	180
Level 1			DD	11	804p / 868+vv	Ponderosa pine	178

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 62 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4480							
Pitstructure 1 (continued)							
Level 1			DD	12		Ponderosa pine	
Level 1			DD	10		Ponderosa pine	
Level 2			DD	23		Ponderosa pine	
Level 2			DD	7		Juniper	
Level 2			DD	4		Ponderosa pine	
Level 2			DD	8		Ponderosa pine	
Level 2			DD	22		Ponderosa pine	
Level 2			DD	1		Ponderosa pine	
Level 2			DD	5		Ponderosa pine	
Level 2			DD	3		Ponderosa pine	
Level 2			DD	24		Ponderosa pine	
Level 2			DD	19	793p / 864B	Ponderosa pine	181
Level 2			DD	6		Ponderosa pine	
Level 2			DD	18		Ponderosa pine	
Level 2			DD	2		Ponderosa pine	
Pitstructure 2							
Level 2			DD	16		Ponderosa pine	
Level 2			DD	21		Ponderosa pine	
Level 2			DD	20		Ponderosa pine	
Level 2			DD	17		Ponderosa pine	
Pitstructure 4							
Surface 1	4	Hearth	AM	1	Used in Dolores Modification		
Pitstructure 5							
Surface 1	3	Hearth	AM	2	Poor results		
5MT4512							
Pitstructure 1							
Surface 1	12	Hearth	CF	6	1630 B.P. ± 80		
Surface 1	12	Hearth	AM	1	Poor results		
Nonstructural Unit 4							
Surface 2	37	Burned pit	AM	2	pre-700; 940-1015		
Surface 2	37	Burned pit	CF	8	1420 B.P. ± 80		
Surface 2	37	Burned pit	DD	2		Pinyon pine	
Surface 2	37	Burned pit	DD	1		Pinyon pine	
Surface 2	37	Burned pit	DD	4		Pinyon pine	
Surface 2	37	Burned pit	DD	3		Pinyon pine	
5MT4545							
Room 1							
Level 1			DD	3	457fp / 598vv	Pinyon pine	149
Level 1			DD	4		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 63 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4545							
Room 1 (continued)							
Level 1			AM	2	Used in Dolores Modification		
Level 1			DD	6		Juniper	
Level 1			DD	7		Juniper	
Level 1			DD	2		Juniper	
Level 1			DD	1	432fp / 552vv	Juniper	148
Level 1			DD	5		Juniper	
Room 3							
Surface 1			AM	6	Used in Dolores Modification		
Room 14							
Full cut	27	Fireplace	AM	1	Poor results		
Pitstructure 1							
Surface 1	17	Hearth	AM	4	pre-700-725		
Pitstructure 2							
	9	Bench	AM	3	700-775; 860-950		
Surface 1	20	Posthole	DD	8		Juniper	
Grid square 100S/34E							
Surface 1	68	Fireplace	AM	7	Poor results		
Grid square 160S/26E							
Surface 1	5	Burned pit	AM	5	1350-post-1425		
Grid square 200S/22E							
Surface 1	96	Posthole	DD	9			
5MT4613							
Pitstructure 1							
Stratum 2			DD	2		Ponderosa pine	
Stratum 2			DD	11		Ponderosa pine	
Stratum 2			DD	4		Ponderosa pine	
Stratum 2			DD	5		Ponderosa pine	
Stratum 2			DD	6		Ponderosa pine	
Stratum 2			DD	7		Ponderosa pine	
Stratum 2			DD	8		Ponderosa pine	
Stratum 2			DD	9		Ponderosa pine	
Stratum 2			DD	10		Ponderosa pine	
Stratum 2			DD	3		Ponderosa pine	
Stratum 2			DD	12		Ponderosa pine	
Stratum 2			DD	13		Ponderosa pine	
Stratum 2			DD	1		Ponderosa pine	
Surface 1	18	Posthole	DD	14		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 64 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4613 (continued)							
Nonstructural							
Unit 1							
Surface 1	5	Burned pit	AM	1	1070-1180		
Surface 1	5	Burned pit	AM	2	1000-1030; 1125-1375		
5MT4614							
Room 3							
Surface 1	134	Fireplace	AM	3	Poor results		
Pitstructure 1							
Stratum 9			CF	5	1590 B.P. ± 90		
Surface 1	17	Hearth	AM	1	Used in Dolores Modification		
Pitstructure 2							
Surface 1	39	Fireplace	AM	2	Used in Dolores Modification		
Surface 1	39	Fireplace	CF	9	1660 B.P. ± 70		
5MT4644							
Room 5							
Surface 1	130	Hearth	AM	9	pre-700; 930-1010; 1325-post-1425		
Pitstructure 1							
	2	Bench	AM	5	Used in Dolores Modification		
	2	Bench	DD	10		Ponderosa pine	
	2	Bench	AM	1	Used in Dolores Modification		
	68	Ventilation system	DD	278		Ponderosa pine	
	68	Ventilation system	DD	272		Ponderosa pine	
	68	Ventilation system	DD	273		Ponderosa pine	
Level 1			DD	22		Ponderosa pine	
Level 1			DD	29		Ponderosa pine	
Level 1			DD	33		Ponderosa pine	
Level 1			DD	17		Ponderosa pine	
Level 1			DD	40		Ponderosa pine	
Level 1			DD	19		Ponderosa pine	
Level 1			DD	15		Ponderosa pine	
Level 1			DD	16		Ponderosa pine	
Level 1			DD	12		Ponderosa pine	
Level 1			DD	27		Ponderosa pine	
Level 1			DD	14		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 65 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4644							
Pitstructure 1 (continued)							
Level 1			DD	263		Ponderosa pine	
Level 1			DD	13		Ponderosa pine	
Level 1			DD	18		Ponderosa pine	
Level 1			DD	25		Ponderosa pine	
Level 1			DD	44		Ponderosa pine	
Level 1			DD	41		Ponderosa pine	
Level 1			DD	53		Ponderosa pine	
Level 1			DD	37		Ponderosa pine	
Level 1			DD	11		Ponderosa pine	
Level 1			DD	54		Ponderosa pine	
Level 2			DD	47		Ponderosa pine	
Level 2			DD	24		Ponderosa pine	
Level 2			DD	39		Ponderosa pine	
Level 2			DD	52		Ponderosa pine	
Level 2			DD	60		Ponderosa pine	
Level 2			DD	63		Ponderosa pine	
Level 2			DD	35		Ponderosa pine	
Level 2			DD	31		Ponderosa pine	
Level 2			DD	55		Ponderosa pine	
Level 2			DD	51		Ponderosa pine	
Level 2			DD	59		Ponderosa pine	
Level 2			DD	43		Ponderosa pine	
Level 2			DD	30		Ponderosa pine	
Level 2			DD	45		Ponderosa pine	
Level 2			DD	61		Ponderosa pine	
Level 2			DD	46		Ponderosa pine	
Level 2			DD	32		Ponderosa pine	
Level 2			DD	48		Ponderosa pine	
Level 2			DD	56		Ponderosa pine	
Level 2			DD	34		Ponderosa pine	
Level 2			DD	23		Ponderosa pine	
Level 2			DD	21		Ponderosa pine	
Level 2			DD	28		Ponderosa pine	
Level 2			DD	36		Ponderosa pine	
Level 2			DD	38		Ponderosa pine	
Level 2			DD	62		Ponderosa pine	
Level 2			DD	42		Ponderosa pine	
Level 2			DD	20		Ponderosa pine	
Level 2			DD	50		Ponderosa pine	
Level 2			DD	26		Ponderosa pine	
Level 2			DD	49		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 66 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4644							
Pitstructure 1 (continued)							
Level 2			DD	57		Ponderosa pine	
Level 2			DD	58		Ponderosa pine	
Level 3			DD	75		Ponderosa pine	
Level 3			DD	84		Ponderosa pine	
Level 3			DD	253		Populus	
Level 3			DD	267		Ponderosa pine	
Level 3			DD	80		Ponderosa pine	
Level 3			DD	255		Ponderosa pine	
Level 3			DD	269		Ponderosa pine	
Level 3			DD	257		Ponderosa pine	
Level 3			DD	87		Ponderosa pine	
Level 3			DD	68		Ponderosa pine	
Level 3			DD	262		Ponderosa pine	
Level 3			DD	258		Ponderosa pine	
Level 3			DD	91		Ponderosa pine	
Level 3			DD	94		Ponderosa pine	
Level 3			DD	66		Ponderosa pine	
Level 3			DD	76		Ponderosa pine	
Level 3			DD	79		Ponderosa pine	
Level 3			DD	256		Ponderosa pine	
Level 3			DD	85		Ponderosa pine	
Level 3			DD	92		Ponderosa pine	
Level 3			DD	72		Ponderosa pine	
Level 3			DD	261		Ponderosa pine	
Level 3			DD	70		Ponderosa pine	
Level 3			DD	251		Ponderosa pine	
Level 3			DD	67		Ponderosa pine	
Level 3			DD	98		Ponderosa pine	
Level 3			DD	260		Ponderosa pine	
Level 3			DD	97		Populus	
Level 3			DD	95		Ponderosa pine	
Level 3			DD	78		Ponderosa pine	
Level 3			DD	64		Ponderosa pine	
Level 3			DD	83		Ponderosa pine	
Level 3			DD	271		Ponderosa pine	
Level 3			DD	96		Populus	
Level 3			DD	274		Ponderosa pine	
Level 3			DD	254		Populus	
Level 3			DD	82		Ponderosa pine	
Level 3			DD	259		Ponderosa pine	
Level 3			DD	268		Populus	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 67 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4644							
Pitstructure 1 (continued)							
Level 3			DD	81		Ponderosa pine	
Level 3			DD	74		Ponderosa pine	
Level 3			DD	65		Ponderosa pine	
Level 3			DD	266		Ponderosa pine	
Level 3			DD	93		Ponderosa pine	
Level 3			DD	77		Ponderosa pine	
Level 3			DD	69		Ponderosa pine	
Level 3			DD	264	723p / 793vv	Ponderosa pine	124
Level 3			DD	73		Ponderosa pine	
Level 3			DD	90		Ponderosa pine	
Level 3			DD	265		Populus	
Level 3			DD	270		Ponderosa pine	
Level 3			DD	88		Ponderosa pine	
Level 3			DD	86		Ponderosa pine	
Level 3			DD	99		Ponderosa pine	
Level 3			DD	89		Ponderosa pine	
Level 3			DD	252	730p / 787v	Ponderosa pine	123
Level 3			DD	71		Populus	
Surface 1			AM	6	pre-700-765; 865-950		
Surface 1	16	Hearth	AM	4	Poor results		
Surface 1	76	Posthole	DD	277		Ponderosa pine	
Surface 1	76	Posthole	DD	276		Ponderosa pine	
Surface 1	80	Posthole	DD	275		Ponderosa pine	
Full cut			DD	6		Populus	
Full cut			DD	7		Ponderosa pine	
Full cut			DD	9		Ponderosa pine	
Full cut			DD	4		Ponderosa pine	
Full cut			DD	2		Ponderosa pine	
Full cut			DD	1		Ponderosa pine	
Full cut			DD	3		Ponderosa pine	
Full cut			DD	5		Ponderosa pine	
Full cut			DD	8		Ponderosa pine	
Pitstructure 2							
	19	Bench	DD	143		Ponderosa pine	
	19	Bench	AM	3	Used in Dolores Modification		
	19	Bench	DD	139		Juniper	
	19	Bench	DD	140		Ponderosa pine	
	19	Bench	DD	142		Juniper	
	19	Bench	DD	138		Ponderosa pine	
	19	Bench	DD	144		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 68 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4644							
Pitstructure 2 (continued)							
	19	Bench	DD	145		Ponderosa pine	
	36	Entry	DD	234		Ponderosa pine	
	36	Entry	DD	233	688p / 747vv	Ponderosa pine	120
	36	Entry	DD	239		Ponderosa pine	
	20	Ventilation system	DD	155		Populus	
	20	Ventilation system	DD	113		Populus	
	20	Ventilation system	DD	120		Populus	
	20	Ventilation system	DD	118		Juniper	
	20	Ventilation system	DD	154		Populus	
	20	Ventilation system	DD	123		Ponderosa pine	
	20	Ventilation system	DD	124	684p / 768vv	Ponderosa pine	101
	20	Ventilation system	DD	128		Ponderosa pine	
	20	Ventilation system	DD	163		Populus	
	20	Ventilation system	DD	151		Ponderosa pine	
	20	Ventilation system	DD	117		Ponderosa pine	
	20	Ventilation system	DD	127		Ponderosa pine	
	20	Ventilation system	DD	162		Populus	
	20	Ventilation system	DD	121		Ponderosa pine	
	20	Ventilation system	DD	122		Ponderosa pine	
	20	Ventilation system	DD	126		Ponderosa pine	
	20	Ventilation system	DD	161		Ponderosa pine	
	20	Ventilation system	DD	164		Ponderosa pine	
	20	Ventilation	DD	129		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 69 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4644							
Pitstructure 2 (continued)							
		system					
	20	Ventilation system	DD	152		Ponderosa pine	
	20	Ventilation system	DD	153		Populus	
	20	Ventilation system	DD	125		Populus	
	20	Ventilation system	DD	148		Populus	
Level 3			DD	108		Ponderosa pine	
Level 3			DD	174		Ponderosa pine	
Level 3			DD	218		Ponderosa pine	
Level 3			DD	115		Ponderosa pine	
Level 3			DD	114		Ponderosa pine	
Level 3			DD	184		Ponderosa pine	
Level 3			DD	178		Ponderosa pine	
Level 3			DD	119		Ponderosa pine	
Level 3			DD	106		Ponderosa pine	
Level 3			DD	192		Ponderosa pine	
Level 3			DD	217		Ponderosa pine	
Level 3			DD	131		Ponderosa pine	
Level 3			DD	177		Ponderosa pine	
Level 3			DD	116		Ponderosa pine	
Level 3			DD	206		Ponderosa pine	
Level 3			DD	180		Ponderosa pine	
Level 3			DD	141	720fp / 776v	Ponderosa pine	105
Level 3			DD	202		Ponderosa pine	
Level 3			DD	207		Ponderosa pine	
Level 3			DD	176	713p / 758vv	Ponderosa pine	110
Level 3			DD	134		Ponderosa pine	
Level 3			DD	111		Ponderosa pine	
Level 3			DD	185		Ponderosa pine	
Level 3			DD	208	716p / 776vv	Ponderosa pine	115
Level 3			DD	146		Ponderosa pine	
Level 3			DD	210		Ponderosa pine	
Level 3			DD	201		Ponderosa pine	
Level 3			DD	109		Ponderosa pine	
Level 3			DD	181		Ponderosa pine	
Level 3			DD	104		Ponderosa pine	
Level 3			DD	156		Ponderosa pine	
Level 3			DD	211		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 70 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT4644							
Pitstructure 2 (continued)							
Level 3			DD	182		Ponderosa pine	
Level 3			DD	195		Ponderosa pine	
Level 3			DD	197		Ponderosa pine	
Level 3			DD	101		Ponderosa pine	
Level 3			DD	149		Ponderosa pine	
Level 3			DD	112		Ponderosa pine	
Level 3			DD	191		Ponderosa pine	
Level 3			DD	110		Ponderosa pine	
Level 3			DD	107		Ponderosa pine	
Level 3			DD	188		Ponderosa pine	
Level 3			DD	212	725p / 775vv	Ponderosa pine	116
Level 3			DD	223		Ponderosa pine	
Level 3			DD	222		Ponderosa pine	
Level 3			DD	175		Ponderosa pine	
Level 3			DD	198		Ponderosa pine	
Level 3			DD	130	720p / 776v	Ponderosa pine	102
Level 3			DD	214		Ponderosa pine	
Level 3			DD	183		Ponderosa pine	
Level 3			DD	204		Ponderosa pine	
Level 3			DD	167	737fp / 776v	Ponderosa pine	109
Level 3			DD	102		Ponderosa pine	
Level 3			DD	179		Ponderosa pine	
Level 3			DD	159		Ponderosa pine	
Level 3			DD	136		Ponderosa pine	
Level 3			DD	186		Ponderosa pine	
Level 3			DD	240		Ponderosa pine	
Level 3			DD	166		Ponderosa pine	
Level 3			DD	203		Ponderosa pine	
Level 3			DD	137		Ponderosa pine	
Level 3			DD	187		Ponderosa pine	
Level 3			DD	135	722p / 776r	Ponderosa pine	103
Level 3			DD	213	725p / 775vv	Ponderosa pine	117
Level 3			DD	237		Ponderosa pine	
Level 3			DD	196		Ponderosa pine	
Level 3			DD	165		Ponderosa pine	
Level 3			DD	215	714p / 776vv	Ponderosa pine	118
Level 3			DD	216		Ponderosa pine	
Level 3			DD	150		Ponderosa pine	
Level 3			DD	220	726p / 776v	Ponderosa pine	119
Level 3			DD	209		Ponderosa pine	
Level 3			DD	221		Juniper	
Level 3			DD	194	728p / 776vv	Ponderosa pine	113

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 71 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4644							
Pitstructure 2 (continued)							
Level 3			DD	160		Ponderosa pine	
Level 3			DD	168		Ponderosa pine	
Level 3			DD	205	723p / 775vv	Ponderosa pine	114
Level 3			DD	147	701p / 768vv	Ponderosa pine	107
Level 3			DD	171		Ponderosa pine	
Level 3			DD	133		Ponderosa pine	
Level 3			DD	132		Ponderosa pine	
Level 3			DD	219		Ponderosa pine	
Level 3			DD	105		Ponderosa pine	
Level 3			DD	157		Ponderosa pine	
Level 3			DD	200		Ponderosa pine	
Level 3			DD	193		Ponderosa pine	
Level 3			DD	103		Ponderosa pine	
Level 3			DD	190		Ponderosa pine	
Level 3			DD	170		Ponderosa pine	
Level 3			DD	169		Juniper	
Level 3			DD	172		Ponderosa pine	
Level 3			DD	158		Ponderosa pine	
Level 3			DD	199		Ponderosa pine	
Level 3			DD	173		Ponderosa pine	
Level 3			DD	100		Ponderosa pine	
Level 3			DD	189		Ponderosa pine	
Surface 1			DD	235	734p / 776vv	Ponderosa pine	121
Surface 1			DD	242		Ponderosa pine	
Surface 1			DD	238		Ponderosa pine	
Surface 1			DD	236		Ponderosa pine	
Surface 1			DD	229		Ponderosa pine	
Surface 1			DD	224		Ponderosa pine	
Surface 1			DD	230		Ponderosa pine	
Surface 1			DD	227		Ponderosa pine	
Surface 1			DD	228		Ponderosa pine	
Surface 1			DD	225		Ponderosa pine	
Surface 1			DD	243		Ponderosa pine	
Surface 1			DD	241		Ponderosa pine	
Surface 1			DD	226		Ponderosa pine	
Surface 1			DD	245		Ponderosa pine	
Surface 1			DD	231		Ponderosa pine	
Surface 1			DD	232		Ponderosa pine	
Surface 1	21	Hearth	AM	2	Used in Dolores Modification		
Surface 1	26	Posthole	DD	247		Juniper	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 72 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4644							
Pitstructure 2 (continued)							
Surface 1	26	Posthole	DD	246		Juniper	
Surface 1	27	Posthole	DD	248		Juniper	
Surface 1	54	Posthole	DD	244		Juniper	
Pitstructure 3							
Surface 1	165	Hearth	AM	8	Used in Dolores Modification		
Grid square 112S/134E							
Surface 1	131	Large floor cist	DD	286		Ponderosa pine	
Surface 1	131	Large floor cist	DD	285		Ponderosa pine	
Grid square 130S/162E							
Surface 1	126	Fireplace	AM	7	pre-700		
5MT4650							
Pitstructure 1							
Surface 1	2	Hearth	AM	1	750-780; 910-950		
Surface 1	20	Posthole	DD	7		Juniper	
Pitstructure 2							
Stratum 2			DD	3		Pinyon pine	
Stratum 3			DD	4		Pinyon pine	
Level 9			DD	1		Douglas-fir	
Level 9			DD	2		Ponderosa pine	
Level 12			DD	5		Ponderosa pine	
Surface 2			DD	6		Ponderosa pine	
5MT4671							
Room 2							
Surface 1	7	Hearth	AM	1	750-780; 855-870; 885-915		
Surface 1	9	Hearth	AM	2	760-790; 850-870; 890-910		
Pitstructure 1							
	113	Ventilation system	DD	3		Ponderosa pine	
	113	Ventilation system	DD	4		Ponderosa pine	
	113	Ventilation system	DD	2		Pinyon pine	
Surface 1			DD	1		Nonconiferous	
Surface 1	119	Hearth	AM	4	770-790; 845-865; 890-915		
Pitstructure 2							
Surface 1	307	Hearth	AM	3	775-795; 835-860		
Surface 1	449	Hearth	AM	5	700-775; 860-925		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 73 of 82)

Provenience			Sample		Dating results*	+Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4683							
Room 1							
Surface 1			DD	5		Quercus	
Surface 1			DD	4		Quercus	
Room 4							
Surface 1	108	Hearth	AM	4	Poor results		
Room 6							
Surface 1	78	Hearth	AM	1	Not near curve		
Room 7							
Surface 1	175	Posthole	CF	4	1095 B.P. ± 60		
Miscellaneous structure							
Surface 1	79	Small floor cist	AM	2	Poor results		
Surface 1	81	Burned pit	AM	3	Poor results		
Nonstructural Unit 1							
Surface 1	2	Hearth	DD	1	915 / 1098vv	Juniper	314
Nonstructural Unit 7							
Surface 1	53	Unburned pit	DD	16		Ponderosa pine	
Surface 1	53	Unburned pit	DD	17		Ponderosa pine	
Surface 1	53	Unburned pit	DD	18		Ponderosa pine	
Excavation unit 1							
Stratum 15			DD	3		Populus	
Stratum 15			CF	3	1050 B.P. ± 60		
Stratum 19			CF	2	1145 B.P. ± 60		
Stratum 21			CF	1	3110 B.P. ± 70		
Stratum 22			DD	11		Ponderosa pine	
Stratum 22			DD	12		Ponderosa pine	
Stratum 22			DD	13		Ponderosa pine	
Stratum 22			DD	10		Ponderosa pine	
Stratum 22			DD	15		Juniper	
Stratum 22			DD	14		Juniper	
Excavation unit 7							
Full cut			DD	6		Quercus	
Full cut			DD	7		Juniper	
5MT4684							
Pitstructure 1							
	29	Bench	AM	2	Poor results		
Level 1			DD	14		Juniper	
Level 2			DD	13		Ponderosa pine	
Level 2			DD	2	575p / 669v	Ponderosa pine	161
Level 2			DD	11		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 74 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4684							
Pitstructure 1 (continued)							
Level 2			DD	12		Ponderosa pine	
Level 2			DD	1		Juniper	
Level 2			DD	6		Ponderosa pine	
Level 2			DD	7		Ponderosa pine	
Level 2			DD	8		Ponderosa pine	
Level 2			DD	5		Ponderosa pine	
Level 2			DD	10		Ponderosa pine	
Level 2			DD	3		Ponderosa pine	
Level 2			DD	4		Juniper	
Level 2			DD	9		Ponderosa pine	
Level 2			DD	15		Ponderosa pine	
Level 2			DD	16		Ponderosa pine	
Level 2			DD	17		Ponderosa pine	
Level 2			DD	18	377fp / 559vv	Juniper	163
Level 2			DD	19		Ponderosa pine	
Level 2			DD	20		Ponderosa pine	
Surface 1	12	Hearth	AM	1	Used in Dolores Modification		
Pitstructure 4							
	51	Bench	AM	3	Poor results		
Level 1			DD	22		Populus	
Level 1			DD	23		Populus	
Level 2			DD	21		Populus	
Level 3			DD	25		Populus	
Level 3			DD	24		Populus	
Level 3			DD	27		Populus	
Level 3			DD	26		Populus	
Level 3			DD	29		Populus	
Level 3			DD	30		Populus	
Level 3	56	Storage bin	DD	28		Populus	
Level 3	57	Storage bin	DD	31		Populus	
Surface 1	55	Hearth	AM	4	700-760; 865-925		
Pitstructure 5							
Surface 1	97	Hearth	AM	5	Used in Dolores Modification		
5MT4725							
Pitstructure 1							
Level 1			DD	10		Ponderosa pine	
Level 1			DD	6		Ponderosa pine	
Level 1			DD	1		White fir	
Level 1			DD	4		White fir	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 75 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4725							
Pitstructure 1 (continued)							
Level 1			DD	3		Ponderosa pine	
Level 1			DD	2	806p / 845r	Ponderosa pine	197
Level 1			DD	5		White fir	
Level 1			DD	32		Ponderosa pine	
Level 1			DD	7		Ponderosa pine	
Level 1			DD	13		Ponderosa pine	
Level 1			DD	33		Ponderosa pine	
Level 1			DD	11		White fir	
Level 1			DD	17		White fir	
Level 1			DD	12		Ponderosa pine	
Level 1			DD	14	822p / 845r	Ponderosa pine	199
Level 1			DD	16	583p / 656vv	Ponderosa pine	201
Level 1			DD	15	817p / 845v	Ponderosa pine	200
Surface 1			DD	9		White fir	
Surface 1			DD	18		Ponderosa pine	
Surface 1			DD	19		Ponderosa pine	
Surface 1			DD	20		White fir	
Surface 1			DD	22		Ponderosa pine	
Surface 1			DD	21		White fir	
Surface 1			DD	27		Ponderosa pine	
Surface 1			DD	23	809p / 845r	Ponderosa pine	202
Surface 1			DD	25		Ponderosa pine	
Surface 1			DD	26		Douglas-fir	
Surface 1			DD	24		Ponderosa pine	
Surface 1			DD	8		Ponderosa pine	
Surface 1	1	Hearth	DD	29		Ponderosa pine	
Surface 1	1	Hearth	AM	2	Used in Dolores Modification		
Surface 1	1	Hearth	DD	28		Ponderosa pine	
Surface 1	1	Hearth	AM	1	Poor results		
Surface 1	5	Posthole	DD	30		Juniper	
Surface 1	15	Posthole	DD	31	811p / 845v	Ponderosa pine	204
Pitstructure 2							
Surface 1	21	Hearth	AM	3	pre-700-750; 875-915		
Pitstructure 3							
Surface 1	30	Hearth	AM	4	Poor results		
Pitstructure 5							
Surface 1	41	Hearth	AM	6	Used in Dolores Modification		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 76 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT4725 (continued)							
Pitstructure 6							
Surface 1	38	Hearth	AM	5	770-795; 845-870; 890-915		
5MT4751							
Pitstructure 1							
Surface 1	8	Hearth	AM	1	1025-1175		
Full cut			DD	1		Juniper	
5MT4763							
Nonstructural Unit 1							
Surface 1	5	Hearth	AM	1	Not near curve		
Surface 1	3	Exterior storage facility	CF	1	1710 B.P. ± 60		
5MT4789							
Grid square 440S/54E							
Stratum 1			DD	2		Ponderosa pine	
Grid square 440S/56E							
Level 1			DD	1		Pinyon pine	
5MT4797							
Excavation unit 1							
Full cut			CF	1	1400 B.P. ± 60		
Grid square 380S/49E							
Full cut			CF	5	1785 B.P. ± 60		
Grid square 400S/51E							
Surface 1	8	Burned pit	CF	9	1490 B.P. ± 60		
Grid square 440S/48E							
Full cut			CF	3	910 B.P. ± 70		
5MT5104							
Pitstructure 1							
	23	Ventilation system	DD	1			
	23	Ventilation system	DD	3			
	23	Ventilation system	DD	2			
5MT5106							
Room 11							
Level 2			DD	1		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 77 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT5106							
Room 11 (continued)							
Level 2			DD	2		Ponderosa pine	
Surface 1			AM	1	750-780; 850-870; 900-925		
Surface 1	25	Posthole	DD	3	718 / 852vv	Juniper	316
Pitstructure 2							
Level 1			DD	7		Ponderosa pine	
Level 1			DD	6		Ponderosa pine	
Surface 1			AM	7	pre-700-750; 865-890; 925-1000		
Surface 1	141	Hearth	AM	6	pre-700-765; 865-930		
Surface 1	65	Posthole	DD	8		Ponderosa pine	
Pitstructure 3							
Surface 1	145	Hearth	AM	4	700-770; 865-925		
Surface 1	145	Hearth	AM	5	725-775; 860-915		
Pitstructure 4							
Level 1			DD	4		Populus	
Surface 1	39	Hearth	AM	3	725-770; 865-915		
Pitstructure 5							
Surface 1	44	Hearth	AM	2	1020-1065		
5MT5107							
Room 28							
Level 1			DD	94		Ponderosa pine	
Room 29							
Surface 1	313	Hearth	AM	2	700-760; 865-885; 910-950		
Room 47							
Stratum 1			DD	95		Ponderosa pine	
Stratum 1			DD	96		Pinyon pine	
Stratum 1			DD	98		Ponderosa pine	
Surface 1			DD	97	689fp / 813+vv	Pinyon pine	342
Room 48							
Level 1			DD	100		Pinyon pine	
Pitstructure 1							
Surface 1	41	Hearth	AM	5	725-775; 860-925		
Pitstructure 2							
			AM	7	700-750; 865-885; 920-955		
Level 1	254	Large floor cist	AM	9	1020-1065		
Level 2			DD	8		Ponderosa pine	
Level 2			DD	21		Ponderosa pine	
Level 2			DD	35		Ponderosa pine	
Level 2			DD	91		Ponderosa pine	
Level 2			DD	13		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 78 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT5107							
Pitstructure 2 (continued)							
Level 2			DD	65		Ponderosa pine	
Level 2			DD	6	806p / 829r	Ponderosa pine	318
Level 2			DD	87		Ponderosa pine	
Level 2			DD	19		Ponderosa pine	
Level 2			DD	28	817p / 843r	Ponderosa pine	322
Level 2			DD	12		Ponderosa pine	
Level 2			DD	11		Ponderosa pine	
Level 2			DD	27	804p / 842+r	Ponderosa pine	321
Level 2			DD	76		Ponderosa pine	
Level 2			DD	80		Ponderosa pine	
Level 2			DD	88	811p / 829r	Ponderosa pine	340
Level 2			DD	24		Ponderosa pine	
Level 2			DD	14		Ponderosa pine	
Level 2			DD	70		Ponderosa pine	
Level 2			DD	23		Ponderosa pine	
Level 2			DD	31		Ponderosa pine	
Level 2			DD	34		Ponderosa pine	
Level 2			DD	22		Ponderosa pine	
Level 2			DD	1	815p / 865vv	Ponderosa pine	317
Level 2			DD	26		Ponderosa pine	
Level 2			DD	30	805p / 829r	Ponderosa pine	323
Level 2			DD	59		Ponderosa pine	
Level 2			DD	47		Ponderosa pine	
Level 2			DD	38	804p / 863vv	Ponderosa pine	324
Level 2			DD	7		Ponderosa pine	
Level 2			DD	15		Ponderosa pine	
Level 2			DD	43		Ponderosa pine	
Level 2			DD	40		Ponderosa pine	
Level 2			DD	36		Ponderosa pine	
Level 2			DD	68		Ponderosa pine	
Level 2			DD	69		Ponderosa pine	
Level 2			DD	44		Ponderosa pine	
Level 2			DD	10		Ponderosa pine	
Level 2			DD	55	798p / 829v	Ponderosa pine	331
Level 2			DD	17		Ponderosa pine	
Level 2			DD	48	802p / 829r	Ponderosa pine	326
Level 2			DD	50	805p / 830r	Ponderosa pine	328
Level 2			DD	37		Ponderosa pine	
Level 2			DD	52		Ponderosa pine	
Level 2			DD	16		Ponderosa pine	
Level 2			DD	53		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 79 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT5107							
Pitstructure 2 (continued)							
Level 2			DD	46		Ponderosa pine	
Level 2			DD	45		Ponderosa pine	
Level 2			DD	58		Ponderosa pine	
Level 2			DD	32		Ponderosa pine	
Level 2			DD	74		Ponderosa pine	
Level 2			DD	49	806p / 829r	Ponderosa pine	327
Level 2			DD	60		Ponderosa pine	
Level 2			DD	56		Ponderosa pine	
Level 2			DD	84		Ponderosa pine	
Level 2			DD	18		Populus	
Level 2			DD	67		Ponderosa pine	
Level 2			DD	39		Ponderosa pine	
Level 2			DD	62		Ponderosa pine	
Level 2			DD	41		Ponderosa pine	
Level 2			DD	3		Ponderosa pine	
Level 2			DD	64		Ponderosa pine	
Level 2			DD	72		Ponderosa pine	
Level 2			DD	54		Ponderosa pine	
Level 2			DD	71	806p / 829r	Ponderosa pine	334
Level 2			DD	63		Ponderosa pine	
Level 2			DD	82		Ponderosa pine	
Level 2			DD	89		Ponderosa pine	
Level 2			DD	25		Ponderosa pine	
Level 2			DD	42		Ponderosa pine	
Level 2			DD	92		Ponderosa pine	
Level 2			DD	29		Ponderosa pine	
Level 2			DD	2		Ponderosa pine	
Level 2			DD	61		Ponderosa pine	
Level 2			DD	86	750p / 823r	Ponderosa pine	339
Level 2			DD	57		Ponderosa pine	
Level 2			DD	20		Ponderosa pine	
Level 2			DD	73		Ponderosa pine	
Level 2			DD	78	777p / 827vv	Ponderosa pine	337
Level 2			DD	33		Ponderosa pine	
Level 2			DD	4		Ponderosa pine	
Level 2			DD	79		Ponderosa pine	
Level 2			DD	9		Ponderosa pine	
Level 2			DD	5		Ponderosa pine	
Level 2			DD	90		Ponderosa pine	
Level 2			DD	83	761fp / 814vv	Ponderosa pine	338
Level 2			DD	77		Ponderosa pine	

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 80 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature No.	Feature Type	Type	No.			
5MT5107							
Pitstructure 2 (continued)							
Level 2			DD	81		Ponderosa pine	
Level 2			DD	93		Ponderosa pine	
Level 2			DD	85		Ponderosa pine	
Level 2			DD	66		Ponderosa pine	
Level 2			DD	75	808p / 829r	Ponderosa pine	336
Surface 1			DD	99		Ponderosa pine	
Surface 1	98	Hearth	AM	8	pre-700-740; 870-900		
Surface 1	16	Posthole	DD	51	584p / 677vv	Ponderosa pine	329
Pitstructure 3							
Surface 1	100	Hearth	AM	3	845-870; 890-915		
Pitstructure 4							
Surface 1	113	Hearth	AM	4	725-780; 860-915		
Pitstructure 9							
Surface 1	379	Hearth	AM	11	750-785; 850-870; 885-925		
Pitstructure 10							
Surface 1	386	Hearth	AM	10	745-785; 855-870; 880-920		
Pitstructure 11							
Surface 1	325	Hearth	AM	6	775-795; 840-860		
Nonstructural Unit 2							
Surface 1	290	Burned pit	AM	1	700-770; 865-885; 915-950		
5MT5108							
Room 4							
Surface 1	20	Posthole	DD	3		Ponderosa pine	
Surface 1	20	Posthole	DD	4		Ponderosa pine	
Room 11							
Surface 1			AM	1	765-790; 850-870, 890-915		
Surface 1	5	Posthole	DD	1		Ponderosa pine	
Surface 1	7	Posthole	DD	2		Ponderosa pine	
Pitstructure 1							
			AM	3	pre-700		
Surface 1	31	Hearth	AM	2	pre-700 750; 870-890; 925-965		
Pitstructure 2							
Surface 1	160	Hearth	AM	4	700-775; 860-920		
Nonstructural Unit 2							
Surface 1	193	Burned pit	AM	5	Poor results		
5MT5361							
Excavation unit 3							
Level 10			CF	17	2185 B.P. ± 100		
Level 10			CF	16	1600 B.P. ± 90		

Table A.1 Absolute dates from excavated sites, Dolores Archaeological Program (Page 81 of 82)

Provenience			Sample		Dating results*	Tree-ring common name	DAR No.
Site No. Structure Vertical subdivision	Feature		Type	No.			
	No.	Type					
5MT5361 (continued)							
Excavation unit 6							
Surface 1	1	Fireplace	DD	1		Pinyon pine	
5MT5863							
Pitstructure 1							
Stratum 1			DD	2			
Stratum 1			DD	3	643fp / 791vv	Juniper	418
Stratum 1			DD	1	669p / 728vv	Douglas-fir	416
Surface 1	1	Posthole	DD	4	674p / 747vv	Douglas-fir	419
Surface 1	2	Posthole	DD	5			
5DL444							
Miscellaneous structure							
Surface 1	3	Posthole	CF	2	290 B.P. ± 50		

Table A.1 Absolute dates from excavated sites,
Dolores Archaeological Program (Page 82 of 82)

* Dates with letters indicate tree-ring dates (explained in notes). All dates are reported in years A.D. unless otherwise noted.
† (a and b).

NOTES: Tree-ring samples with a taxon identification only did not yield a date. DAR numbers, taxa, dates, and the following tree-ring symbols were provided by the Laboratory of Tree-Ring Research, University of Arizona, Tucson. Tree-ring dates to the left of the slash represent inside dates; those to the right of the bar represent outside dates.

- p - Pith ring present.
- fp - The curvature of the inside ring indicates that it is far from the pith.
- ±p - Pith ring present, but due to the difficult nature of the ring series near the center of the specimen, an exact date cannot be assigned to it. The date is obtained by counting back from the earliest dated ring.
- ± - The innermost ring is not the pith ring and an absolute date cannot be assigned to it. A ring count is involved.
- B - Bark present.
- G - Beetle galleries are present on the surface of the specimen.
- r - Less than a full section is present, but the outermost ring is continuous around available circumference.
- v - A subjective judgment that, although there is no direct evidence of the true outside on the specimen, the date is within a very few years of being a cutting date.
- vv - There is no way of estimating how far the last ring is from the true outside.
- + - One or more rings may be missing near the end of the ring series whose presence or absence cannot be determined because the specimen does not extend far enough to provide an adequate check.
- ++ - A ring count is necessary due to the fact that beyond a certain point the specimen could not be dated.

n.o. - No observation could be made.
AM - Archaeomagnetic sample.
CF - Radiocarbon sample.
DD - Tree-ring sample.
RDA - Recent disturbance area.

APPENDIX B

SITE REPORT ABSTRACTS

Sheep Skull Camp (Site 5MT2202), DAP-004 (Schlanger 1983)

Sheep Skull Camp (Site 5MT2202) is a prehistoric limited activity locus in the Sagehen Flats Locality, Escalante Sector, southwestern Colorado. The site is located on a hilltop overlooking the Sagehen Flats marsh to the south. For purposes of intensive investigation, the site was divided into 3 sampling strata based on distribution of surface artifacts. Sixty-five test squares were selected, via a stratified random sampling design, and excavated; backhoe tests, a magnetometer survey, and blading were also conducted at the site after preliminary investigations had been completed. Results of this extensive subsurface sampling were largely negative, although 1 rock-outlined hearth was encountered approximately 10 to 15 cm below surface (by the blading program) and artifacts were found in loose surficial deposits in some of the test pits. There appears little likelihood that significant undisturbed subsurface deposits exist at the site.

On the basis of the differential distribution of surface artifactual material, 3 areas of prehistoric activity were defined; analysis of artifact composition suggests some differences in activities among the 3 areas. The site appears to have functioned primarily as a resource procurement and processing locus, rather than as a habitation or storage site.

Sagehill Hamlet (Site 5MT2198), DAP-005 (Hewitt 1983)

Sagehill Hamlet (Site 5MT2198), a small Anasazi habitation located approximately 5 miles northwest of Dolores, Colorado, was excavated during the summer of 1978 as part of the Dolores Project Cultural Resources Mitigation Program. Field operations were conducted during the months of August and September; a University of Colorado crew excavated and recorded a small pithouse and associated surface features. Sagehill Hamlet was probably the domicile and home base of a single household group practicing limited agriculture and foraging in the Escalante Sector. Because of the scant nature of the material collection and the lack of any major architectural remodeling, it is assumed that the site was inhabited for a relatively short time. While Sagehill Hamlet is clearly associated with the Sagehen Phase (A.D. 600-850), more precise dating of the site is problematic: tree-ring dates indicate that pithouse construction probably occurred during the last half of the 7th century A.D., while ceramic analysis suggests that the occupation occurred during the 8th century, terminating by A.D. 775.

Little House (Site 5MT2191), DAP-007 (Hewitt 1983)

Little House (Site 5MT2191) is a small Anasazi seasonal habitation or agricultural field house located approximately 5 mi (8 km) northwest of Dolores, Colorado. The site was excavated during the summer of 1978 as part of the Dolores Project Cultural Resources Mitigation Program. Field operations were conducted during the months of July and August. A crew consisting of University of Colorado and Youth Conservation Corps personnel investigated the small surface structure comprising 4 small rooms and associated features. On the basis of ceramic analysis, Little House has been assigned to the early part of the McPhee Phase (A.D. 850-970). Site 5MT2191 was probably the seasonal abode for a small household or intrahousehold group practicing small-scale agriculture in the immediate site vicinity. It is inferred that the site was occupied only during the growing and harvest season (May through September). The lack of any major remodeling episodes and the small size of the material collection suggest the site was in use for a short period of time, perhaps no more than a single generation.

Tres Bobos Hamlet (Site 5MT4545), DAP-025 (Brisbin and Varien 1981)

Tres Bobos, Site 5MT4545, is a small Basketmaker III habitation in extreme southwestern Colorado, near the present town of Dolores. Excavations by the DAP (Dolores Archaeological Program) discovered 1 pithouse, 14 noncontiguous surface rooms, and numerous ancillary features. The number and spatial distribution of the surface rooms in 2 discreet areas around the single pithouse indicate that 2 occupations were centered around the pithouse. The differential spatial configuration of these room sets and the well-developed antechamber of the pithouse reflect the transition from

late Basketmaker to early Pueblo times, a period associated with a dependency on agriculture. This spatial configuration of rooms, the architectural style, and the ceramics collected at the site indicate Tres Bobos was occupied during an early portion of the Sagehen Phase (A.D. 600-850, according to Dolores Archaeological Program temporal designations).

Apricot Hamlet (Site 5MT2858), DAP-026 (Montgomery 1982)

Apricot Hamlet, Site 5MT2858, is a multiple occupation Basketmaker III III/Pueblo I habitation site. Apricot Hamlet is located in Montezuma County, in southwestern Colorado, and was excavated in 1979 as a part of the DAP field operations. The site was excavated to acquire information on cultural patterning of the dispersed community that existed on the highlands west of the Dolores River valley during the Sagehen Phase (A.D. 600-850) of the Anasazi Tradition. Excavations revealed a pithouse, with main chamber and antechamber, several peripheral features, and a second, unfinished pitstructure. The antechamber contained a hearth and deflector mold, indicating that it was used at some time for domestic activities. Based on ceramic evidence, archaeomagnetic dating samples, and the presence of a midden deposit in the pithouse, the site is believed to have been occupied between A.D. 635 and 680, abandoned, and then reoccupied briefly between A.D. 750 and 800, during which time the second pitstructure was begun.

Pheasant View Hamlet (Site 5MT2192), DAP-027 (Yarnell 1982)

Pheasant View Hamlet (Site 5MT2192), excavated in 1979 by the DAP, represents a single-family household cluster occupied during the Pueblo I period. The site, located in Montezuma County in southwestern Colorado, consists of a pithouse, adjacent roomblock, borrow pit, and associated features. The architectural style of the roomblock, contiguous surface rooms with a basal course of slabs which probably supported jacal walls, suggests a temporal setting of approximately A.D. 780-825. The ceramic profile, in particular the presence of Moccasin Gray ceramics, suggests a temporal setting of at least A.D. 775. It is therefore inferred that Pheasant View Hamlet was occupied sometime between A.D. 775 and 825. The absence of remodeling to the structural units, the low frequency of artifacts, and the volume of midden deposits indicate an occupation of less than 20 years.

Two postoccupational burials were encountered at the site, probably interred there by occupants of a nearby household.

Dos Casas Hamlet (Site 5MT2193), DAP-028 (Brisbin et al. 1982)

Dos Casas Hamlet (Site 5MT2193) is a small Basketmaker III/Pueblo I Anasazi site located approximately 8 km northwest of the town of Dolores, Montezuma County, Colorado. During the summer of 1978, the University of Colorado excavated the site as part of first-year operations associated with the Dolores Cultural Resources Mitigation Program. These investigations recorded 2 prehistoric pithouses and an arc of associated surface rooms and outdoor occupation areas to the north at Site 5MT2193. The pithouses are alined north-south with the ventilator tunnel of the northern structure dug through the northern wall of the southern structure, indicating that 2 occupations, or elements, were present, perhaps both using the same group of surface facilities. These 2 hypothetical elements are borne out by the dates for tree-ring samples recovered from the 2 pithouses. The more southerly house (Pithouse 1) was constructed around A.D. 760 and Pithouse 2 was constructed approximately 10 years later, about A.D. 770. The site is located in the Sagehen Flats Locality, Escalante Sector, Yellowjacket District, and was occupied during the Sagehen Phase (A.D. 600-850). The site is classified as a small hamlet or semipermanent to permanent habitation and is inferred to have been the abode of a family unit (perhaps 6 to 9 individuals) practicing small-scale agriculture in the local area. This family is postulated to have been one social unit of the West Sagehen Neighborhood, a local dispersed Anasazi community inhabiting the area in the eighth century A.D.

Prairie Dog Hamlet (Site 5MT4614), DAP-029 (Yarnell 1982)

Prairie Dog Hamlet, Site 5MT4614, was excavated in 1979 by the University of Colorado under the auspices of the DAP. Located in Montezuma County in southwestern Colorado, the site dates to the late Basketmaker III-early Pueblo I periods of the Anasazi Tradition.

The site had 2 occupations, represented by 2 separate pithouses with associated surface structures and features, and a single episode represented by the partial construction of a pitstructure. Although the 2 occupations were separated by a short cultural hiatus, both were components of the Sagehill Subphase (A.D. 600-760) of the Sagehen Phase, according to DAP temporal systematics. Spatially, the 2 occupations represent family habitations in the West Sagehen Community, a dispersed local community that consisted of horticulturally based households located near cultivated fields. The site was excavated to expand the Dolores Archaeological Program sample of sites that were a part of this Anasazi community.

Casa Bodega Hamlet (Site 5MT2194), DAP-030 (Brown 1982)

Casa Bodega Hamlet (Site 5MT2194) is a Pueblo I habitation site excavated during the 1979 field season by the DAP. The site is located in Montezuma County in southwestern Colorado. It was excavated as part of the sample of habitations from the West Sagehen Neighborhood, a dispersed Anasazi community in the Sagehen Flats Locality during the Sagehen Phase (A.D. 600-850, according to program systematics).

Excavations revealed a single household cluster consisting of a pithouse, 3 informal storage facilities, a peripheral work area, and a sheet trash area. Architecturally, the site is characteristic of the Sagehill Subphase (A.D. 600-760). The ceramic data, however, based on the occurrence of Moccasin Gray sherds, places the occupation of the hamlet between A.D. 775 and 850. The small number of features and artifacts and the small size of the pithouse suggest the site was occupied by a small group, perhaps a nuclear family, for no more than a single generation.

Moonlight House (Site 5MT2205), DAP-031 (Kleidon 1982)

Moonlight House (Site 5MT2205), located in extreme southwestern Colorado, is a two-room structure dating to the Pueblo I period (A.D. 750-900) of the Anasazi Tradition. The site was excavated in 1979 by the DAP as an example of a nonhabitational, special-use site. Upon excavation of Moonlight House, it was determined the site served primarily as a storage facility and food-processing center.

Casa Roca (Site 5MT2203), DAP-032 (Brisbin 1982)

Casa Roca, Site 5MT2203, is a small, seasonal use, single-component site located in southwestern Colorado. The site was excavated in 1979 by the DAP as part of a representative sample of sites, by site type and temporal period, from the borrow areas of the Dolores Project, a Bureau of Reclamation water storage project. Casa Roca is assigned to the McPhee Phase (A.D. 850-970) as defined by the program temporal system. This corresponds to the late Pueblo I and early Pueblo II periods of the Pecos Classification. The major architectural feature at the site is a masonry surface room with a stone-lined floor. It is inferred that this site was a field house, which was occupied seasonally. In addition to the surface structure, 7 exterior subsurface features were located, including 5 basin-shaped heating pits and a large slab-lined fireplace.

Faraway House (Site 5MT4763), DAP-033 (Kleidon 1982)

Faraway House, Site 5MT4763, was excavated in 1979 as part of the DAP, located in extreme southwestern Colorado. The site was selected for excavation to expand the sample of limited activity/seasonal use sites in the program data base. The site consists of a masonry storage bin and 2 hearths and is located near arable soils. It is inferred that the site was built by the Anasazi during the Pueblo I or Pueblo II period and was used seasonally for the storage of a cultigen grown nearby.

Cascade House (Site 5MT4512), DAP-034 (Wilshusen 1982)

Cascade House (Site 5MT4512) is a Pueblo I field house excavated in 1979 as part of the DAP. The main architectural features at the site are Anasazi in form but smaller than typical Anasazi; a small pithouse and pitroom, and 2 masonry/jacal surface storage rooms were excavated. Over 20 food-processing pit features were found in a crescent around the pithouse, and several discrete clusters of hearths and a concentration of artifacts appeared to be specific activity areas. It is argued that the site was only seasonally occupied as a field house because it lacks domestic space and features types. It is thought that the site was occupied for at least 2 seasons and possibly for as long as a decade. The location of the site near a main drainage and near good agricultural land supports the hypothesis that it was the field headquarters of a group of Anasazi dryland farmers. The ceramics associated with the site date it as contemporaneous with some of the nearby early pueblos. Cascade House appears to have been occupied during the first half of the ninth century A.D., making it one of the earliest occurrences of a seasonally used field house in the Dolores Project area.

Marshview Hamlet (Site 5MT2235), DAP-035 (Wilshusen 1982)

Marshview Hamlet (Site 5MT2235), a small Pueblo III habitation site located northwest of Dolores, Colorado, was excavated during the 1978 field season as part of the DAP. Between 24 July and 2 November 1978, a small pithouse and associated surface structures and features of this small unit hamlet were excavated and documented by University of Colorado crew members and personnel of the Bureau of Reclamation Youth Conservation Corps and Young Adult Conservation Corps. In October 1979, the site was regridded for a more extensive surface collection.

Materials and artifacts collected from Marshview Hamlet suggest the prehistoric inhabitants were a family of

horticulturalists subsisting on crops grown in fields near the site. Faunal remains indicate the inhabitants augmented their diet by hunting small game.

The main occupation at Marshview Hamlet occurred in the Sundial Phase (A.D. 1050-1200), according to program temporal systematics. Soon after the main abandonment, a multiple burial was placed in the pithouse; the relationship of the burial to the main occupation of the site remains uncertain. Other evidence suggests that the site also served as a limited activity locus after the main occupation.

The Testing Program, DAP-036 (Hewitt 1983)

During the 1979 field season of the DAP, 9 sites were partially excavated as part of a testing program. These sites are Charred House (5MT2844), Cansado Camp (5MT2857), Lee Side Camp (5MT4513), Desecho Camp (5MT4642), Roadside Camp (5MT4649), Lone Pine Hamlet (5MT2162), Rusty Ridge Hamlet (5MT2848), Deer Hunter Hamlet (5MT2853), and Sunflower Hamlet (5MT4640). This program was initiated to supplement data obtained from more fully excavated sites. Specifically, this program was designed to provide additional information about the occupation of the Sagehen Flats Locality of the Dolores Project area during the Sagehen Phase, which is comparable to the Basketmaker III-Pueblo I period. Each site investigated as part of this program was subjected to standard testing procedures designed to extract a considerable amount of data without expending the time and effort required for intensive excavation. Investigations at these sites revealed that 5 of them were limited activity sites and 4 were hamlets. All were occupied or used during the Sagehen Phase.

Horse Bone Camp (Site 5MT2199), DAP-037 (Brown 1982)

Horse Bone Camp, Site 5MT2199, is located on a low knoll in the southern portion of the Sagehen Flats Locality. During initial survey, the site was described as an extensive lithic scatter. Excavation during the 1979 field season of the DAP revealed the only cultural features found at the site, a burned pit and a hearth, neither of which could be dated. The artifact assemblage indicates both the Archaic and Anasazi Traditions are represented at the site. The lack of architecture, types of artifacts recovered, low artifact density, and site location suggest that Horse Bone Camp served as a limited activity locus, possibly associated with hunting activities, during both the Archaic and Anasazi time periods.

Horsefly Hamlet (Site 5MT2236), DAP-038 (Kane and Chenault 1982)

Horsefly Hamlet (Site 5MT2236) is an Archaic camp/Anasazi habitation site in the Sagehen Flats Locality of the Dolores Archaeological Program study area. Investigations were initiated during the fall of 1979 as part of the project's standard fall testing program; the goal of the work was to add information to the Sagehen Flats cultural data bases, specifically to the Sagehen Phase West Sagehen Neighborhood and Archaic North Marsh Band categories. The site was reopened in 1981 to resolve interpretational ambiguities concerning the architectural units discovered during the initial season of operation. Two major use components are inferred to have occurred at the site. The first apparently represents seasonal or temporary use of the site area by Archaic peoples, perhaps about 2500 B.C. The second use was by an Anasazi group who built and used a roomblock and pitstructure. Tree-ring analysis suggests the Anasazi component dates to the time span A.D. 760-780. Two burials were also recovered from the site and apparently date to the Anasazi component. Slight evidence indicates a later Anasazi use or visitation of the site, but lack of evidence precludes definitive descriptions.

Ridge Line Camp (Site 5MT2242), DAP-039 (Southward 1982)

Investigations at Ridge Line Camp, Site 5MT2242, were undertaken during the 1979 field season of the DAP. The site is located in the Sagehen Flats Locality. Two firepits were discovered at the site, and flaked lithic, nonflaked lithic, and ceramic artifacts were recovered. The results of artifact analyses and a radiocarbon date of 3710 ± 90 years B.P. indicate the site was occupied during the Archaic and Anasazi (Pueblo I, Pueblo II, and Pueblo III) time periods. No structures were found at Ridge Line Camp, suggesting that use of the area during both the Archaic and Anasazi periods was impermanent in character. Based on the artifacts collected, activities at the site may have included food procurement or processing, and flaked lithic tool manufacturing.

Hawk House (Site 5MT4681), DAP-040 (Brown 1981)

Hawk House (Site 5MT4681) is a multifunctional limited activity site located in extreme southwestern Colorado near the present town of Dolores. The site was excavated in September 1979 as a part of the Dolores Project Cultural Resources Mitigation Program.

The flaked lithic tool assemblage consists of highly curated items associated with hunting and game processing; these items may have been associated either with

an Archaic group of with a highly specialized Anasazi group. The nonflaked lithic tool assemblage contains predominately food-processing tools characteristic of the Archaic Tradition. Ceramic and architectural data indicate site usage between A.D. 850-900, or during the McPhee Phase (A.D. 850-970), according to DAP temporal systematics.

The paucity of features at Hawk House indicates the site had restricted use, but the material culture assemblage reflects both hunting and food-processing activities, possibly occurring as early as Archaic times and also during the McPhee Phase.

Climbing Cactus Camp (Site 5MT4682), DAP-041 (Wilshusen 1982)

Site 5MT4682, Climbing Cactus Camp, was initially investigated through a 10-percent surface artifact collection by survey crews. This survey was conducted in 1979 as part of the DAP. The site was identified during initial inventory survey as being a hunting camp with multiple temporal components. Based on a high percentage of projectile points and bifaces recovered in the 10-percent survey collection, it was decided an intensive (100 percent) surface artifact collection in 8- by 8-m grid units might produce data for a more precise interpretation of the site. Of particular concern was the possibility of an Archaic component. The only temporally diagnostic artifacts from the site are 13 sherds that date the site to the Anasazi period, between A.D. 600-900. The main portion of the collection is lithic tools and debris. The site is located on a small knoll immediately north of present-day Sagehen marsh; assuming the marsh existed prehistorically, it might have served as a natural attraction for animals. The high percentage of projectile points also suggests a functional interpretation of the site related to hunting activities.

The Grass Mesa Locality Testing Program, DAP-081 (Gross 1984)

Eighteen sites were tested in the Grass Mesa Locality during the 1979 and 1980 field seasons. Test excavations, including both probability and judgmental excavation, were conducted at Hanging Rock Hamlet (Site 5MT4650), Cougar Springs Cave (Site 5MT4797), Quasimodo Cave (Site 5MT4789), Dos Cuartos House (Site 5MT2174), Calmate Shelter (Site 5MT4651), and DTA Site (Site 5MT5361). The remaining 12 sites were investigated through surface collection, occasionally augmented by shovel scraping or minimal excavation. The goal of the program was to obtain sufficient information to allow the placement of these sites in the DAP spatial and temporal systems with better accuracy than was possible from survey records alone. This report describes the investigations at each of these sites and discusses the structures, features, and artifacts encountered. Temporal and functional assignments are made for each of the sites.

Prince Hamlet (Site 5MT2161), DAP-082 (Sebastian and Howes 1983)

Prince Hamlet, Site 5MT2161, is a Pueblo I habitation site investigated by the DAP during the 1979 and 1980 field seasons. Evidence of 3 separate periods of occupation was encountered. The first occupation appears to have begun sometime after A.D. 720 and to have ended prior to A.D. 840. The exact nature and areal extent of this occupation is uncertain, but it definitely included at least 1 substantial surface structure and probably 1 pitstructure. The second occupation, believed to have taken place sometime between A.D. 840 and 900, was marked by the construction of a large, double-row roomblock and 2 large, masonry-lined pithouses. The third occupation of the site appears to have been quite brief and was localized in and around the partially filled depression of 1 of the pitstructures. This use of the site, represented by a cluster of late ceramics that may be associated with the remains of a temporary shelter, is believed to have occurred sometime during the A.D. 1050-1200 time period.

LeMoc Shelter (Site 5MT2151), DAP-083 (Hogan 1983)

LeMoc Shelter (Site 5MT2151) is a small, stratified site on the south-facing slope of the Dolores River canyon. During excavation of the shelter by the DAP, the remains of 5 successive Anasazi occupations that date to between A.D. 750 and 950 were discovered. During the earliest documented occupation, which dates to the late Sagehill Subphase (A.D. 750-780), the shelter appears to have been occupied year-round by a nuclear family or small extended family. The next clearly defined occupation occurred during the late Dos Casas and early Periman Subphases – between A.D. 840 and 860. Again, the shelter appears to have served as a permanent residence. In this case, however, the simultaneous use of a pithouse and a surface habitation suggest that an extended family was the basic residential unit.

Following an occupation hiatus, the site was reoccupied sometime between A.D. 875 and 890 – the Grass Mesa Subphase. During this period, the shelter apparently served as a seasonal farming station. Presumably, the main residence was located at Grass Mesa Village (Site 5MT23).

The last 2 occupational episodes suggest short-term use of the shelter as a camp from which wild resources were procured. Both of these episodes are assigned to the Cline Subphase and date to approximately A.D. 920-930 and A.D. 930-950, respectively. Between A.D. 950

and 1150, the shelter appears to have been used only rarely.

Periman Hamlet (Site 5MT4671), Area 1, DAP-090 (Wilshusen 1983)

Area 1 of Periman Hamlet (Site 5MT4671) contains a large Anasazi roomblock and pitstructure tested by the DAP in 1979 and almost fully excavated in the 1980 field season. The site is located in the Dolores River valley on an alluvial fan just above the main flood plain. Intensive excavations in Area 1 defined and documented a block of 18 surface rooms and an associated pitstructure. Based on general spatial and architectural characteristics, the main element of occupation is temporally placed within the late Dos Casas Subphase of the Sagehen Phase. While no absolute dates could be ascribed to the main occupation, comparisons with better dated sites within the project area, 3 archaeomagnetic dates, and the overlap of the range of dates for floor-associated ceramics all suggest that Area 1 dates to sometime between A.D. 800 and 850. Soon after excavation at the site was completed, a haul road destroyed the site. The site was excavated not only because of its impending dam-construction related destruction, but also because it was one of the few large hamlets in the project study area actually located directly on the river valley flood plain.

Periman Hamlet (Site 5MT4671), Areas 2, 3, 4, and 7, DAP-091 (Yarnell 1983)

Areas 2, 3, 4, and 7 at Periman Hamlet (Site 5MT4671), an Anasazi site in southwestern Colorado, were investigated during the 1979 and 1980 field seasons of the DAP. Cultural remains in Areas 2 and 3 consist only of surface artifacts deposited by slope wash from the adjacent areas (Areas 1 and 4). In Area 4, the remains of 2 elements, or occupations, were recognized and fully excavated. The earlier element is manifested by a roomblock, an isolated room, a pithouse, a special-use pitstructure, and the middens and outdoor use areas associated with these structures. This element has been dated to approximately A.D. 780-810, which places the element within the Dos Casas Subphase of the Sagehen Phase (according to DAP systematics), or to the Pueblo I period (according to the Pecos Classification). The later element was represented by a field house and associated burial and midden. This element was short-lived and occurred sometime between A.D. 880 and 910, during the transition between the Periman and Cline Subphases of the McPhee Phase (i.e., during the Pueblo II period). Area 7 included a roomblock and associated pithouse, which were only partially excavated. Only one element of occupation was identified for Area 7. The occupation was apparently brief and probably took place sometime between A.D. 820 and 850 (i.e., during the late Dos Casas Subphase, or the Pueblo I period). Two human burials, probably associated with the occupation of the site, were recovered during investigations at Periman Hamlet.

Hamlet de la Olla (Site 5MT2181), DAP-095 (Etzkorn 1983)

Site 5MT2181 (Hamlet de la Olla), a Pueblo I habitation located 7.6 km northwest of Dolores, Colorado, was test excavated during the 1980 field season of the DAP. Also excavated was a small field house located within sufficient proximity to warrant its investigation during test operations. The hamlet dates to AD. 780-800/810, which corresponds to the Dos Casas Subphase of the Sagehen Phase according to program temporal systematics. The exact temporal affiliation of the field house is not known; however, it is speculated that it postdates the hamlet by at least 40 to 50 years. The prehistoric inhabitants of the hamlet probably were agriculturalists who also practiced hunting and gathering to complete their subsistence base. Less is known about the group or groups responsible for the construction of the field house, but it is assumed that they, too, were primarily agriculturalists.

Aldea Alfareros (Site 5MT4479), DAP-100 (Kleidon 1983)

Aldea Alfareros (Site 5MT4479) is a large Anasazi site located approximately 7 km northwest of Dolores, Colorado. This site was selected for excavation by the DAP to gather data from a Pueblo I settlement. The site was completely excavated; these investigations revealed the remains of 9 surface rooms and 2 pitstructures as well as numerous outdoor occupation areas. These structures were occupied simultaneously by 2 household groups. These households are believed to have been part of the McPhee Community; a nucleated community that consisted of an aggregation of large and small habitation units. Ceramic, architectural, and archaeomagnetic evidence indicate Aldea Alfareros was occupied sometime between A.D. 850 and A.D. 890. According to the program phase scheme, this site was occupied during the Periman Subphase of the McPhee Phase.

Tres Chapulines Pueblo (Site 5MT4725), DAP-102 (Chenault 1983)

Tres Chapulines Pueblo (Site 5MT4725) is a small Anasazi habitation located approximately 6 km northwest of Dolores, Colorado. During the summer of 1980, the site was excavated as part of a DAP testing program. These investigations resulted in the discovery of 6 pitstructures and associated rooms. These remains represent 2 temporally distinct, but sequential, occupations. Ceramic materials, architectural style, and

1 tree-ring date indicate that the site was inhabited sometime during the Pueblo I period (A.D. 750-900).

Kangaroo Camp (Site 5MT4690), DAP-105 (Greenwald and Phagan 1983)

Kangaroo Camp (Site 5MT4690) is an aceramic site in the Sagehen Flats area. The artifact assemblage is small and consists only of flaked lithic tools, debitage, and a few nonflaked lithic items. A comparison of artifact profiles suggests the site is likely to represent a mixture of Archaic and aceramic Anasazi components.

Chindi Hamlet (Site 5MT4684), DAP-106 (Tucker 1983)

Site 5MT4684, Chindi Hamlet (Ghost Hamlet), is a small hamlet located in the Dolores River valley. The site was excavated between May and October of 1980 as part of an intensive testing program established by the DAP. Excavated units at the site include 2 typical Basketmaker III pithouses, 1 atypical pithouse, and 2 surface structures. Four additional surface structures were identified but unexcavated. Two temporally distinct elements are believed to have occurred at Chindi Hamlet during A.D. 650-700.

Aldea Sierritas (Site 5MT2854), DAP-107 (Kuckelman 1983)

Aldea Sierritas (Site 5MT2854) is a small Anasazi hamlet located approximately 8 km northwest of Dolores, Colorado. Excavations were carried out under the direction of the DAP during the 1979 and 1980 field seasons. Investigations revealed 2 pithouses, 3 surface rooms, and many associated features. Two spatially overlapping but temporally separate occupations were recognized at the site. Available data suggest the site is characteristic of the Sagehen Phase (A.D. 600-850). The characteristics of the initial occupation suggest an assignment to the transition between the Tres Bobos and Sagehill Subphases; the characteristics of the final occupation suggest a Sagehill Subphase association. These phase and subphase designations roughly correspond to the Basketmaker III-Pueblo I transition of the Pecos Classification.

Windy Wheat Hamlet (Site 5MT4644), DAP-108 (Brisbin 1984)

Windy Wheat Hamlet (Site 5MT4644) is a Pueblo I habitation located in the Sagehen Flats Locality of the DAP study area. Three elements of occupation, occurring between A.D. 740 and the early 800's, have been recognized at Windy Wheat Hamlet. During the earliest element, which dates to the late Sagehill Subphase, one pitstructure was occupied at the site. No surface rooms were found to be associated with this element, but extensive plowing may have destroyed evidence of such structures. After a brief period of abandonment, the site was reoccupied and one pitstructure and several surface rooms were constructed. This occupation, termed Element 2, began in A.D. 776 (based on tree-ring dates) and has been assigned to the Dos Casas Subphase. In approximately A.D. 800, another pitstructure and several additional surface rooms were constructed. Thus, this final occupation (Element 3), which has been assigned to the Dos Casas Subphase, was manifested by 2 pitstructures and a series of surface rooms. In the early 800's, the structures at the site were burned and the site was abandoned.

Due to the excellent preservation of Pitstructure 1, an intensive botanical and pollen sampling program was implemented in this structure. The results of this sampling program are provided in the report appendixes.

Sundance Pueblo (Site 5MT2215), DAP-109 (Harriman 1983)

Sundance Pueblo, Site 5MT2215, is a late Pueblo II-Early Pueblo III site excavated during the summer of 1980 by the University of Colorado as part of the DAP. The site represents a limited Anasazi occupation during the Sundial Phase (A.D. 1050-1200). Sundance Pueblo consists of a two-unit masonry roomblock and an incomplete pitstructure located on a spur overlooking the Dolores River and House Creek.

Southview House (Site 5MT2241), DAP-110 (M. Morris 1983)

Southview House (Site 5MT2241) was an Anasazi seasonal, special use site excavated by personnel of the DAP in 1980. The site was used during 2 distinct periods within the broad time ranges of A.D. 750 to 900 and A.D. 1050 to 1150. A single masonry structure, 6 nonstructural units, and 6 economic activity areas were investigated. The use of Southview House appears to have been related to its location on a topographic prominence and its association with specific vegetation zones.

Dos Piedras Camp (Site 5MT4779), DAP-111 (Etzkorn 1983)

Dos Piedras Camp (Site 5MT4779) is an Anasazi site overlooking the Dolores River and flood plain 7.5 km northwest of the town of Dolores, Colorado. The site was test excavated during the 1980 field season of the DAP. Based on the low artifact density and lack of architectural remains, the site is believed to have been a limited activity locus subject to brief, probably repeated, episodes of use or occupation. Two large sandstone rocks that create protective overhangs appear to

have been the focal point of prehistoric activity. One of these rocks bears several anthropomorphic petroglyphs. Identification of the activities (beyond the production of the rock art) that may have been conducted at the site is difficult; however, the artifact assemblage and the location of the site suggest possible associations with lithic quarrying tasks or food-processing activities. Based on ceramic typology, Area 1 of Dos Piedras Camp can be dated no more precisely than A.D. 600-950; Areas 2 and 3 are dated to A.D. 760-925 and A.D. 800-850, respectively. These date ranges encompass the Basketmaker III, Pueblo I, and Pueblo II periods of the Pecos Classification, and the Sagehen and McPhee Phases according to DAP temporal systematics.

Jeddito Hamlet (Site 5MT4541), DAP-112 (Greenwald 1983)

Jeddito Hamlet (Site 5MT4541) is a multicomponent site located in the Sagehen Flats Locality. Surface rubble and associated ceramics indicate the presence of a Sundial Phase hamlet (A.D. 1050-1200). Surface sherds also indicate the probable presence of an earlier component dating to the McPhee Phase (A.D. 850-970) and a later limited use of the site between A.D. 1325 and 1600. The site is situated on private property as well as land purchased for the construction of the McPhee Reservoir. That portion of the site scheduled to receive construction impact was tested during May and June of 1980 by the University of Colorado (DAP). Magnetometer survey, blading, and limited excavation produced no evidence of structures or features in the area of the site scheduled for destruction.

Los Atavios (Site 5MT5399), DAP-113 (Chenault 1983)

Los Atavios (Site 5MT5399) is located in a small drainage on a hillside in Montezuma County, Colorado. According to the DAP spatial systematics, the site is in the Sagehen Flats Locality. The site is the burial location of an adult female, approximately 20 to 25 years old at the time of death. Historic artifacts, including numerous glass trade beads, were discovered with the burial. Analysis of the artifacts indicates the burial may have taken place between A.D. 1850 and 1890. The artifacts and the nature of the burial suggest that the person was a Native American, possibly Shoshonean.

Star Bead Shelter (Site 5MT5380), DAP-114 (Hovezak 1983)

Star Bead Shelter, Site 5MT5380, was selected for excavation to study a nonhabitational, special-use site that appeared to date to the Protohistoric Period. Several lithic and ceramic artifacts also indicated the possibility of an Anasazi component. Star Bead Shelter consists of 4 crevices and a rock overhang in the east-facing Dakota Sandstone rimrock overlooking the Dolores River canyon above the old town site of Big Bend. Star Bead Shelter appears to have been used briefly during the Pueblo II period and was the site of a human burial during the Protohistoric Period.

Pueblo de las Golondrinas (Site 5MT5107), DAP-130 (Brisbin 1984)

Pueblo de las Golondrinas (House of the Swallows), Site 5MT5107, is a multiple-occupation site within the larger McPhee Village habitation complex. The site is situated in the Dolores River valley (Montezuma County, southwest Colorado), west of the river at the base of the sandstone cliffs that constitute the western limits of the valley. The DAP investigated this site in 1981, using a testing approach. The testing procedures (657 person-days of investigation) revealed a single contiguous roomblock containing 48 rooms in a double-row arrangement, a plaza area containing 10 pitstructures (some of which were superimposed), and a large refuse midden south of the plaza. Occupation of the site persisted for approximately 150 years during the Pueblo I period from A.D. 730 to 880. Four distinct building-occupation periods (or elements) are represented; a fifth element represents an abortive reuse of the site, probably in the early A.D. 900's.

Weasel Pueblo (Site 5MT5106), DAP-131 (Morris 1984)

Weasel Pueblo, Site 5MT5106, is an Anasazi habitation located in the Dolores River valley; the site is approximately 6.4 km northwest of Dolores, Colorado. Excavation at the site by the DAP revealed 2 components. The early component consisted of 3 pitstructures, 18 contiguous surface rooms, and an area of sheet trash. This component is dated to A.D. 865-885 on the basis of ceramic types, ceramic neckband dates, archaeomagnetic dates, and pitstructure morphology; it has been assigned to the Periman Subphase (A.D. 850-900) of the McPhee Phase. The late component contained a sequence of 2 pitstructures, 1 superimposed on the other, and a single surface room. The late component is tentatively dated to A.D. 1050-1150 on the basis of ceramic types and one archaeomagnetic date; it has been assigned to the Marshview Subphase (A.D. 1050-1125) of the Sundial Phase. During the McPhee Phase, the pueblo was probably a permanent habitation associated with several nearby roomblock units referred to collectively as the McPhee Community Cluster. During the Sundial Phase, the site was probably used for limited or specialized activities by people from a nearby habitation.

Golondrinas Oriental (Site 5MT5108), DAP-132 (Kuckelman 1983)

Golondrinas Oriental, Site 5MT5108, is a large Anasazi hamlet located on the west bank of the Dolores River approximately 7.5 km northwest of Dolores, Colorado. The DAP directed excavation of the site during August and September 1981. Excavations revealed a continuous arc of 14 masonry rooms and 2 associated pitstructures characteristic of the Periman Subphase of the McPhee Phase. Ceramic evidence suggests the major occupation of the site occurred between A.D. 850 and 900.

Pozo Hamlet (Site 5MT4613), DAP-133 (Nelson 1984)

Pozo Hamlet (Site 5MT4613) was recorded in 1978 by the DAP survey crew as a possible Basketmaker III-Pueblo I habitation. Test excavations at Pozo Hamlet exposed a Sagehen Phase transitional pitstructure that exhibited both Sagehill Subphase (A.D. 700-780) and Tres Bobos Subphase (A.D. 600-700) construction traits. Architectural remodeling of the pitstructure and an adobe cap on the hearth indicate a probable shift from year-round to seasonal use. Four small, nonmasonry storage rooms were located southwest of the pitstructure; refuse in the fill of these rooms indicates they had fallen into disuse prior to abandonment of the site. The construction of Montezuma County Main Canal 2 would have destroyed any additional features or architecture located north of the pitstructure.

When Pozo Hamlet was abandoned, the roof of the pitstructure was razed and 2 of the support posts were removed; the remaining structural debris that had collapsed onto the floor was burned. The absence of trash deposits overlaying the burned roof fall in Pitstructure 1 indicates the inhabitants not only abandoned the site but the immediate area as well.

Willow Flat Pueblo (Site 5MT5104), DAP-136 (Nelson 1985)

Willow Flat Pueblo (Site 5MT5104) is an Anasazi habitation investigated by the DAP during the 1982 field season. The site is located approximately 5 km northwest of Dolores, Colorado. Willow Flat Pueblo is a spatially discrete part of the McPhee Community Cluster; available evidence suggests the site was occupied during the Periman Subphase (A.D. 850-900). The site consists of a masonry roomblock, a small protokiva with an unusual U-shaped wingwall, and a poorly defined area of sheet trash south of the structure complex. The roomblock consists of 1 large living room, 2 large contiguous storage rooms, and 4 peripheral rooms considered to be additions to the central core of rooms. The presence of the large living room and small protokiva indicates the site may have served as a year-round habitation.

Standing Pipe Hamlet (Site 5MT5985), DAP-137 (Nelson 1985)

Archaeological remains from Standing Pipe Hamlet (Site 5MT5985) consist of the incomplete remains of a partially, articulated primary inhumation of a young adult; the interment is associated with a cist and a hearth. The site was heavily disturbed by the construction of a Civilian Conservation Corps access road during the 1930's and was later further damaged during construction of the McPhee Dam access road. The site is located along the west bank of the Dolores River near the town of Dolores, Montezuma County, Colorado. Investigations at Standing Pipe Hamlet were conducted by the DAP in 1981. It is inferred that the burial and features are probably associated with the remnant of a shallow pitstructure and that the site as a whole represents a Basketmaker III or early Pueblo I Anasazi hamlet that was largely destroyed by road construction activities.

Rio Vista Village (Site 5MT2182), DAP-160 (comp, Wilshusen 1985)

Rio Vista Village (Site 5MT2182) is a large, multicomponent village in the Dolores River valley. The site is located on a gently sloping bench just above the flood plain. It was occupied as early as the Sagehill Subphase (A.D. 700-780) of the Sagehen Phase (A.D. 600-850) and as late as the Grass Mesa Subphase (A.D. 880-925) of the McPhee Phase (A.D. 850-975). The earliest occupations at Rio Vista Village consist of pitstructure dwelling units that predate the period of aggregation into pueblos. The largest occupation dates to A.D. 860-880 and consists of 4 areas of roomblocks that range in size from less than 10 rooms to more than 30. Some of the pitstructures that date to this period have special ceremonial features that indicate these structures might have functioned as protokivas. The final occupation consists of small pitstructures scattered across the site.

The majority of the site was tested using only a probability sampling design; a total of 57 probability squares was excavated in 4 different areas of the site. Based on this sample, comparing the relative precision of the different sampling designs used in each area was possible. The only extensive excavations at the site were in Area 1. The site was tested as part of the DAP because it was 1 of the 3 McPhee Phase villages below the low waterline of the proposed McPhee Reservoir.

Masa Negra Pueblo (Site 5MT4477), DAP-161 (Kuckelman 1984)

Masa Negra Pueblo is an Anasazi habitation dating to the Pueblo I and Pueblo II periods. The site is located along the Dolores River in the southwestern corner of

Colorado. The site had 2 occupations, 1 during the Periman Subphase (A.D. 850-900), and the other during the Cline Subphase (A.D. 900-975) of the McPhee Phase (A.D. 850-975). Masa Negra Pueblo is part of the McPhee Community Cluster and was investigated by the DAP in 1980 and 1982.

During the first occupation 1 large, slightly arc-shaped masonry roomblock (containing approximately 50 rooms) and 5 pitstructures were constructed. Major construction during the first occupation has been tree-ring dated to A.D. 871. An unknown number of rooms and 2 pitstructures were constructed during the second occupation. Ceramic and archaeomagnetic dates place and end of the second occupation at about A.D. 950.

Pinyon House (Site 5MT4751), DAP-162 (Kuckelman 1984)

Pinyon House (Site 5MT4751) is an Anasazi habitation or seasonal site dating to the Pueblo II period. The site is located near the Dolores River in the southwestern corner of Colorado. The occupation of the site is thought to have occurred during the Marshview Subphase (A.D. 1050-1125) of the Sundial Phase (A.D. 1050-1200). The site consists of 1 badly vandalized masonry surface room, 1 small circular pitstructure, an open work area, and a midden.

Rabbitbrush Pueblo (Site 5MT4480), DAP-163 (Kuckelman and Harriman 1984)

Rabbitbrush Pueblo (Site 5MT4480) is a large Pueblo I Anasazi habitation along the Dolores River in southwestern Colorado. The site is part of the larger McPhee Village settlement and was occupied during the Periman Subphase (A.D. 850 to 900) of the McPhee Phase. Architectural units at the site include an unusual E-shaped roomblock 148 m long and 8 pitstructures. The roomblock had been constructed of vertical slab and horizontally coursed masonry; the pitstructures are of the "protokiva" type. The site was tested by the DAP during the 1980 and 1982 field seasons.

McPhee Pueblo (Site 5MT4475), DAP-164 (Brisbin et al. 1984)

McPhee Pueblo was excavated by the DAP during the 1978, 1980, 1982, and 1984 field seasons. The site is located approximately 0.5 km west of the Dolores River and 6 km northwest of the town of Dolores, in Montezuma County, Colorado. The site will be directly impacted by the construction of the McPhee Dam and Reservoir. An estimated 2/3 of the site was excavated; structures and extramural surfaces were intensively excavated, and backhoe trenches were used extensively across the site to clarify spatial organization and temporal sequences.

McPhee Pueblo is a large, multicomponent site belonging to the McPhee Community Cluster, as defined by the DAP. It was occupied over a period of approximately 200 years during the Pueblo I and II periods. This span crosscuts 2 phases and 3 subphases of the DAP temporal system. The first occupation (Element 1) has been assigned to the Dos Casas Subphase (A.D. 760-850) of the Sagehen Phase (A.D. 600-850). The next occupation (Element 2) began around A.D. 860 and falls into the Periman Subphase (A.D. 850-900) of the McPhee Phase (A.D. 850-975). The masonry rooms and pitstructures from this occupation comprised the majority of the site. The site was abandoned around A.D. 880-900. At approximately A.D. 920, McPhee Pueblo was reoccupied. This final occupation (Elements 3 and 4) has been assigned to the Cline Subphase (A.D. 920-980) of the McPhee Phase. This period is marked by considerable reuse and remodeling of the earlier structures.

Dovetail Hamlet (Site 5MT2226), DAP-165 (Nelson 1985)

Dovetail Hamlet (Site 5MT2226), located near Dolores, Colorado, is a Pueblo I habitation dated with ceramics to the A.D. 825-875 time period. This temporal range falls within the Dos Casas Subphase (A.D. 760-850) and the Periman Subphase (A.D. 850-900). Evidence indicates a brief reuse of the site sometime after the termination of the main occupation; this brief use of the site is dated to the Periman Subphase. The site is in the House Creek Locality of the Escalante Sector and forms part of the House Creek Community Cluster. Dovetail Hamlet was investigated in 1982 by the DAP. Features and structures at the site include a surface roomblock continuing approximately 9 rooms, a single pitstructure, and an amorphous area of sheet trash.

Kin Tl'iish (Site 5MT2336), DAP-166 (Dohm and Gould 1985)

Excavations were conducted at Kin Tl'iish (Site 5MT2336) by the DAP during the summer of 1982 to augment the data base from the south end of the McPhee Reservoir area. The site is located on a terrace above the east bank of the Dolores River, about 2.4 km downstream from Dolores, Colorado.

Probability sampling was conducted to provide a data set comparable to those collected from other project area sites. Intensive excavations of structures and use surfaces were carried out to expose the surfaces and thereby obtain information on spatial organization within these units.

The earliest occupation at Kin Tl'iish is known from a Sagehen Phase (A.D. 600-850) Dos Casas Subphase

(A.D. 760-850) pitstructure and the associated nonmasonry rooms in the southeast portion of the site. Other remains that may be associated with this occupation were located beneath more recent McPhee Phase (A.D. 850-975) structures. The most substantial occupation is assigned to the McPhee Phase and is represented by 2 masonry roomblocks and 2 pitstructures. At least 2 additional occupations followed abandonment of the McPhee Phase structures. The earlier of these has been assigned to the late McPhee Phase or the early Sundial Phase (A.D. 1050-1200) and is represented by 2 small, circular pitstructures. These may be associated with ephemeral occupation surfaces and at least 1 masonry room. The last use of Kin Tl'iish is recognized by the presence of late black-on-white sherds in the upper fill of one of the small, circular Sundial Phase pitstructures. The interment of several individuals may be associated with this final use, but no affiliated structures were identified. Kin Tl'iish functioned primarily as a habitation. However, at least following the McPhee Phase occupation, use of the site was probably seasonal.

Casa de Nada (Site 5MT2731), DAP-167 (Kane et al. 1985)

Casa de Nada is a small portion of Site 5MT2731, located on a south-sloping tableland west of the Dolores River, and northwest of the town of Dolores, Colorado. Excavations at Casa de Nada were conducted by the DAP during the 1982 and 1983 field seasons. Investigations within a 206-m^2 area to a depth of about 20 cm revealed 1 nonmasonry surface structure and several pits outside of the structure. The surface structure and 3 of the 6 outside pits are interpreted as a temporary shelter and associated extramural features used seasonally during the Archaic Period (5000 B.C. to A.D. 500). The remaining 3 extramural features are probably associated with limited use of the site during the Anasazi occupation of the Dolores Project area (A.D. 610-1200).

Beaver Trap Shelter (Site 5MT4654), DAP-168 (Hewitt and Harriman 1984)

Beaver Trap Shelter is a small rock overhang located about 7 km northwest of Dolores, Colorado. This site was tested by the DAP because it appeared to contain the remains of several occupations, including a Pueblo II occupation, a period not well represented in the program research area. Limited investigation of the site revealed the shelter had a complex use history, including a major Anasazi occupation dating to the Pueblo II period. Associated with the major occupation were 7 structures, including an aboveground kiva. Pre-Pueblo II deposits and possible protohistoric deposits were also discovered, but these occupations are poorly dated.

Paintbrush House (Site 5MT2729), DAP-169 (Kleidon 1984)

Paintbrush House (Site 5MT2729), an archaeological site once inhabited by the Anasazi, is located atop a high plateau west of the Dolores River valley in southwestern Colorado. Used seasonally or as a special use site, Paintbrush House displays site layout and architectural characteristics consistent with the pattern defined for the Marshview Subphase of the Sundial Phase. The dates assigned to the Marshview Subphase are currently A.D. 1050-1125, but 2 archaeomagnetic dates and the date range of the ceramic assemblage at Paintbrush House suggest the initiation of the subphase was somewhere near A.D. 1025-1030. Investigations of Paintbrush House were conducted by the DAP during the 1982 field season and consisted of the excavation of a probability sample of the site (fourteen 2- by 2-m grid squares) and 3 trenches. In addition , fill from one 2- by 2-m grid square was partially removed using a backhoe. A small pitstructure and 4 exterior pits were located at the site. The occupation of Paintbrush House appears brief, based on the relatively small assemblage of artifacts recovered.

Squawbush Hamlet (Site 5MT2322), DAP-170 (Harriman 1984)

Squawbush Hamlet (Site 5MT2322) was test excavated by the DAP during the latter part of the 1982 field season as part of the blading operations. The site consists of a small Dos Casas Subphase (A.D. 760-850) habitation in the Periman Locality in the Dolores River valley. The site is located within the proposed pool line of the McPhee Reservoir.

Nuthatch Hamlet (Site 5MT5863) and River Rat Rockshelter (Site 5DL452), DAP-171 (Kleidon 1984)

Nuthatch Hamlet (Site 5MT5863) and River Rat Rockshelter (Site 5DL452) were test excavated by the DAP during October and November of 1981. Nuthatch Hamlet consists of 2 spatially distinct Pueblo I roomblocks. One pithouse associated with the northern roomblock was excavated and is dated by a tree-ring sample and associated ceramics to the A.D. 791-825 time period. Ceramics in the fill of the pitstructure and from the site surface suggest continued occupation of the roomblock until about A.D. 840. No subsurface excavations were carried out in the area of the southern roomblock, but surface ceramics indicate an occupation sometime between A.D. 840 and A.D. 910.

Excavations at River Rat Rockshelter indicate use of the site as a seasonal hunting camp, and ceramics indicate it was used either during the A.D. 910-950 time period or that it was used both between A.D. 860 and 910 and briefly after A.D. 950.

Cougar Springs Cave (Site 5MT4797), DAP-172 (Gross 1984)

Cougar Springs Cave (Site 5MT4797) is a small rockshelter located on the northwest-facing slope of Dry Canyon approximately 0.65 km from the point where the canyon joins the Dolores River. Test excavations in 1980 and intensive excavations in 1982, both conducted by the DAP, indicate the site is a Basketmaker II seasonal site. The Basketmaker II assignment is based on comparisons of the artifact assemblage from Cougar Springs Cave with other Basketmaker II sites and is supported by several dating techniques.

The majority of the excavation units at the site were contiguous 1- by 1-m squares. This allowed examination of artifact distributions over a 52-m^2 area, in which the highest concentrations of artifacts at the site occurred; artifact densities dropped off markedly at the northern and southern edges of this area. Examination of artifact distributions at the site suggests spatial segregation of activities within the shelter. The southern half of the 52-m^2 area contained 2 concentrations of flaked lithic debitage accompanied by hammerstones and cores. Between the 2 debitage concentrations was an area with relatively large amounts of bone and used flakes. The northern half of the 52-m^2 area contained 2 burned pits, each with a metate and manos nearby.

The major activity represented in the shelter is the reduction of 1 specific type of lithic raw material. This material, a white to buff quartzite from the Burro Canyon Formation of Dakota Sandstone, was probably collected at an outcrop located in the vicinity of the shelter. The material appears to have been transported to the shelter in the form of rough, bifacially worked blanks, which were further reduced to a thin biface stage at the site.

While camping in the shelter, the inhabitants appear to have fed themselves primarily through a combination of expedient hunting and plant gathering. Charred corn was recovered from the site in small quantities and was probably transported to the site from a base camp.

The site is unusual in the Dolores Project area because it is an undisturbed preceramic site, and currently is the only evidence recognized for a Basketmaker II occupation in the project area. This site serves as the basis for the definition of the Cougar Springs Phase.

Sites 5DL444, 5DL445, and 5DL446, DAP-173 (Kleidon 1984)

Investigation of Sites 5DL444, 5DL445, and 5DL446 were scheduled because portions of the sites were to be impacted by the widening of the Ormiston Point Road. The DAP surveyed the site in 1981 and began investigations in October 1982. Surface artifacts were collected from each of these sites, and the area was then bladed with a grader; however, no cultural features were located. Permission to include 3 subareas of Site 5DL444 not scheduled for impact by road improvements in the investigations was granted by the U.S. Forest Service. Evidence of a possible temporary structure and a limited activity area were located in 2 of the 3 subareas. One radiocarbon date of 290 ± 50 B.P. (Beta-6134) suggests the possibility of a post-Anasazi occupation.

Singing Shelter (Site 5MT4683), DAP-180 (Nelson and Kane 1985)

Singing Shelter is a multiple-occupation site located in a rockshelter in the north canyon wall of the House Creek drainage, southwestern Colorado. Fieldwork at the site was conducted during the 1981, 1982, and 1983 field seasons by the DAP. These investigations revealed cultural occupations of Singing Shelter from pre-Pueblo times, through the Pueblo period, and into the post-Pueblo period.

Periodic use of Singing Shelter during the Great Cut Phase (2000 B.C.-A.D. 500, part of the Archaic Tradition) or Cougar Springs Phase (A.D. 1-600; part of the Anasazi Tradition) is evidenced only by sparse cultural material and dispersed charcoal lenses in the lower strata of a 4.8-m-deep trench. Anasazi use of the shelter during the early to middle Sagehen Phase (A.D. 600-780) is indicated by the presence of a large burned feature (Feature 80) also found in this same trench. The succeeding occupation, also thought to date to the early to middle Sagehen Phase and exposed only in the trench, consisted of the construction and use of a pit-structure and an associated extramural occupation surface.

Five rooms and one outside occupation area were exposed during intensive investigation of a Dos Casas Subphase (A.D. 760-850) occupation. Above these surfaces are the remains of the second major Anasazi occupation of Singing Shelter, a very large, unroofed, Periman Subphase (A.D. 850-900) great kiva and 4 peripheral rooms. Evidence for the last level of Anasazi use at the site consists of the remains of 1 room and 2 outside occupation areas dating to A.D. 1025-1175.

The final prehistoric or protohistoric use of the shelter is documented by the presence of 2 micaceous brown ware sherds, possibly indicating a Shoshonean visitation.

House Creek Village (Site 5MT2320), DAP-181 (Robinson and Brisbin 1984)

House Creek Village (Site 5MT2320) is a large Anasazi habitation located 1.3 km east of the Dolores River and 5.7 km northwest of Dolores, Colorado. The site contains an east-west arc of building rubble comprising 4 major mounds. Three smaller rubble mounds are associated with this arc. Limited excavations at House Creek Village fully or partially exposed 12 rooms and 4 pitstructures. The primary occupation at the site is assigned to the Periman Subphase (A.D. 850-900) of the McPhee Phase (A.D. 850-975) according to DAP systematics, or to the Pueblo I period according to the Pecos Classification. An earlier occupation at the site during the Dos Casas Subphase (A.D. 760-850; Pueblo I) of the Sagehen Phase (A.D. 600-850) is also present. An inferred high status burial is associated with the Dos Casas occupation.

Poco Tiempo (Site 5MT2378), DAP-182 (Brisbin 1984)

Poco Tiempo Hamlet (Site 5MT2378) is a single-component Basketmaker III habitation consisting of 5 noncontiguous surface rooms and 1 pitstructure with an antechamber. Intensive excavations were conducted at Poco Tiempo Hamlet by the DAP in 1983. One of the reasons for excavating the site was that it lay within the right-of-way for the Dove Creek Canal Reach 1. The site is located on a rolling plain 2 km west of the Dolores River and 9.5 km northwest of the town of Dolores in Montezuma County, Colorado. Situated around the rooms and pitstructure are numerous extramural features, including postholes, storage cists, and food-processing facilities. Evidence of a ramada was indicated by a posthole pattern east of one of the surface rooms. An area of sheet trash on a fairly steep slope in the southeast portion of the site was identified as the midden. Based on architectural style and ceramic and archaeomagnetic dating, it is estimated Poco Tiempo Hamlet was occupied between A.D. 690 and 730; the site has been assigned to the Sagehill Subphase (A.D. 700-780) of the Sagehen Phase (A.D. 600-850).

Grass Mesa Village (Site 5MT23), DAP-195 (comp, Lipe et al. 1985)

Grass Mesa Village (5MT23) is located in the deeply entrenched Dolores River canyon at the juncture of Beaver Creek and the Dolores River. Fieldwork consisted of an intensive surface collection, a magnetometer survey, a probability sample of test pits, extensive exploratory trenching, and intensive block excavations in selected locations. Work was done in the 1979, 1980, 1982, and 1983 field seasons by Washington State University, under a subcontract from the University of Colorado, as part of the DAP.

In this volume, fieldwork results are reported for the 8 areas into which the site was subdivided for administrative and sampling purposes. The area chapters present descriptions of stratigraphy and of structures and other cultural study units. Interpretations of the dating and prehistoric uses of these units are offered, and their spatial and functional interrelationships are discussed. The volume also includes chapters on surface investigations, the probability sample, geoarchaeology, artifact analysis, faunal and floral remains, and a test of an economic intensification model using catchment data. A final chapter reviews the chronology and distribution of structures and synthesizes the evidence of population and economy. Two appendixes are presented in tabular form: one summarizes artifact distributions by provenience unit, and the other provides the dating sample results.

Although Grass Mesa may have been occupied as early as A.D. 720, the principal early occupation was between about A.D. 750 and 825, and spanned the late Sagehill and early Dos Casas Subphases of the Sagehen Phase. The Sagehill occupation consisted of scattered, probably residential, pitstructures lacking associated roomblocks. Settlement density was higher at Grass Mesa than elsewhere in the project area during this subphase. Population at the site was probably 16 to 24 households at any one time.

During the Dos Casas Subphase, small surface roomblocks were built as residences for groups of households that jointly used an associated pitstructure for domestic and ritual activities. Momentary population at the end of the A.D. 700's may have been as great as 35 to 53 households; population appears to have declined to a very low level or to abandonment by about A.D. 825. A large great kiva was built at approximately A.D. 800; it probably served other settlements in addition to Grass Mesa.

After a period of low population or abandonment, several Periman Subphase roomblock units were built in the A.D. 850's or 860's. These were composed of interhousehold units each consisting of several residential surface roomsuites and an associated jointly used pitstructure. At least 4 of the Grass Mesa Periman Subphase pitstructures had floor areas over 35 m^2 and may have functioned as "great pithouses" with integrative functions more extensive than the interhousehold. Estimates of momentary population during the period A.D. 850-880 range from about 84 to over 100 households, with the lower estimates being the more likely.

Some Periman structures continued to be occupied for a time after A.D. 800, and were contemporaneous with a new type of settlement used to define a new subdivision – the Grass Mesa Subphase. This subphase is represented by numerous, very small pitstructures,

some of which were associated with surface roomsuites, but many of which were not. The Grass Mesa Subphase occupation appears to have been brief, and the site was probably abandoned by A.D. 895 or 900, and certainly by A.D. 910. Momentary population between A.D. 880 and abandonment was probably over 100 households, with a best estimate of 154.

Evidence is presented that both economic intensification and social elaboration accompanied the increase in regional and Grass Mesa population during the middle A.D. 800's. The Grass Mesa Subphase is thought to represent a response to deteriorating climatic conditions in the late A.D. 800's. Though regional population decreased, Grass Mesa population remained high for a time. Farming remained important, but distant as well as nearby fields were being used, and the Grass Mesa site may have been used primarily as a winter residence. In addition to cultigens, wild foods were more heavily exploited. Architectural patterns appear to reflect both increased mobility and decreased hierarchy and rigidity in the social order.

APPENDIX C

ANNOTATED BIBLIOGRAPHY

Christine K. Robinson, Barbara J. Cullington, and G. Timothy Gross

A large number of manuscripts were prepared by the DAP, and these manuscripts were available to report authors in different forms, ranging from authors drafts to finished publications. This appendix is intended to assist in locating the DAP documents in the technical report series or in the publications dealing with program results cited by report authors.

The history and development of report production have been reviewed in the introduction (chap. 1) but the important points for this discussion are that reports existed in a number of different forms during their transformation from author's draft to finished report, that publication came well after final submission of reports in most cases, and that the content of published volumes was in a state of flux almost until the end of the program. These facts combined to make it impossible to provide reference to the final, most accessible form of a report in the references cited section of most DAP reports.

Production Steps

The report production process began for a report when the report was initially planned. Investigations at most excavated sites were described in individual reports, although some sites that were simply tested were reported as parts of yearly descriptions of the testing program. Other reports were planned concurrent with analysis planning or execution. Special analytic studies were generally accompanied by the planning of some sort of report. As these reports were planned, their titles were tentatively grouped together into projected publications. Prior to 1981, reports were grouped both by year and by general topic into numbered volumes in which each report was to be a numbered chapter. Many of the early reports cite other DAP reports by the volume and chapter numbers. Both of the first 2 DAP publications (Dolores Archaeological Program 1983, 1984 [refer to the "Publication Bibliography"]) contain references in which the volume number appeared as a roman numeral and the chapter number appeared as an arabic numeral in parentheses.

In 1982, as planning for the first DAP published volume was being finalized, it became apparent that the previously planned volumes would not be workable. For reasons discussed later, some reports had been deleted from planned publication and several of the volumes did not contain enough chapters to stand by themselves. A new system of consecutive numbers prefixed by the initials "DAP" was instituted. This allowed report production to continue without committing the program to any given set of publications, but allowed instead for the planning of volume contents to proceed along with the production of reports. Table C.1 allows conversion of volume and chapter numbers into the report number system that replaced them.

After planning, the next major step in the report production process was the submission of reports to the report production staff. Because a backlog in report production always existed, manuscripts were often only cataloged at this point. As each year's editorial work was being planned, the editing and production of each report was scheduled and it was entered into the system.

Although some review of reports by authors' immediate supervisors occurred at different stages in the writing, this process was seldom very formal and the first major review of any report was usually during the first edit. The first edit usually included a check of the accuracy of data presented in the report and checks for consistency. Because of the time lag between the writing of a report and its editing and data checking, and because DAP data files were constantly being edited and checked for consistency, a great potential for discrepancies between the data presented in the report and that contained in the computer files existed. Also, with the earlier reports in particular, major changes in program terminology happened between the writing and the editing. Where necessary, corrections were made in the reports as part of the editing process.

Following the first edit, the report was submitted to the Bureau of Reclamation, where it was reviewed. At the same time, for reports prepared as a result of work prior to 1981, the reports were reviewed internally by selected

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 1 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
I-1	001	Publication	Field investigations and analysis-1978	Kane	1978
I-2	002	Publication	Field investigations and analysis-1978	Kane et al.	1978
I-3	003	Publication	Field investigations and analysis-1978	Kane	1978
I-4	004	Publication	Field investigations and analysis-1978	Schlanger	1978
I-5	005	Publication	Field investigations and analysis-1978	Hewitt	1978
I-6	006	In house		Brisbin et al.	1978
I-7	007	Publication	Field investigations and analysis 1978	Hewitt	1978
I-8	008	In house		Brisbin	1978
I-9	009	In house		Bussard	1978
I-10	010	Nonpublication		Hogan	1978
I-11	011	Nonpublication		Kane et al.	1978
I-12	012	Nonpublication		Hathaway	1978
I-13	013	Publication	Field investigations and analysis-1978	Hathaway	1978
II-1	014	Nonpublication		Petersen	1978
II-2	015	Nonpublication		Farley	1978
II-3	016	Nonpublication		Moore	1978
II-4	017	Nonpublication		Lucius	1978
II-5	018	Nonpublication		Emslie	1978
II-6	019	Nonpublication		Litzinger	1978
II-7	020	Publication	Field investigations and analysis-1978	Huggins/Weymouth	1978
II-8	021	Publication	Field investigations and analysis-1978	Eddy/Kane	1978
III-1	022	In house		Baker	1978
III-2	023	In house		Dykeman et al.	1978
V-1	024	Nonpublication		Greenwald	1979
V-2	025	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Brisbin/Varien	1979
V-3	026	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Montgomery	1979
V-4	027	Nonpublication		Yarnell	1979
V-5	028	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Brisbin et al.	1979

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 2 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
V-6	029	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Yarnell	1979
V-7	030	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Brown	1979
V-8	031	Nonpublication		Kleidon	1979
V-9	032	Publication	Anasazi Communities at Dolores: early Anasazi sites in the Sagehen Flats area	Brisbin	1979
V-10	033	Publication	Aceramic and late occupations at Dolores	Kleidon	1979
V-11	034	Publication	Anasazi communities at Dolores: early Anasazi sites in the Sagehen Flats area	Wilshusen	1979
V-12	035	Publication	Aceramic and late occupations at Dolores	Wilshusen	1979
V-13	036	Publication	Anasazi communities at Dolores: early Anasazi sites in the Sagehen Flats area	Hewitt	1979
V-14	037	Nonpublication		Brown	1979
V-15	038	Nonpublication		Kane/Chenault	1979
V-16	039	Publication	Aceramic and late occupations at Dolores	Southward	1979
V-17	040	Nonpublication		Brown	1979
V-18	041	Nonpublication		Wilshusen	1979
VI-1	042	Nonpublication		Farley	1979
VI-2	043	Nonpublication		Lucius	1979
VI-3	044	Nonpublication		Phagan	1979
VI-4	045	Nonpublication		Nylander	1979
VI-5	046	Nonpublication		Ryan/Rohr	1979
VI-6	047	Nonpublication		Bye	1979
VI-7	048	Nonpublication		Emslie	1979
VI-8	049	Nonpublication		Scott	1979
VI-9	050	Nonpublication		Leonhardy/Clay	1979
VI-10	051	Nonpublication		Flander	1979
VI-11	052	Nonpublication		Hathaway/Eighmy	1979
VII-1	053	In house		Duranceau	1979
VII-2	054	In house		Duranceau	1979
	055	Publication	Dolores Archaeological Program synthetic report 1978-1981	DAP	1979
VIII-1	056	Nonpublication		D. Breternitz	1980

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 3 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
VIII-2	057	Publication	Dolores Archaeological Program research designs and initial survey results	Knudson et al.	1980
VIII-3	058	Nonpublication		Kane	1980
VIII-4	059	Publication	Dolores Archaeological Program research designs and initial survey results	Blinman	1980
VIII-5	060	Publication	Dolores Archaeological Program research designs and initial survey results	Phagan	1980
IX-1	061	Nonpublication		Benz/Clay	1980
IX-2	062	Nonpublication		Shuster	1980
IX-3	063	Nonpublication		Weiner	1980
X-1	067	Nonpublication		Farley	1980
X-5	071	Nonpublication		Hilton	1980
XI-6	077	Nonpublication		Raffensperger	1980
XI-7	078	Nonpublication		Burns et al.	1980
XI-8	079	Nonpublication		Kohler et al.	1980
XII-1	080	Nonpublication		Lipe	1980
XII-2	081	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Gross	1980
XII-3	082	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Sebastian	1980
XII-4	083	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Hogan	1980
XII-5	084	Nonpublication		Kohler	1980
XII-6	085	Nonpublication		C. Breternitz	1980
XII-7	086	Nonpublication		Ahlstrom/Dohm	1980
XII-8	087	In house		Emerson et al.	1980
XII-9	088	In house		Dohm	1980
XIII-1	089	Nonpublication		Hewitt	1980
XIII-2	090	Publication	Anasazi communities at Dolores: Middle Canyon area	Wilshusen	1980
XIII-3	091	Nonpublication		Yarnell	1980
XIII-4	092	In house		Fields	1980
XIII-5	093	In house		Yarnell	1980
XIII-6	094	In house		Wilshusen	1980
XIII-7	095	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Etzkorn	1980

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 4 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
XIII-8	096	In house		Greenwald	1980
XIV-1	097	Nonpublication		Greenwald	1980
XIV-2	098	In house		Brisbin	1980
XIV-3	099	In house		Kuckelman	1980
XIV-4	100	Publication	Anasazi communities at Dolores: McPhee Village	Kleidon	1980
XIV-5	101	In house		Harriman	1980
XIV-6	102	Nonpublication		Chenault	1980
XV-1	103	Nonpublication		Hewitt	1980
XV-2	104	In house		Robinson	1980
XVI-1	105	Nonpublication		Greenwald/Phagan	1980
XVI-2	106	Nonpublication		Tucker	1980
XVI-3	107	Publication	Anasazi communities at Dolores: early Anasazi sites in the Sagehen Flats area	Kuckelman	1980
XVI-4	108	Publication	Anasazi communities at Dolores: early Anasazi sites in the Sagehen Flats area	Brisbin	1980
XVI-5	109	Publication	Aceramic and late occupations at Dolores	Harriman	1980
XVI-6	110	Nonpublication		M. Morris	1980
XVI-7	111	Nonpublication		Etzkorn	1980
XVI-8	112	Nonpublication		Greenwald	1980
XVI-9	113	Publication	Aceramic and late occupations at Dolores	Chenault	1980
XVI-1	114	Publication	Aceramic and late occupations at Dolores	Hovezak	1980
XVI-1	115	Nonpublication		Emslie	1980
XVII-1	116	Publication	Dolores Archaeological Program research designs and initial survey results	Goulding/Orcutt	1980
XVII-2	117	Publication	Dolores Archaeological Program research designs and initial survey results	Orcutt/Goulding	1980
XVII-3	118	Publication	Dolores Archaeological Program research designs and initial survey results	Schlanger/Harden	1980
XVII-4	119	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Kohler	1980
XVII-5	120	Publication	Dolores Archaeological Program research designs and initial survey results	Orcutt	1980

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 5 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
XX-1	130	Publication	Anasazi communities at Dolores: McPhee Village	Brisbin	1981
XX-2	131	Publication	Anasazi communities at Dolores: McPhee Village	Morris	1981
XX-3	132	Publication	Anasazi communities at Dolores: McPhee Village	Kuckleman	1981
XX-4	133	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Nelson	1981
XX-7	136	Nonpublication		Nelson	1981
XX-8	137	Nonpublication		Nelson	1981
XXI-1	138	Publication	Dolores Archaeological Program research designs and initial survey results	Petersen et al.	1981
XXI-7	144	Publication	Dolores Archaeological Program supporting studies: additive and reductive technologies and architecture	Blinman	1981
XXII-1	146	Nonpublication		Kane/Robinson	1981
XXII-2	147	Nonpublication		Bohnenkamp et al.	1981
XXII-3	148	Nonpublication		Farley	1981
XXII-4	149	Nonpublication		Blinman et al.	1981
XXII-5	150	Nonpublication		Phagan/Hruby	1981
XXII-8	153	Nonpublication		Staff	1981
	154	In house		Miller	1983
	155	Publication	Anasazi communities at Dolores: Middle Canyon area	Orcutt	1983
	156	Publication	Anasazi communities at Dolores: McPhee Village	Orcutt	1983
	157	Publication	Aceramic and late occupations at Dolores	Wilson/Blinman	1983
	158	Publication	Aceramic and late occupations at Dolores	Errickson/Wilson	1983
	159	Publication	Dolores Archaeological Program research designs and initial survey results	Schlanger	1983
	160	Publication	Anasazi communities at Dolores: Middle Canyon area	Wilshusen	1982
	161	Publication	Anasazi communities at Dolores: McPhee Village	Kuckelman	1982
	162	Publication	Aceramic and late occupations at Dolores	Kuckelman	1982
	163	Publication	Anasazi communities at Dolores: McPhee Village	Kuckelman/Harriman	1982

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 6 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
	164	Publication	Anasazi communities at Dolores: McPhee Village	Brisbin et al.	1982
	165	Nonpublication		Nelson	1982
	166	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Dohm/Gould	1982
	167	Publication	Aceramic and late occupations at Dolores	Kane et al.	1982
	168	Nonpublication		Hewitt/Harriman	1982
	169	Publication	Aceramic and late occupations at Dolores	Kleidon	1982
	170	Nonpublication		Harriman	1982
	171	Nonpublication		Kleidon	1982
	172	Publication	Aceramic and late occupations at Dolores	Gross	1982
	173	Nonpublication		Kleidon	1982
	174	Publication	Dolores Archaeological Program supporting studies: additive and reductive technologies and architecture	Phagan	1983
	175	Publication	Anasazi communities at Dolores: McPhee Village	Phagan/Hruby	1983
	176	Publication	Anasazi communities at Dolores: McPhee Village	Clay	1983
	177	Publication	Anasazi communities at Dolores: McPhee Village	Matthews	1983
	178	Publication	Anasazi communities at Dolores: McPhee Village	Neusius	1983
	179	Publication	Anasazi communities at Dolores: McPhee Village	Kane	1983
	180	Publication	Anasazi communities at Dolores: Middle Canyon area	Nelson/Kane	1983
	181	Publication	Anasazi communities at Dolores: Middle Canyon area	Robinson/Brisbin	1983
	182	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Brisbin	1983
	183	Publication	Anasazi communities at Dolores: Middle Canyon area	Robinson	1983
	184	Publication	Anasazi communities at Dolores: Middle Canyon area	Blinman/Wilson	1983
	185	Publication	Anasazi communities at Dolores: Middle Canyon area	Hruby	1983

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 7 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
	189	Publication	Anasazi communities at Dolores: McPhee Village	Blinman/Wilson	1983
	190	Nonpublication		DAP	1984
	191	Nonpublication		Stodder	1984
	192	Publication	Dolores Archaeological Program: studies in environmental archaeology	Petersen et al.	1983
	193	Publication	Dolores Archaeological Program supporting studies: additive and reductive technologies and architecture	Hathaway	1984
	194	Publication	Anasazi communities at Dolores: early Anasazi sites in the Sagehen Flats area	Kane et al.	1983
	195	Publication	Anasazi communities at Dolores: Grass Mesa Village (Site 5MT23)	Lipe et al.	1984
	196	Publication	Dolores Archaeological Program research designs and initial survey results	Kane	
	197	Publication	Anasazi communities at Dolores: early small settlements in the Dolores River canyon and western Sagehen Flats area	Kohler	
	198	Publication	Aceramic and late occupations at Dolores	Gross	
	199	Publication	Anasazi communities at Dolores: McPhee Village	Scott	
	200	Publication	Prehistory and cultural dynamics in the Dolores area: the Dolores Archaeological Program final report	Breternitz et al.	1984
	201	Publication	†	Schlanger/Orcutt	1985
	202	Publication	†	Keane/Clay	1985
	203	Publication	†	Petersen	1985
	204	Publication	†	Petersen	1985
	205	Publication	†	Goulding	1985
	206	Publication	†	Petersen/Clay	1985
	207	Publication	†	Clay et al.	1985
	210	Publication	†	Clay et al.	1985
	211	Publication	†	Clay/Petersen	1985
	213	Publication	†	Petersen	1985
	214	Publication	†	Petersen	1985
	215	Nonpublication		Goulding	1985

Table C.1 Listing of Dolores Archaeological Program technical reports (Page 8 of 8)

Volume-chapter	DAP No.	Status	Publication volume title	Author/s*	Fiscal year
	217	Publication	†	Goulding	1985
	218	Publication	†	Petersen	1985
	219	Publication	†	Clark et al.	1985
	221	Publication	†	Neusius/Phagan	1985
	222	Publication	†	Flint/Neusius	1985
	223	Publication	†	Petersen	1985
	224	Publication	†	Petersen et al.	1985
	225	Publication	†	Petersen	1985
	227	Publication	†	Orcutt	1985
	228	Publication	†	Petersen/Scott	1985
	230	Publication	†	Petersen	1985
	234	Publication	†	Petersen/Orcutt	1985
	235	Publication	†	Schlanger	1985
	252	Publication	§	Errickson	1985
	253	Publication	§	Wilson	1985
	255	Publication	§	Phagan	1985
	256	Publication	§	Wilson et al.	1985
	257	Publication	§	Wilson/Blinman	1985
	258	Publication	§	Waterworth	1985
	260	Publication	§	Hruby	1985
	262	Publication	§	Blinman/Wilson	1985
	265	Publication	§	Neusius	1985
	268	Nonpublication		Phagan	1985
	269	Publication	§	Blinman	1985
	270	Publication	§	Phagan	1985
	273	Publication	§	Wilshusen	1985
	274	Publication	§	Wilshusen	1985
	275	Publication	§	Wilshusen	1985
	276	Nonpublication		Wolf	1985
	277	Nonpublication		Wolf	
	278	Publication	§	Wilshusen	1985
	279	Publication	§	Wilshusen	1985
	280	Publication	§	Wilshusen	1985
	282	Publication	§	Kohler et al.	1985
	283	Publication	§	Blinman et al.	1985
	285	Publication	†	Griffitts	1985
	286	Publication	†	Petersen	1985

* Please refer to the technical reports references for complete listing of authors.
† Dolores Archaeological Program supporting studies: settlement and environment.
§ Dolores Archaeological Program supporting studies: additive and reductive technoloiges and architecture.

members of the DAP senior staff and by the analytic specialists. Both types of review usually led to comments and suggestions for revisions in data presentation, organization, and inference. The internal reviews were extensive, and, as a result, this process was rescheduled to occur before submission to the funding agency so that the problems identified by these reviews could be remedied in the early stages of production. With regard to the Bureau of Reclamation comments, the program was required by contract to either comply with the requested changes or to provide written explanations of why the comments were not followed. These reviews were usually the major source of changes in reports after the first submission to the Bureau of Reclamation.

After comments were received, the final edit in the production process entailed a review of the report and consideration of changes suggested in the various reviews. The reports were then submitted in final form to the

Bureau of Reclamation, where they were directed either to the Technical Publications Branch or to storage, where they awaited transmission to NTIS (National Technical Information Service). (As of this writing, only the 1979 reports and the published volumes are available from NTIS.)

For reports published prior to the close of the program (Dolores Archaeological Program 1983, 1984; Petersen et al. 1985 [see the "Publication Bibliography"]), the involvement of the DAP did not stop at the final submission to the funding agency. DAP editors reviewed and copy marked the galley proofs and page proofs. In a few cases, new information became available during this review and was incorporated into the report.

Changes in Reports

As the preceding description of the major steps in the editorial process indicates, there was the potential for change at each step in the process after report planning. These changes could be trivial, neither affecting inference nor data, but they could also be serious, changing inferences that could have ramifications throughout the report. File editing, refinement of analysis systems, and the accumulation of data all led to necessary changes.

In some cases, problems identified in the reviews or data checks were extensive enough that major revision or rewriting was necessary. Such problems were often detected after the original author was no longer with the program and was unavailable to perform the work. In such cases, other program personnel were assigned to either revise the report or, in a few instances, to rewrite it. Authorship was changed to reflect these revisions or rewrites; a report could have different authors at various stages in the production process. This also made providing consistent references to the same report very difficult.

The potential for changes in the reports at each step in the editing process had an impact on the citation of specific reports. Since report information, or even authorship, could change with the accumulation of data and analysis results, it was necessary to indicate which draft of a report was being cited or a specific piece of information. Although cumbersome (i.e., several different versions of a report, often with different dates, may be cited), this situation does accurately reflect both the nature of the data available to the authors and the possible sources of discrepancies between published versions of reports and characterizations of sites or analysis results attributed to earlier versions of those reports. One of the primary ways in which this bibliography can be useful to a researcher trying to locate specific information about the DAP is in providing a means of finding what the final versions of reports cited as author's drafts or final draft submissions actually became. Also the most accessible form of the report, be it a published volume, an NTIS copy, or an archive copy, is also indicated.

Forms of Citation

Reports were usually cited in 1 of 5 forms depending upon what the author citing the report had available: in progress, a manuscript on file, submitted as a first draft, submitted as a final report, or published. However, reports for the 1978 and 1979 field and analysis seasons use a sixth form of citation – reference to the volume and chapter numbers of the publications proposed at that time.

References that indicate a report was in progress were used when the report was actively being written and the manuscript was in the possession of the author at the time of citation. When the author's draft was completed it was submitted to the report production staff and became a manuscript on file. To distinguish between reports at this stage and those at later stages in the production process, another convention, in addition to noting the stage ("report in progress" or "Ms. on file") of the report, was used. References to these reports usually contained no underlining or italics, as did reports completed through the first submission or beyond. That convention had also been followed in the "Technical Reports Bibliography" here.

While early reports referred to chapter and volume numbers, all later reports used the report number in the reference. Once a report was published, however, the report number was dropped and reference was made to the volume that contained the report. References to published reports are to be found in the "Publication Bibliography" that follows, and these are cross-referenced in the "Technical Reports Bibliography."

Levels of Reporting

Some debate has occurred in recent years about the desirability of publication of the products of cultural resource management programs and just how much of the material that results from such work should be published. The DAP policies, developed in consultation with Bureau of Reclamation archaeologists, recognize that in a large program, materials have different levels of utility to the profession and to the public, and decisions about publication should take utility into account. On the other hand, both the DAP and the Bureau of Reclamation believed strongly that as much information as possible should be made available about the data and results of the program. To resolve the conflict between wanting to provide publications useful to a large number of researchers and wanting to maximize

the availability of information about the DAP 3 levels, or tracks, of reporting have been employed: in-house reports, reports available only through NTIS (nonpublication track), and reports to be published (publication track).

Reports at the in-house level include both progress reports on sites where excavations were continuing or reports where results did not live up to expectations for some reason. Some reports became unnecessary due to changes in direction by either the program or the Bureau of Reclamation and the manuscripts for these reports were also treated as in-house reports. In-house reports received very little editorial attention and did not undergo the rigorous data checking that went into the other levels of reports. All in-house reports, as well as other documents such as letter reports on small surveys, yearly administrative reports, and important program memorandums are available in the archives of the Anasazi Heritage Center, Dolores, Colorado. Many of the in-house reports are indicated as simply being manuscripts on file in the "Technical Reports Bibliography."

Nonpublication track reports are reports considered not to be of sufficient general interest to warrant publication, or reports that had problems of some sort. All reports submitted to the Bureau of Reclamation as Dolores Archaeological Program Technical Reports will be available through NTIS, but nonpublication track reports are most readily available through this means.

Publication track reports contain information considered to be of most value to other archaeologist. These reports have been grouped into 13 separate volumes. Each volume is composed of reports that contain specific information according to that volume title.

The Bibliographies

The remainder of this appendix consists of a table that provides cross-references for the DAP technical reports and 5 bibliographies. The table and bibliographies should allow for researchers to determine the most accessible form of any DAP report.

Table C.1 provides a cross reference for the DAP technical reports. An explanation of the columns on table C.1 follows:

1. "Volume/chapter number" is the designation assigned to reports prior to the formulation of the current numbering system. These designations were used from 1979 through 1981.

2. "DAP number" is the current number assignment for all technical reports. This series of numbers was assigned in 1982. All volume/chapter numbers were replaced by DAP numbers, and all reports proposed at that time were assigned DAP numbers. Revisions in the publication plan, as well as budget and time constraints, led to the deletion of some reports; those numbers are not listed in table C 1.

3. "Status" refers to the report track. Publication track reports are planned for publication and should be available from the Bureau of Reclamation Technical Publication Branch, Engineering and Research Center, Denver. Nonpublication track reports will be available only through NTIS. Reports designated in-house will be available in the archives of the Anasazi Heritage Center, Dolores, Colorado.

4. "Publication volume title" lists the title of the publication that contains the report or is planned to contain the report when it is published.

5. "Author/s" can be used to locate the report in the "Technical Reports Bibliography."

6. "Fiscal year" is the year for which that report was contracted.

Five bibliographies have been provided: technical reports, publications, manuscripts on file, papers presented and other publications, and theses and dissertations.

The "Technical Reports Bibliography" contains those reports that were part of the formal technical report series and received numbers in that system. Listed for each report (where applicable) are the dates for: (1) manuscript on file; (2) first draft submission; and (3) final draft in progress (for those reports still not submitted in final form when this bibliography was compiled).

Several reports are exceptions to the normal process of production and citation. DAP-061, although submitted to the Bureau of Reclamation in final form, is usually referenced only as a first draft because DAP-192 is what the DAP intended to represent the final version of DAP-061. DAP-055 and DAP-192 were completed within such a short period of time that no "ms. on file" date is given.

Cross references have been provided for those cases in which authorship changed at various stages in the editorial process. Report titles sometimes changed as well during writing or editing and these changes may be reflected in citations. In most cases these changes were

minor and thus are not noted; however, in some instances where the original title was quite different from the final title, the old title has been noted.

Publication dates have been listed for reports included in the first 3 DAP publications (refer to the "Publication Bibliography"). NTIS numbers have been listed for the reports available through that agency when this bibliography was compiled. All publication and nonpublication track reports are scheduled to be transmitted to NTIS by the Bureau of Reclamation.

The "Publication Bibliography" contains only those reports published in the first 3 DAP publications. As publications are compiled, the DAP number is dropped and individual reports become chapters (with the exception of DAP-055, DAP-192, DAP-195, and DAP-200, which were prepared as whole volumes in themselves). When this bibliography was being prepared, many reports were in the process of being published.

The "Manuscript Bibliography" contains citations for manuscripts, letter reports, and memorandums related to the DAP. Selected memorandums have been included because many of these were cited in DAP reports. Important information on analysis systems and results was often circulated to report writers as memorandums before it was available in reports.

The "Papers Presented and Other Publications Bibliography" includes papers prepared from DAP research presented at various professional meetings. Some of these papers were published subsequent to their presentation and the published form is listed in the bibliography.

Finally, the "Theses and Dissertations Bibliography" lists those theses and dissertations that contain DAP data and were completed prior to the compilation of the bibliography. Additional theses and dissertations are also in preparation.

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APPENDIX D

DOLORES ANASAZI RESOURCE MIX: AN ALTERNATIVE APPROACH

Allen E. Kane

The intent of this appendix is to provide additional analysis and interpretation regarding the problem of Dolores Anasazi resource mix. In this appendix, the term "resource mix" refers to the subsistence composition of the local Anasazi groups. This discussion examines the extent to which the local Dolores groups relied on agricultural produce (in this case, corn) and the extent to which they relied on wild plants. Resource mix is an extremely important determinator in terms of the DAP models of cultural process (chap. 6), and the results of studies addressing resource mix can also be used in inferential descriptions of local Anasazi lifeways. This particular treatment of resource mix was developed as an alternative to the discussion presented in chapter 7; the intent here is to augment the chapter 7 discussion with interpretations that reflect a contrasting point of view. Controlling noncultural "noise" in the data sets used to develop inferences regarding resource mix is difficult because of the ambiguity between archaeological context and actual prehistoric behavior. Archaeological data pertinent to the resource mix problem therefore is usually equivocal in terms of interpretation.

SELECTION OF A DATA BASE

For this treatment of resource mix, the botanical data was exclusively focused upon. To minimize the effects of noncultural "noise," it was thought necessary to control for 3 archaeological factors: (1) comparability of collection during excavation; (2) comparability of context; and (3) minimum representation of each modeling period.[1] These factors are similar to those evaluated by Neusius (chap. 4, sect. 4) for faunal material and are briefly discussed by Matthews (chap. 4, sect. 2) for botanical material.

1. Outside the limits of the bulk soil sampling program guidelines (Litzinger 1979), collection of botanical material was at the discretion of the individual crew chief (Kane et al. 1981). For example, the inordinately high corn amount measurements for Period 5 reported by Petersen (chap. 7:table 7.5 and fig. 7.11) probably reflect archaeological factors rather than cultural behavior. Period 5 had a greater amount of sampled contexts than any other period, and this sampling bias is compensated for in the chapter 7 discussion. However, certain other possible biases were not compensated for. The high Period 5 corn measurements probably also reflect certain noncontrolled field collection techniques. The field crews discovered several burned Period 5 storage rooms with large quantities of charred bulk corn (for example, Room 13 at Mesa Negra Pueblo [Kuckelman 1984a:181]) and often collected sizable amounts of this material. This obviously would significantly affect the measurements based on amount of collected corn, especially since such contexts were infrequently encountered during other periods. Petersen (chap. 7) recognizes the problem with measurements based on gross amounts of recovered corn and amounts of corn to sherd ratios and concludes these particular indices are not good indicators of resource mix change. Thus, only within the limits of the bulk soil sampling program was botanical material collected with any degree of consistency or control. Because botanical material collected outside the limits of the bulk soil sampling program does not provide any basis for statistical evaluation, only botanical material collected in bulk soil samples was considered in the analyses presented.

2. The problem of comparability of context was evaluated in-depth by Neusius (chap. 4, sect. 4) for faunal material. Within the scope of the bulk soil sampling program, the most consistently

[1]Modeling periods were selected as temporal units so these results could be compared directly with the results obtained by the environmental archaeology staff.

sampled archaeological contexts from which botanical materials were analyzed are hearths/fireplaces within structures (table D.1). None of the other sampled contexts demonstrated broad distribution through space. Only material recovered from bulk soil samples collected from hearths and fireplaces is considered in the following treatments.

3. To investigate changes in resource use through time, representation of all 7 periods was needed. Within the scope of the bulk soil sampling program, the most consistently sampled context from which botanical material was analyzed was again the hearth/fireplaces within structures group (table D.2). None of the other sampled contexts demonstrated as broad a distribution through time. Periods 1, 6, and 7 were represented in the DAP cultural resource data bases by only a small number of occupations when compared to the other 4 periods; this unevenness is reflected in table D.2. Due to these small sample sizes, the results of tests that suggest differences involving these three periods should be viewed with caution.

In addition to the 3 archaeological factors for which it was possible to compensate, several other factors have not been controlled for in the following treatments: (1) differences in sample size between modeling periods; (2) differences in volume between individual bulk soil samples; and (3) differences in number of samples collected per feature (individual hearths/fireplaces may be represented by more than one bulk soil sample). To provide maximum strength for the tests that follow, only samples that could be conservatively assigned to a single period were included in the treatment.

In using the hearth-collected bulk soil data base to determine resource mix for various case sets, a crucial and perhaps somewhat shaky assumption is necessary. It must be assumed the contents of hearths reflect meal consumption. It seems reasonable to assume the particular hearths selected for this study (centrally located hearths within habitation rooms or within pitstructures) were used for meal preparation, and that through spillage, discard of scraps, and cleaning of cooking utensils, hearth contents do reflect the composition of meals consumed by the groups using the hearth. However, the contents of these central hearths would reflect other activities as well. A large portion of hearth contexts would be consumed and partially consumed fuel (firewood and other combustibles, perhaps including corn cobs). Also, refuse and accidental waste from other hearth-related activities (e.g., initial processing of animal and plant resources as foodstuffs and other products) would probably also constitute a portion of central hearth contents. The development of a procedure to control for the hearth content problem would be very complex and beyond the scope of this discussion. Thus, the hearth contents are simply viewed as reflecting resource mix; it is recognized a contribution from other-than-food sources complicates interpretation. Shifts in fuel resources might particularly affect hearth contents; the project staff has developed a "wood depletion" model (Kohler and Matthews 1984), in which variability in the availability and use of fuel resources is discussed.

GENERAL EXPECTATIONS

Expectations for resource mix are developed according to the precepts of the least cost (economic) and leadership (social organization) models. When specifically considering resource mix in terms of the 2 models, basic differences in the motivating factors are responsible for changes in resource mix. These separate motivations result in a difference in the timing of change in resource mix. The direction of the predicted change is probably similar during some periods, but perhaps different for the time with the greatest observed cultural change, Period 5 (A.D. 880-920; corresponds to the late Periman and Grass Mesa Subphases).

In the least cost model (see Lipe's discussion, chap. 6), changes in resource mix are viewed as a response to fluctuating costs. The general thrust of economic decisions will be to keep costs as low as possible in coping with demand; the least cost model developed by the project staff is thus a "satisficing" formulation. Costs, the "driver" in the model, are governed by supply and demand. Supply is affected by such variables as climate (e.g., drought, fluctuations in growing season length), availability of targeted animal and plant resources, and access to and fertility of agricultural lands. Demand primarily reflects population density and growth rates, although large populations might create greater proportional demand because of the management and integrative "overheads" associated with large groups. Situations where costs are driven up by low supply, or increasing demand, or a combination of factors, trigger a response in economic strategies and ultimately resource mix. Increasing costs initially will result in an increase in investment in agricultural produce. Later, as the rising cost of agriculture makes alternate sources more attractive, a diversification to animal and wild plant resources occurs that previously had been relatively expensive (Lipe, chap. 6). This process is termed "agricultural intensification" or "subsistence intensification" by the DAP and should be testable through examination of pertinent archaeological data. Changes in resource mix should be correlated with periods of steeply rising costs. At Dolores, these are

Table D.1 – Contexts from which botanical material from bulk soil samples was analyzed, by locality

Proveniences	Locality							
	Sagehen	Periman	House Creek	Grass Mesa	Dolores	Escalante	Other*	Total
Inside Structures:								
Fills and features in fills	23	39	8	34	5	1	5	115
Surfaces	24	31	4	36	0	1	4	100
Hearths/fireplaces	19	60	18	94	4	3	5	203
Ash pits	7	10	1	11	0	1	0	30
Pits without burning	7	14	2	25	2	1	0	51
Other feaures†	28	35	21	23	2	1	1	111
Outside structures:								
Grid squares/excavation units	26	40	22	42	1	1	1	133
Surfaces	2	2	3	0	0	0	0	7
Hearths/fireplaces	14	11	9	4	1	1	3	43
Pits without burning	5	6	1	2	2	0	1	17
Other features†	16	13	0	4	2	3	4	42
Total	171	261	89	275	19	13	24	852

* This column contains contexts outside the boundaries of the takeline of the Dolores Project area.
† All feature types grouped here are absent from at least one locality, and no one feature type contains more than 11 cases.

Table D.2 – Contexts from which botanical material from bulk soil samples was analyzed, by period

Proveniences	Period								
	1	2	3	4	5	6	7	Other*	Total
Inside structures:									
Fills and features in fills	3	11	17	10	27	9	3	36	116
Surfaces	10	9	9	11	21	5	3	32	100
Hearths/fireplaces	4	18	14	26	82	12	6	43	205
Ash pits	2	4	2	4	12	1	1	4	30
Pits without burning	2	4	5	7	15	1	0	17	51
Other features†	6	7	11	17	26	4	7	33	111
Outside structures:									
Grid squares/excavation units	3	8	29	22	0	1	7	66	136
Surfaces	0	1	3	0	0	1	2	0	7
Hearths/fireplaces	0	1	11	4	187	4	12	11	43
Pits without burning	0	3	3	4	2	1	0	4	17
Other features†	3	4	7	4	2	3	3	18	42
Total	33	70	111	109	187	42	42	264	§858

* This column contains contexts earlier than Period 1 and later than Period 7, as well as contexts that could not be assigned to a single period.
† All feature types grouped here are absent from at least 2 periods, and no one feature type contains more than 10 cases.
§ The total number of contexts is greater than the total in table D.1 because some contexts were used in more than one period.

Period 4, when rapid population increase created rising demand and a "pinch" on available agricultural land, and Period 5, when population was still high but when unstable climate adversely affected supply. The direction of the change should correspond to the "intensification" track just presented.

In the leadership model, changes in resource mix are viewed as a response to organizational requisites. With the appearance and rise to prominence of leadership hierarchies, resource mix would be manipulated to produce the surplus necessary to create a source of controllable wealth for leadership growth and to promote population growth (Lipe, chap. 6). This is an economic "optimizing" model. Changes in resource mix should correspond with periods of population growth and aggregation, the appearance of leadership groups, and changes in household organization. At Dolores, these are Periods 2 and 3, and possibly Period 4. It is assumed that the most practical means of creating a manipulable, storable food surplus is by emphasizing agricultural production, perhaps at the expense of other economic strategies. This change might be "intensification" of a sort, but it would not be accompanied or preceded by a diversification to wild animal and plant resources. Within the precepts of the leadership model, Period 5 economic stress resulting from unfavorable and unpredictable climate would have necessitated a response. This response is viewed primarily as organizational. The disappearance of agricultural surpluses (Wolf 1985) in the last decades of the ninth century would have destroyed the wealth and attractiveness of the leadership groups, and rendered these groups (the top of the social pyramid; Stuart and Gauthier 1981) expendable in terms of system survival. Local groups would have reverted to a simpler form of social organization. Without the emphasis on production of a surplus, agricultural production would be de-emphasized and alternate resources would be more attractive.

The leadership model also has implications for nontemporal variation in the data. If leadership groups are indeed powerful within local Anasazi society, then it might be expected that wealth would be concentrated and consumed near the residences of these groups. These residences are thought to correspond to the management-associated ritual and ceremony locations identified by Kane (chap. 14) and the "potluck" locations specified by Blinman (chap. 15). Thus, a difference in "resource mix" between the residences of the common people and those of the groups vested with leadership or management privilege and wealth might occur. While the necessity of a management overhead for large groups is a precept of the least cost model, accumulation of wealth and its consumption to promote the ends of leadership groups are not "least cost" in principal. According to the least cost model, there should be relatively little variation in resource mix between resident locations.

THE TESTS

Based on the derived resource mix expectations for each model, a battery of tests was developed and implemented. These tests were focused on 2 particular aspects of the DAP hearth-collected bulk soil sample data base: first, the total or mean number of plant families represented in the particular case set used for a particular test; and second, the proportion of samples containing corn for each particular case set. The results of the tests generally are presented in 2 fashions. First, bar graphs are shown to facilitate visual comparison among case sets; these comparisons directly reflect the resource mix expectations derived from the general precepts of the models. Second, statistical tests are implemented to objectively evaluate the perceived variability among the case sets. However, the degrees of differences predicted by the modeling expectations may not be manifest as statistically significant differences between sample populations.

Tests Results and Interpretations

The implemented tests can be grouped into several sets according to which model expectations are being evaluated. The following discussion of test results is organized according to these expectation sets.

Test Set 1: Number of Botanical Families, By Period

This test set was assembled to evaluate the temporal expectations developed for resource mix diversity. Briefly, according to the least cost model, resource diversity should increase during Periods 4 and 5, when rising economic costs are absorbed by subsistence intensification. According to the leadership model, resource diversity should decrease during Periods 2 and 3 and remain low during Period 4, as agricultural production is emphasized at the expense of other subsistence strategies. During Period 5, dwindling surpluses result in organizational simplication and subsistence diversification. The results of the individual analyses in this test set are summarized in figures D.1, D.2, D.3, and D.4, and in table D.3. If total identified botanical families by modeling period are considered (fig. D.1), then resource mix apparently diversifies during Period 5, as predicted by both models. However, this measurement does not substantiate the other temporal trends derived from the least cost and leadership formulations. The very even numbers of families identified for Periods 1 through 4 seem contradictory, given the documented variation in other project data bases (for example, settlement patterns and architecture).

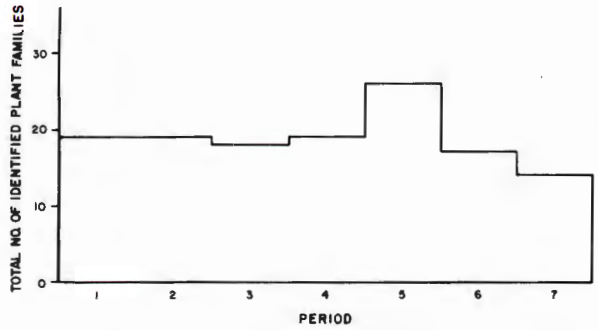

Figure D.1 – Total number of identified plant families in each period.

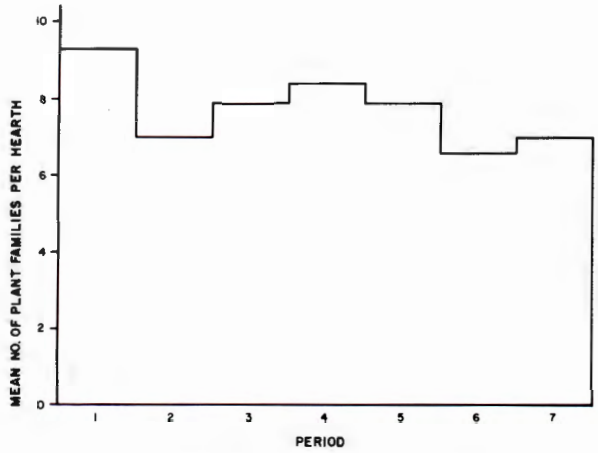

Figure D.2 – Mean number of plant families per hearth, by period (individual bulk soil samples for each hearth were combined).

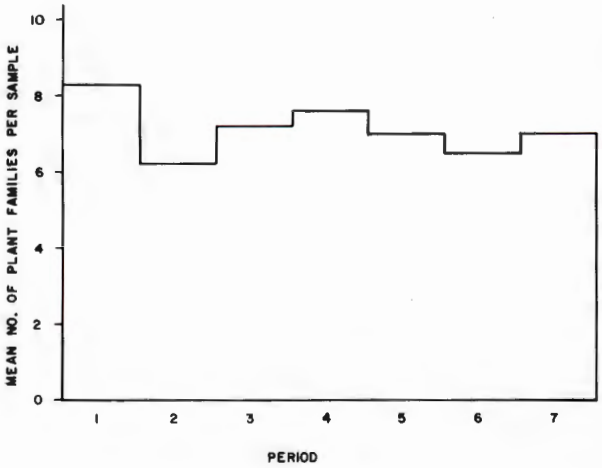

Figure D.3 – Mean number of plant families in the largest bulk soil sample from individual hearths, by period.

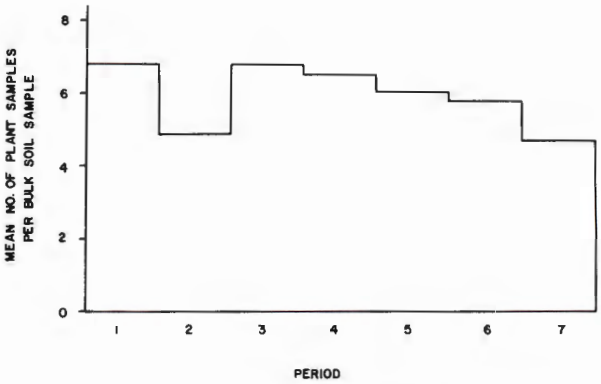

Figure D.4 – Mean number of plant samples per bulk soil sample, by period.

Measurements of hearth content diversity, based on mean number of botanical families per hearth and per sample (figs. D.2 through D.4), show a quite different pattern of temporal variation. Very high diversity (the greatest for any period) is exhibited in Period 1; this is followed by low diversity in Period 2, similar to the predicted trend derived from the leadership model. However, the small increases during Periods 3 and 4 and decreases during Periods 5 and 6 are not consistent with the other predictions from this model. The increase over Period 3 and relatively high values in Period 4 would seem consistent with the predictions derived from the least cost formulation, but disappointingly, the decrease during Period 5 is unpredicted. Thus, the trends in botanical diversity, as measured by total number of families per hearth or per sample, do not match well with the predictions of the models.

To examine more fully what other factors might be responsible for the observed variablity in this data set, a number of additional tests were undertaken (table D.3). First, the magnitude of the observed variability among the modeling periods was tested with a chi-square comparison between the observed values for each possible pair of periods.

Based on the obtained values and the sizes of the individual period sample universes, no statistically valid variation existed within this data set (table D.3). The observed distribution could result from chance factors (sampling error) affecting a data set with virtually no temporal variation. Even the visually prominent difference in total number of plant families between Periods 4 and 5 was not statistically significant (table D.3).

Based on visual inspection, the temporal distribution of total families per period resembled that for number of collected samples by period (fig. D.5); the periods for which many samples were analyzed had relatively many identified plant families, while the periods for

Table D.3 – Tests of significance for test set 1

A. Between total number of plant families and period (fig. D.1)

Null hypothesis: There is no association between the total number of plant families represented and period.

This hypothesis is accepted ($\chi^2 = 4.182$; $p = 0.652$). There is no association between the period and the total number of plant families represented.

B. Between total number of plant families in Period 4 and the total in Period 5 (fig. D.1).

Null hypothesis: There is no difference between the total number of plant families represented in Period 4 and Period 5.

This hypothesis is accepted ($\chi^2 = 1.089$; $p = 0.297$). There is no difference between Period 4 and Period 5 as regards to the total number of plant families represented per period.

C. Between mean number of plant families per bulk soil sample and period (fig. D.4).

Null hypothesis: There is no association between the number of plant families represented per bulk soil sample and period.

This hypothesis is rejected ($F = 2.146$; $p = 0.0488$). There is an association between period and the number of plant families represented per bulk soil sample. However, based on the correlation ratio (eta^2), the largest part of the total variance in the number of families (96 percent) is due to factors other than period. Also, when Scheffe's* procedure is applied, no two groups are significantly different at the 0.05 level. Therefore, the relationship tested probably had no substantive significance.

* Scheffe's procedure tests (SPSS) for significant differences between any two of the modeling periods, which may have been hidden in the initial test (Nie et al. 1975).

which few samples were available had fewer identified families.

It appears that a certain minimum threshold of sample size (perhaps 15 to 20 samples) will lead to the identification of most of the common plants used by the Anasazi for food or fuel, but a great many samples (the 136 for Period 5 is an example) are required if the rarely used plants are to be identified. If this relationship is

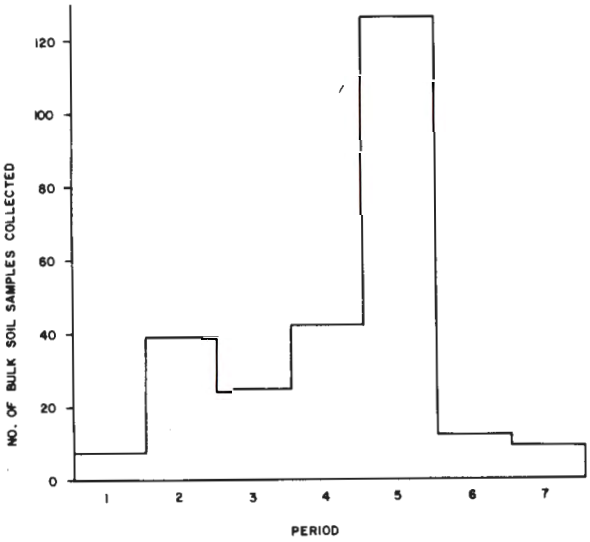

Figure D.5 – Number of bulk soil samples collected per period.

valid, the large increase in identified plant families during Period 5 reflects the large sample universe more than it does cultural practice. It also suggests the diversity of plant resource mix actually might have been greatest during Period 1, which has as many identified plant families as Periods 2, 3, and 5, but from only 7 analyzed samples. The total sample universe for Period 1 was only about 20 to 30 percent of that for Periods 2 through 4. This interpretation is similar to those made on the basis of the mean number of plant families per hearth or per sample measurements.

The variation among periods was significant for mean number of families per bulk soil sample (table D.3); also, the variation could be attributable to factors other than merely the variations in mean values among modeling periods. This suggests the differences in this data set might be attributable to cultural factors. These measurements of subsistence diversity, based on the contents of room and pitstructure hearths, do not provide much in the way of consistent support for either model. A greater diversity of plant resources may have occurred during Period 1 with a decrease during Period 2 and subsequent periods. This interpretation supports the leadership model. A large portion of the variability observed in this data set may be the result of unsuspected cultural factors (abandonment practices, season of hearth deposition) or archaeological factors (differential presentation, variable sample size).

Test Set 2: Proportions of Samples Containing Corn, by Period

This test set was developed to evaluate the model predictions for dependence on agricultural produce. To approximate use of agricultural produce, the percent of

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corn identified in the total sample universe for each modeling period was calculated. Two different approaches were employed; first, using any part of the corn plant as a positive identification (fig. D.6); and second, using only corn kernels to constitute an identification (fig. D.7). By limiting identifications to kernels only, it was thought that the Anasazi use of corn for purposes other than food (the use of corn cobs for fuel, for example) might be balanced.

The predictions derived from the models regarding the importance of corn (agricultural produce) are as follows: according to the precepts of the least cost model, dependence on agricultural produce should be highest during Periods 4 and 5, with the greatest increase in dependence occurring between Periods 3 and 4. In the leadership model, Periods 3, 4, and 5 should exhibit relatively high dependence, with increases in dependence first evident during Period 2. The trends in the all-corn measurements, with the exception of the unanticipated dip in Period 4, closely mirror the predictions of the leadership model. The documented trends in this index appear to provide less support for the least cost model, although the relatively high percent of corn in Period 5 hearths is a critical supporting point. The kernel-only measurements do not support either model and also do not correlate well with the total corn indices. This measurement will be disregarded in later discussion.

Test Set 3: Further Examination of the Variability Within Period 5

As Period 5 is a critical time span in terms of the predictions for both models, and as understanding of the cultural processes occurring in the last portion of the 9th century and first portion of the 10th century is important in terms of the prehistory of the Dolores Anasazi, some additional measurements were developed to further assess the characteristics of resource mix during this period. These measurements were tests of statistical significance performed on several subsets of the data (table D.4).

Based on variations in architectural patterns, some basic shifts in household organization and group mobility occurred during the last part of the ninth century (refer to earlier Periman and Grass Mesa Subphase discussions in this chapter). The groups residing at McPhee Village and perhaps the large villages on the highlands to the west of the river valley (Cline Crest Village and Windy Ruin) maintained the traditional cooperating families (interhousehold) form of organization with relatively low mobility. However, some groups residing at Grass Mesa Village and Rio Vista Village may have shifted to a simpler nuclear family based household organization and relatively high mobility. This basic dichotomy within the period should also be reflected in resource mix. It is expected that Grass Mesa hearths would contain a greater diversity of total plant families and lesser proportions of corn when compared to the Periman Subphase hearths at McPhee Village.

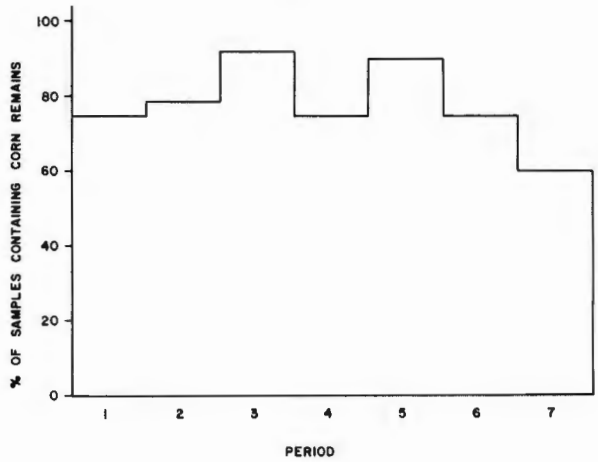

Figure D.6 – Percent of hearths containing corn remains (all plant parts), by period.

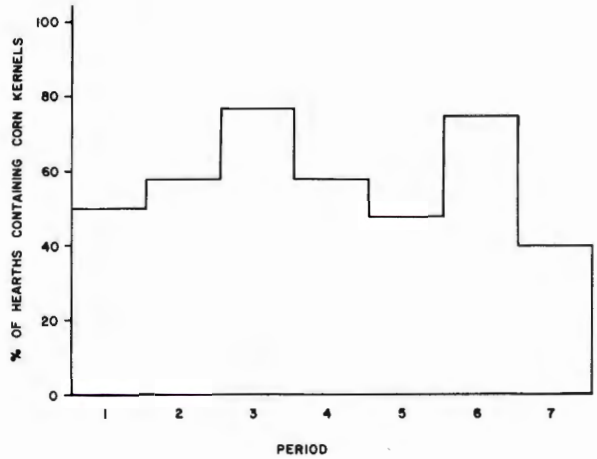

Figure D.7 – Percent of hearths containing corn kernels, by period.

A complicating factor is the possiblity the Grass Mesa Subphase occupation at Grass Mesa Village was primarily a winter occupation, and the residents were subsisting primarily on stored produce, principally corn, during the winter (Lipe et al., comps. 1985:18.94). If so, then the contents of the Grass Mesa Subphase hearths would not be an accurate reflection of the true annual resource mix. The contents of 65 Periman Subphase and 71 Grass Mesa Subphase hearths were evaluated. The mean number of plant families per hearth for the Periman data set was 6.18 versus 6.08 for the

Table D.4 – Tests of significance for test set 3

A. Mean number of plant families per hearth in Periman Subphase versus mean number in Grass Mesa Subphase

Null hypothesis: During Period 5 there is no association between the number of plant families represented in a sample and the subphase which the sample represents.

This hypothesis is accepted ($F = 2.01$; $p = 0.836$). During Period 5 there is no significant association between the subphase which a sample represents and the number of plant families represented in the sample.

B. Presence or absence of corn in Periman Subphase hearth bulk soil samples versus presence or absence in Grass Mesa samples.

Null hypothesis: During Period 5 there is no association between the presence or absence of *Zea mays* in a sample and the subphase that the sample represents.

This hypothesis is rejected ($\chi^2 = 4.38$; $p = 0.0363$). During Period 5 there is an association between the subphase that a sample represents and the presence or absence of *Zea mays* in the sample. A higher proportion of the samples representing the Periman Subphase contain *Zea mays*, while lower proportions of the samples representing the Grass Mesa Subphase contain *Zea mays*. However, examination of the value of phi ($\emptyset = 0.18$) suggests that the association is very weak and may not have substantive significance.

Grass Mesa set. The difference in composition between the sets was not statistically significant (table D.4). When proportions of samples containing corn were calculated for the 2 data sets, 78.5 percent of the Periman hearths yielded corn versus 62.0 percent for the Grass Mesa hearths. This difference was statistically significant based on a 0.05 level of probability (table D.4). These results indicate that Periman and Grass Mesa groups were exploiting similar ranges of plant resources but that Periman groups may have been depending to a greater extent on corn. The expectation that Grass Mesa was primarily a winter residence during the Grass Mesa Subphase was not supported by this analysis.

Test Set 4: Comparison of Nuclear Family Hearths and Interhousehold Hearths

This and the following test sets were generated to examine some aspects of nontemporal variability in resource mix as reflected in hearth contents. Generally, these measurements and tests were developed to evaluate the relationship between social organization and resource mix. Test set 4 in particular was developed to examine the differences, if any, between resource mix at the nuclear family level and resource mix at the interhousehold level during the period when household organization is believed to be relatively complex. During the A.D. 780-910 period (approximately Periods 3, 4, and 5), hearths in surface rooms are believed to have been used by individual nuclear families, while hearths in pitstructures were shared by the several nuclear families that constituted an interhousehold. It is assumed that the interhousehold as a unit shared some meals and food resources while in the pitstructure. No specific predictions were used for this test set; rather, the intent was to determine whether any variability occurred between the 2 socially distinct types of hearths. The sample set contained a total of 150 surface room (nuclear family) hearths for Periods 3, 4, and 5, and contained 101 pitstructure (interhousehold) hearths. The mean number of plant families per hearth was 5.9 (SD = 2.4) for surface rooms and 6.5 (SD = 3.0) for pitstructures. This may suggest slightly greater diversity in meals and resources for interhousehold groups; however, the difference between the hearth content populations was not statistically significant (table D.5). When presence or absence of corn (all plant parts) was considered, corn was present in 67.9 percent of the nuclear family hearths and 69.3 percent of the interhousehold hearths. This difference is too slight to be considered significant in terms of interpretation and was statistically insignificant as well (table D.5).

Test Set 5: Intercommunity Variability in Resource Mix

This set of measurements was developed to further examine the predictions of the leadership model regarding their "poor cousins" at the smaller communities. However, the first part of this expectation might be affected by variability in catchment, which may result from a variety of behaviors. For example, groups accessing catchments with relatively small acreages of agricultural lands but with varied wild plant resources might have a dietary preference for the latter.

In the following presentation, McPhee Village is considered a "large" community, Grass Mesa Village is a "smaller" community, and House Creek and Rio Vista Villages are the "smallest" communities; this characterization is based on the comparative total roomblock lengths provided in chapter 14, figure 14.3. The sample universe was restricted to the Periman Subphase portion of Periods 4 and 5, so possible variability resulting from the different social structures of Grass Mesa Subphase groups would be eliminated. A total of 132 samples was included in the analysis—66 from McPhee

Table D.5 – Statistical tests for test set 4

A. Mean number of plant families per nuclear family hearth versus number per interhousehold hearth.

Null hypothesis: During Periods 3, 4, and 5 there is no association between the number of plant families represented in a sample and whether the sample is interpreted to represent within-household or between-household use

This hypothesis is accepted ($F = 1.53$; $p = 0.079$). During Periods 3, 4, and 5 there is no association between the interpretation of within-household or between-household use and the number of plant families represented in the sample.

B. Presence or absence of corn in nuclear family hearths versus presence or absence in interhousehold hearths.

Null hypothesis: There is no association between the presence of absence of corn in a sample and whether the sample is interpreted to represent within-household or between-household use.

This hypothesis is accepted ($\chi^2 = 0.059$; $p = 0.808$). There is no association between the interpretation of within-household or between-household use and the presence or absence of corn in the sample.

Village, 46 from Grass Mesa Village, and 20 from Rio Vista and House Creek Villages (combined). The mean number of plant familes per hearth was 6.4 (SD = 3.11) for McPhee Village, 5.4 (SD = 2.70) for Grass Mesa Village, and 7.4 (SD = 2.60) for House Creek and Rio Vista villages combined. The differences among communities are statistically significant (table D.6). These results provide only partial support for the predicitons derived from the leadership model. Contents of McPhee Community cluster hearths were more diverse than those representing Grass Mesa, which is consistent with model predictions. However, neither the McPhee or the Grass Mesa data universe was as diverse in terms of mean number of plant families as the one representing the smallest villages (House Creek-Rio Vista); this result contradicts the prediction of the leadership model. The sample size for the smallest villages is small, but the statistical test indicates the observed differences are significant. This suggests that factors other than those integral to the model predictions are affecting the distributions—perhaps other cultural factors or sampling error. The other prediction, regarding a possible relationship between catchment characteristics, was also not well supported by the results of this test. Grass Mesa Village has the most desirable catchment in terms of wild plant resource variability, but the hearth contents from Grass Mesa were comparatively low in terms of plant family diversity.

The proportion-of-corn measurement also yielded ambiguous results in terms of model predictions: 74.4 percent of the McPhee Village hearths contained corn versus 63.0 percent for Grass Mesa hearths and 80.0 percent for House Creek-Rio Vista; these differences were not statistically significant (table D.6). Thus, the relationship between McPhee and Grass Mesa was as anticipated, but the proportions for the House Creek-Rio Vista hearths were much higher than expected. It may be coincidence or a result of legitimate cultural or archaeological factors that both the plant diversity and corn proportion measurements for the smallest villages were much higher than anticipated.

Test Set 6: Measurement of Resource Variability in Oversized Pitstructures

According to the leadership model, "oversized" pitstructures should be locations of suprahousehold organization ritual and ceremony. Some of the ceremonial activities might have been in the form of "potlucks" hosted by high-status groups residing at the roomblock units associated with the oversized structures. Consumption of special foods may have been a facet of these potlucks. Based on these assumptions, oversized pitstructure hearths would exhibit less variability in plant families because of the specialized, ritual nature of the foods consumed in oversized structures. Also, because stored corn has been assumed to represent the wealth of the local Anasazi groups and because corn is assumed to be a staple, probably used as a major ingredient in ritually distributed foods, the proportion of corn remains in oversized pitstructure hearths might be expected to be higher than that in other structures.

The measurements in test set 6 provided partial support for these hypotheses. The mean number of plant families in oversized pitstructure hearth samples was 4.6 compared to 6.2 for other structures; this difference is statistically significant (table D.7). The corn measurements were not so clear cut. Of the 13 bulk soil samples from oversized pitstructure hearths, 7 (53.8 percent) contained corn; of the 194 samples from other structures, 134 (69.1 percent) contain corn. Hence, the leadership model prediction was not borne out in this case. The difference between the 2 sample sets was not significant in a statistical sense, however, because of the lower number in the oversized pitstructure sample set (table D.7). The differences in the proportions therefore may be result of chance factors and not the result of cultural factors.

Table D.6 – Statistical tests for test set 5

A. For significant association among mean number of plant families in McPhee, Grass Mesa, and Rio Vista-House Creek Community Cluster hearths.

Null hypothesis: During Periods 4 and 5, when only samples assigned to the Periman Subphase are considered, there is no association between the number of plant families represented in a sample and the community cluster from which the sample was collected.

This hypothesis is rejected (F= 3.462; p = 0.0342). During Periods 4 and 5, when only samples assigned to the Periman Subphase are considered, there is an association between the community cluster from which a sample was collected and the number of plant families represented in the sample. However, based on the correlation ratio (eta^2), the largest part of the total variance in the number of plant families (95 percent) is due to factors other than period. When Scheffe's procedure is applied, the Grass Mesa Community Cluster is shown to have significantly fewer plant families represented in a sample than the group of samples collected from the Rio Vista, House Creek, and May Canyon Community Clusters. The mean number of plant families per sample from the McPhee Community Cluster falls between the two other means, but cannot be distinguished from either of the other means on the basis of this test.

B. For significant association the presence or absence of corn in a hearth bulk soil sample and the community cluster from which the sample was collected.

Null hypothesis: During Periods 4 and 5, when only samples assigned to the Periman Subphase are considered, there is no association between the presence or absence of corn in a sample and the community cluster from which the sample was collected.

This hypothesis is accepted (χ^2 = 2.546; p = 0.2799). During Periods 4 and 5, when only samples assigned to the Periman Subphase are considered, there is no significant association between the community cluster from which a sample was collected and the presence or absence of corn in the sample. The results of this test support the previous test where both Periman and Grass Mesa Subphase samples were considered.

Table D.7 – Statistical test for test set 6

A. Mean number of plant families in oversized pitstructure hearths versus number in other structure hearths.

Null hypothesis: During Periods 4 and 5, oversized pitstructures do not have a significantly greater number of plant families per sample than the remainder of the structures from which samples were collected.

This hypothesis was rejected (T = 2.11; p = 0.018: one-tailed test). Oversized pitstructures have a significantly lesser number of plant families per sample than the remainder of the structures when only samples from Periods 4 and 5 are considered. The mean number of plant families per sample for oversized pitstructures was 4.62, and the mean number of plant families per sample for the remainder of the structures was 6.25.

SUMMARY AND CONCLUSIONS

The resource mix measurements developed provided only minimum support for either the leadership or least cost models. The variability in the DAP bulk soil data set is the result of many complex factors, some of which are cultural, and others of which can be characterized as archaeological in origin.

Considering the temporal trends in the data, resource mix diversity was probably highest during Period 1 (A.D. 600-700), as predicted by the leadership model, and was perhaps lower and fairly stable for the succeeding periods. Resource mix diversity may have decreased during Period 7, but a stronger statement is impossible because of the small sample size. Dependence on corn apparently was greatest during Periods 3, 4, and 5 (A.D. 800-920). The apparent shift to high dependence on corn (before the time of peak population and climatic uncertainty in the last half of the ninth century) supports the leadership model.

Additional measurements based on inferred variability in social organization and other precepts of the leadership model also yielded mixed results. Resource mix variability within Period 5 may be partially correlated with organizational variability. The simple organizational household groups at the Grass Mesa Community may have been less dependent on corn as a staple than were the more complex organizational groups at McPhee Village. Resource mix diversity, however, seemed to be similar for the 2 communities—a finding that supports the least cost model. The predictions of the winter-residence model for Grass Mesa Village

(continued high proportions of corn in the diet of resident groups) were not borne out by this study. Interhousehold groups sharing meals in pitstructures may have incorporated a slightly greater diversity of plant foods. The predictions of the leadership model regarding better standards of living and perhaps a more varied and more highly corn dependent diet at larger communities was not supported by the measurements in this study, although the comparative values for McPhee Village and Grass Mesa Village were consistent with the expectations. Finally, "potlucks" at oversized pitstructures may have included ritual foods with specialized ingredients; however, the measurements did not indicate the use of corn as a standard ingredient in these activities.

Great care must be used in rendering interpretations based on these data. The initial impression that both cultural and archaeological factors, often very difficult to separate or identify, were responsible for the variability within the data set was borne out. While efforts were made to limit noncultural factors at the initiation of the study, this effort was only partially successful. Thus, the summary statements presented in this final assignment must be regarded as tentative. The DAP bulk soil data base has great potential for further profitable research beyond what has been attempted in this report, both in terms of pioneering appropriate analytical methodologies and in evaluating the cultural factors responsible for some of the variability in this data set.

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