Dolores Archaeological Program: Synthetic Report 1978-1981

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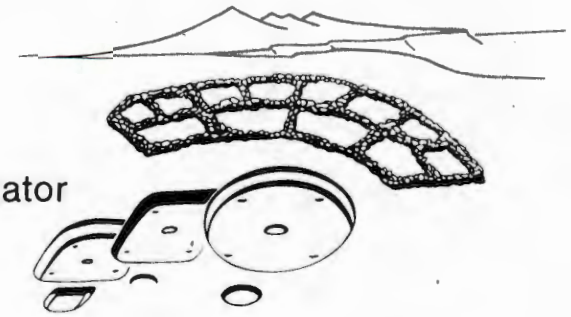

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FOREWORD

Dolores Archaeological Program Synthetic Report 1978-1980 is the second publication in a series of reports by the Bureau of Reclamation, U.S. Department of the Interior, on the findings of the Dolores Archaeological Program including excavation activities, and the preservation and analysis of newly discovered artifacts.

Preliminary investigations of the Dolores Project, a Reclamation water supply and delivery project near the town of Dolores in southwestern Colorado, found extensive archaeological resources which would be adversely affected by construction.

In recognition of the unusual concentration of prehistoric Anasazi sites in southwestern Colorado, the Department of the Interior supported the passage of Public Law 96-301 in 1980. This law authorized an increase in program expenditures for archaeological research, from one percent to four percent of total project costs. The additional funds have provided for more comprehensive data collection, analysis, and documentation. A portion of the funds will be used to construct the Anasazi Heritage Center to provide public display and interpretation of the artifacts found.

The Dolores archaeological reports discuss a portion of each year's activities. They are supplemented by more detailed contractor reports which will be available to the public through the U.S. Department of Commerce's National Technical Information Service in Springfield, Virginia.

The Dolores archaeological research reflects Reclamation's commitment to quality scientific study. Without this research supported and published by the Bureau of Reclamation, and conducted by the University of Colorado, an important opportunity to learn more about the Anasazi peoples and their early culture would have been lost. It is Reclamation's policy that cultural resources should be preserved and interpreted for the best scientific and widest public uses. This series of publications is an example of Reclamation's dedication to that goal.

ACKNOWLEDGMENTS

The DAP (Dolores Archaeological Program) and the contributing authors of the DAP Synthetic Report 1978-1981 wish to gratefully acknowledge the following individuals for their support and hard work in the production of this report. Without the devotion and dedication of these people, this report would not have been possible; citations are presented in alphabetical order.

Overall report coordination was the responsibility of Christine K. Robinson (technical) and Lora Van Renselaar (production).

Editing was performed by Mary C. Etzkorn, G. Timothy Gross, and Lynn L. Udick, with special assistance from Meredith H. Matthews. Formatting and typing were done by Barbara Basham, Kathy M. Clow, Thirza A. Doudy, Kristin A. Kuckelman, and Cathy Watts; collation of figures and tables was performed by Alexis A. Hamilton; reference checks were done by Alexis A. Hamilton, Melinda S. Russell, and Scott E. Travis. Line graphics were provided by the Drafting Section (under the supervision of Lee R. Schmidlap); work was performed by Gary A. Brown, Thomas C. May, and Lee R. Schmidlap. Photographic illustrations were generated by the Photographic Section (under the supervision of John P. Nylander) by Marcia Gross and John P. Nylander. Data Processing output (under the supervision of Arthur L. Rohr) was produced by Debra M. Gardner, Arthur L. Rohr, Dorin E. Steele, and Jane A. Ward.

In addition, the text was reviewed by all of the Senior Staff and by most other members of the DAP lab and field staff. Final production assistance was provided by David A. Breternitz, Judith L. Burk, Douglas A. Goulding, and Nancy J. Hewitt.

Finally, the DAP wishes to thank Edna J. Hunsinger, Editor, Bureau of Reclamation Technical Publications Branch, for the considerable assistance she has given in the preparation of this report for publication.

ABSTRACT

The Dolores Project is a large water project currently under construction by the Bureau of Reclamation in extreme southwestern Colorado. The Dolores Archaeological Program is responsible for the Dolores Project Cultural Resources Mitigation Program under Bureau of Reclamation Contract No. 8-07-40-S0562. At the request of the Bureau of Reclamation, the Dolores Archaeological Program has produced this report entitled Dolores Archaeological Program Synthetic Report 1978-1981. This report will provide the Bureau of Reclamation with a mechanism for evaluating Dolores Archaeological Program synthetic results for future budget and program decisions.

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Chapter 1

AN OVERVIEW OF THE DOLORES ARCHAEOLOGICAL PROGRAM

Chapter 1

AN OVERVIEW OF THE DOLORES ARCHAEOLOGICAL PROGRAM

by David A. Breternitz,
Senior Principal Investigator

INTRODUCTION

The Dolores Project is a water reclamation project currently under construction by the Bureau of Reclamation in southwestern Colorado, north of Mesa Verde National Park. Major project features include the McPhee Dam and Reservoir, the Great Cut Dike, borrow areas, buffer lands surrounding the central reservoir (the boundary of these buffer lands is called the project takeline), and a water distribution system consisting of two main canals, lateral lines, and two small supportive reservoirs (fig. 1).

The DAP (Dolores Archaeological Program) is the portion of the Dolores Project responsible for the Dolores Cultural Resources Mitigation Program. A comprehensive history of both the Dolores Project and the DAP is reported by Madden and Weakly (1980).

With regard to cultural resources, the Bureau of Reclamation operates under the following Federal laws: (1) the Reservoir Salvage Act of 1960 as amended (16 U.S.C. 469) and (2) the National Historic Preservation Act of 1966 as amended (16 U.S.C. 470).

In 1978 the Bureau of Reclamation entered into a Memorandum of Agreement with the President's Advisory Council on Historic Preservation (with the concurrence of the Colorado State Historic Preservation Officer) for the development of a cultural resources data recovery program as part of the Dolores Project. A Memorandum of Understanding was signed between the Bureau of Reclamation and the Bureau of Land Management to maintain long-term curation of Dolores collections and for development of the Anasazi Heritage Center.

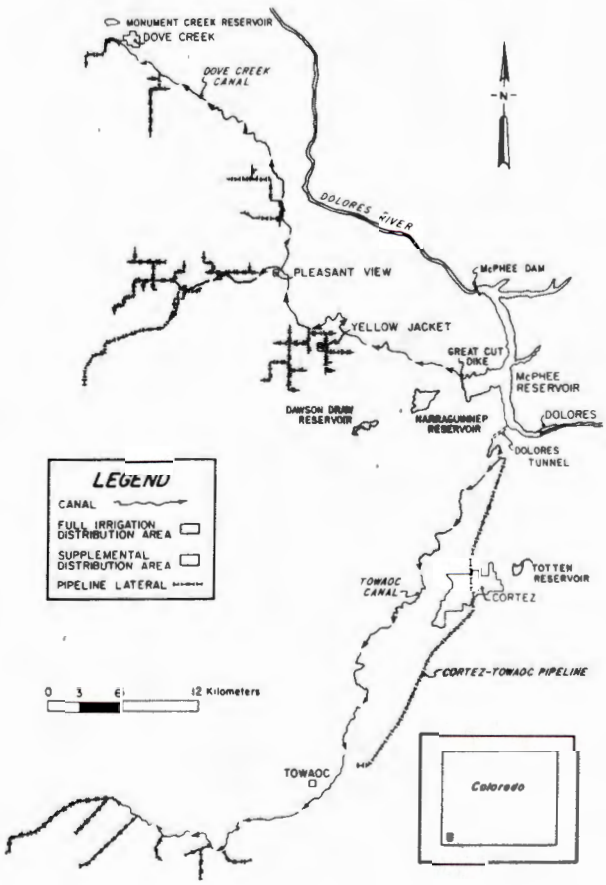


Figure 1. Dolores Project area and features.

At the same time, the basic contract agreement to conduct cultural resources mitigation for the Dolores Project was signed between the Bureau of Reclamation and the University of Colorado (6 June 1978, Contract No. 8-07-40-S0562). Preliminary fieldwork by the University of Colorado began on 12 June 1978 and full-scale excavation commenced on 19 June 1978. The Lebanon Laboratory Facility, which serves as the sole housing for the DAP, was not operational until the end of August 1978. However, the Dolores Cultural Resources Mitigation Program has been active on a year-round basis since the signing of the contract.

ORGANIZATION OF THE DOLORES ARCHAEOLOGICAL PROGRAM

Administrative Organization

The Dolores Archaeological Program is a complex organization involving not only the University of Colorado, the prime contractor, but also a variety of subcontractors (most notably Washington State University) and consultants. The original contract between the Bureau of Reclamation and the University of Colorado stipulates that activities and analyses which could not be performed by the University of Colorado be subcontracted to appropriate experts.

A review of the concepts advanced by Mintzberg (1981) indicates that the DAP is structurally similar to both a professional bureaucracy and an adhocracy. This organizational configuration may well be representative of organization on other large-scale archaeological projects.

Ultimate authority and responsibility for the DAP rests with the Senior Principal Investigator, D.A. Breternitz. The Bureau of Reclamation-University of Colorado contract specifies the designation of at least two, but no more than four, Co-Principal Investigators. Currently there are three Co-Principal Investigators: Allen E. Kane, CU (University of Colorado), appointed June 1978; William D. Lipe, WSU (Washington State University), appointed June 1978; Tim Kohler, Washington State University, appointed August 1980.

As a group, the Senior Principal Investigator, Co-Principal Investigators, and the Technical Performance Manager (Christine K. Robinson, University of Colorado, appointed August 1980) currently compose the DAP Senior Staff. This group designs, plans, and implements activities which will meet the directives of the Bureau of Reclamation and the Dolores Project Cultural Resources Mitigation Design, the primary program planning document (Knudson et al. n.d.). The Senior Principal Investigator and the Co-Principal Investigators serve as the major DAP decision-making unit; final decisions rest with the Senior Principal Investigator. Within the current DAP Senior Staff, each member serves a multifunctional role in design, planning, and performance functions. The Senior Principal Investigator provides primary input on administrative and technical matters. Co-Principal Investigator Lipe provides major input on technical and Washington State University administrative functions. Co-Principal Investigators Kane and Kohler provide input primarily on technical and, to a lesser extent, administrative functions. The Technical Performance Manager provides a mechanism for coordinating between the Senior and Co-Principal Investigators and monitors progress in task areas.

Current consultants to the DAP Senior Staff provide outside expertise into technical and management functions of the DAP. Consultants to the Senior Staff currently include Robert A. Bye, Department of Environmental, Population, and Organismic Biology, University of Colorado; Steven E. James, Woodward-Clyde Consultants; Ruthann Knudson, Department of Anthropology, University of Idaho, and Woodward-Clyde Consultants.

A second level of supervisory personnel, the Task Specialists, is responsible to the DAP Senior Staff and, ultimately, to the Senior Principal Investigator. DAP Task Specialists have been assigned direction over specific field and laboratory operations; Support Service Task Specialists and their staffs make up a separate operational area.

Field Organization

Co-Principal Investigators Kane and Kohler serve as DAP Field Directors in addition to their other responsibilities. Currently, there are two Supervisory Archaeologists (David Greenwald and Nancy J. Hewitt) at the Task Specialist level who are responsible to Co-Principal Investigator Kane. The Supervisory Archaeologists' duties include coordination of field equipment and direct supervision of day-to-day field and reporting activities for excavation. Survey operations are directly supervised by a Task Specialist (Janet D. Orcutt).

Organization of Analysis Task Groups

Analysis-oriented Task Specialists include a Reductive Task Specialist dealing with lithics and worked bone (Carl J. Phagan), an Additive Task Specialist dealing with ceramics and basketry (William A. Lucius), and an Environmental Studies Task Specialist (Bruce F. Benz).

Support Service Organization

Supportive Task Specialists include a Technical Performance Manager (Christine K. Robinson), a Laboratory Supervisor (Paul J. Farley), a Data Processing Task Specialist (Arthur L. Rohr), and a Photographic Task Specialist (John P. Nylander). Two other support functions consist of an Editorial Report Services Group (Lora Van Renselaar, Coordinator) and the Administrative Assistant to Senior Principal Investigator Breternitz (Judith L. Burk).

Below the Task Specialist and Supervisory Archaeologist level are Crew Chiefs who serve as field excavation supervisors and are responsible for excavation reporting. Additional Crew Chiefs supervise the day-to-day activities which are the ultimate responsibility of the Task Specialists. Crew Chiefs are aided by Assistant Crew Chiefs; the Analysis field and laboratory crew members compose the basic working force of the DAP.

During the tenure of the contract, a number of consultants have been involved in specific task areas and specialized studies. These include the following: University of Arizona Laboratory of Tree-Ring Research; Colorado State University (Jeffrey Eighmy - Archaeomagnetic Investigations); University of Nebraska (John Weymouth and Robert Huggins - Magnetometer Investigations); Center for Western Studies (Steven Emslie - Faunal Analysis); Palynological Analysts (Linda Scott); University of Arizona (Robert Van Devender - Packrat Midden Analysis); University of Idaho (Frank Leonhardy - Soil/Geological Studies); University of Colorado (Vance Holliday and Lucy Piety - Geologic Consultants); University of Colorado (Louisa Flander - Physical Anthropological Consultant.)

Three other original subcontractors in 1978 who are no longer involved in DAP operations were: Centuries Research, Inc., for Historic Studies; Woodward-Clyde Consultants; and Western Audio-Visual, to produce a requested public relations documentary film.

RESULTS OF THE PROGRAM THROUGH THE 1980 FIELD SEASON

A significant data base has been assembled during the 3-year tenure of the DAP. In dealing with the cultural resources available to the DAP, some indication of the extent of this resource base is informative.

Survey/Inventory Activities

Table 1 summarizes the extent of cultural resources currently known for the Dolores Project as the result of surface survey/inventory activities. The table includes not only those activities which have been conducted since 1978, but also previous investigations (began in 1972) associated with the proposed Dolores Project. As of 18 May 1981, a total of 1076 cultural resource entities, both historic and prehistoric, have been documented.

Field Excavations and Investigations

Table 2 summarizes excavation and magnetometer survey efforts to date. It is broken down by crew-weeks; a crew-week is the equivalent of 10 persons each working a 40-hour week. A total of 305.2 crew-weeks have been expended on excavation and testing through the 1980 field season, at a total of 71 sites.

Also included in table 2 is the effort expended in the magnetometer survey (implemented to increase the amount of description available in the Class III inventory reports). Through the 1980 field season, a total of 175 magnetometer grids (each 20 by 20 m) have been mapped at 55 sites. Based on magnetometer survey, some sites have been selected for additional excavation or testing, so there is some overlap in the site investigation totals among excavation, testing, and magnetometer survey.

Table 1. Known cultural resources in the Dolores Project area

	Dolores Project takeline impacts			Dolores Project outside takeline impacts			Total
Survey project	Primary[1]	Secondary	Subtotal	Primary[2]	Secondary	Subtotal	
Pre-1978 CU Dolores River Surveys[3]	109	46	155	376	32	408	563
DAP/YACC* Survey (Dykeman et al. 1981)	78	74	152	1	0	1	153
DAP/Centuries Research (Baker and Smith 1981)	13	0	13	0	0	0	13
DAP/CU 1979-81	207	36	243	22	1	23	266
DAP/WSU 1979-80	3	45	48	0	0	0	48
Miscellaneous other[4]	1	3	4	27	2	29	33
TOTAL	411	204	615	426	35	461	1076

*Young Adult Conservation Corps

[1]Includes McPhee Dam and Reservior, Great Cut Dike, and borrow areas.

[2]Includes Dove Creek and Towaoc Canals, laterals, and secondary reservoirs.

[3]Breternitz and Martin (1973), Toll (1974), Kane (1975 a, b, 1977).

[4]Unpublished Colorado University-Bureau of Land Management Survey (1965-1969), Adams (1973), Reed (1979), Ward-Williams (1976), Woodward-Clyde Consultants (1980).

Table 2. Crew effort expended at sites excavated, tested, or surveyed by magnetometer, 1978-80

	Excavated	Tested	Total	Magnetometer survey
1978				
Number of sites	7.0	—	7.0	15.0 (46 G*)
Labor in crew-weeks	46.5	—	46.5	1.5
1979				
Number of sites	16.0	16.0	32.0	23.0 (70 G*)
Labor in crew-weeks	109.2	5.8	115.0	3.0
1980				
Number of sites	9.0	23.0	32.0	22.0 (56 G*)
Labor in crew-weeks	138.8	4.9	143.7	1.5
Total				
Number of sites	32.0	39.0	71.0	60.0 (172 G*)
Labor in crew-weeks	294.5	10.7	305.2	6.0

*G=grids

PURPOSE OF THIS REPORT

The following chapters will document the efforts expended, the progress to date, and the results of field and analytical investigations by the DAP since its inception. The report is designed to address Bureau of Reclamation directives of 18 December 1980, 2 March 1981, and 30 April 1981. This document will also be provided to a peer review board to be formulated by the Bureau of Reclamation during the summer of 1981. Production of this report has allowed the DAP to internally assess its progress in terms of the Mitigation Design; the report also provides a basis for more selective work in the future to increase the confidence in the existing data base.

In chapter 2, "Method and Technique: Prehistory," the general program orientation is discussed. Specific program research goals and methods are presented in terms of DAP design, planning, and performance functions with respect to the prehistoric data base of the project. Appendix F is included to reference current DAP modeling efforts as part of the overall Mitigation Design.

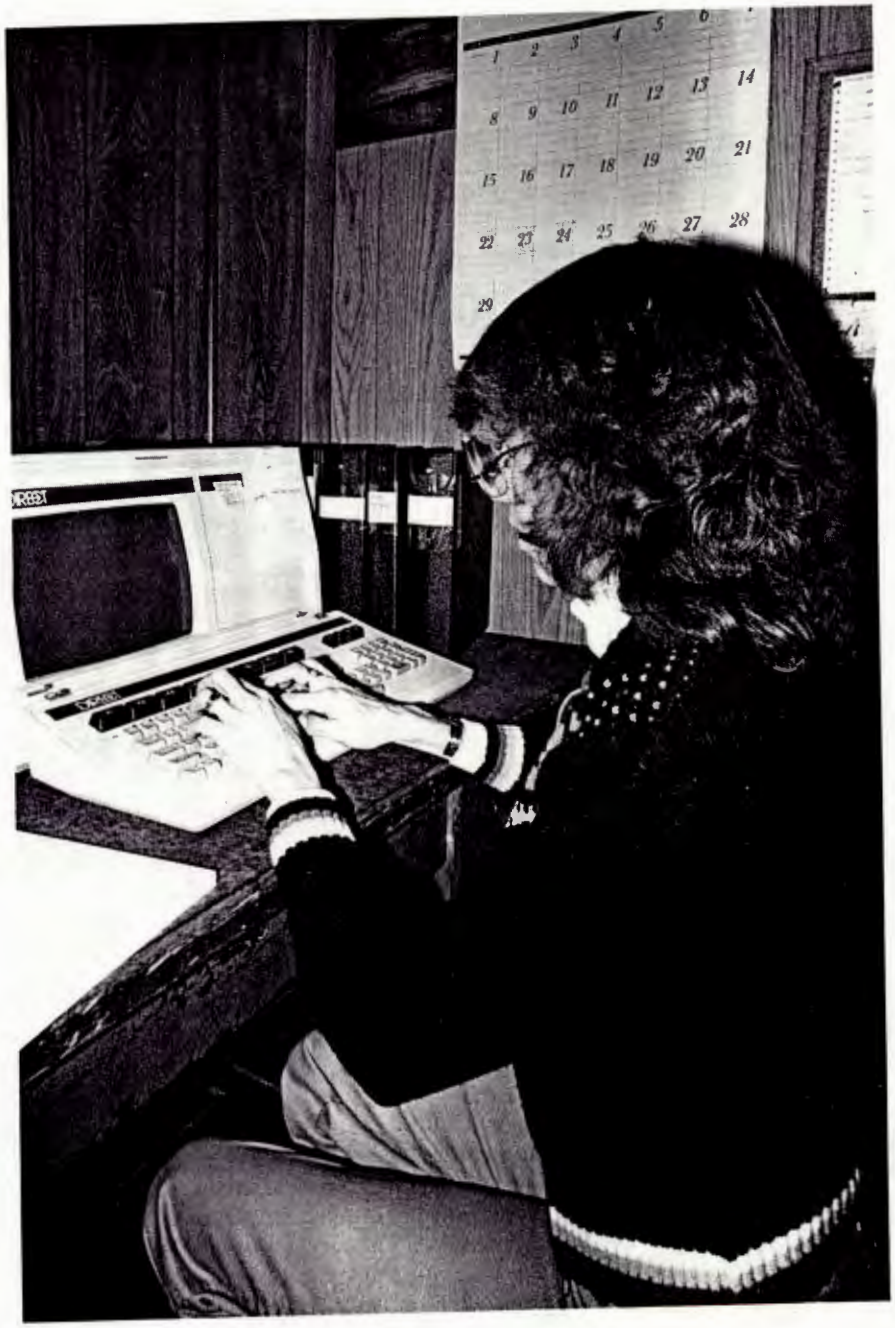
Chapter 3, "The Prehistory of the Dolores Project Area," is an assessment of DAP progress in relation to the five problem domains of the Research Design. The information presented in this section is supported by data included in appendixes A through E.

"Historic Studies," chapter 4, was rather hurriedly written during the last week of the DAP history program (terminated 18 May 1981 at the request of the Bureau of Reclamation). Nonetheless, it does provide some understanding of the historic resources of the Dolores Project area.

Chapter 5 is composed of a selection of analytical studies completed or in progress by the DAP. They can be subsumed under the following major topics: (1) sampling, (2) paleodemography, (3) paleoecology, (4) ceramic analysis, (5) lithic analysis, (6) trade and exchange network analysis, and (7) intersite and intrasite analysis.

The "Summary and Conclusions" portion, chapter 6, presents concluding statements and an assessment of future DAP directions.

Finally, a series of appendixes (A through F) are provided as supporting data for individual chapters and in their own right serve as data set assessments on a more specific level.



Chapter 2

METHOD AND TECHNIQUE: PREHISTORY

Chapter 2

METHOD AND TECHNIQUE: PREHISTORY

by William D. Lipe and Timothy A. Kohler

GENERAL PROGRAM ORIENTATION

The DAP (Dolores Archaeological Program) is a mitigative data recovery program; that is, it is designed to mitigate, or compensate for, the loss of cultural resources — and the information about the past they contain — that is being brought about by the construction of the Dolores Project. The overall structure of the DAP research effort is set forth in the DAP Mitigation Design (Knudson et al. n.d.). This document presents (1) basic concepts which guide the work; (2) the Research Design, which provides a logical structure of inquiry within which specific questions can be addressed; and (3) the Implementation Design, which provides a conceptual approach to relating levels of data recovery to levels of adequacy in addressing basic questions about the cultural resources of the Dolores Project area. Because the Mitigation Design is intended to orient the approach to data recovery taken by DAP, its main provisions are briefly reviewed here.[1]

Basic Concepts

When a Federal earth-disturbing project is expected to affect archaeological resources, it is legally required to implement a program to mitigate or alleviate the impacts of the planned construction on those threatened resources. The Dolores Project is a large Bureau of Reclamation water development project, and the very nature of this project precludes such measures as avoidance of cultural resources or preservation of these resources in place. The specific location of the Dolores Project and the extent of construction are dictated by national economic needs and co-occur with an area of high cultural resource density. Because it is desirable to alleviate, to some extent, the adverse effects of construction on the cultural resources located within the impact zones and because preservation and avoidance are not options in this case, only one approach to mitigation is feasible — mitigation through investigation of the resources. Investigation, as it is used here, is characterized as "the conservation of information through adequate study of the resources before they are destroyed" (McMillan et al. 1977:29) and is a major focus on the DAP. Because accumulation of raw data and boxes of specimens does not in itself provide information or knowledge about the resources that will be lost, analysis and synthesis of these data must be accomplished and the results presented in written reports before the desired mitigation is achieved.

The Mitigation Design (Knudson et al. n.d.) is the basic planning document for the program and presents the three main functions of the information recovery efforts of the DAP. These functions are design, planning, and performance.

Design. Primary responsibility for developing a proposed conceptual design for program research has been delegated to the contractor by the Bureau of Reclamation and such a design is subject to approval by Reclamation. The contractor's conceptual design efforts include the development of (1) a guiding structure for program research efforts (as detailed in the Research Design and the Implementation Design) which serves to ensure both reliability and validity of results; (2) a structure for midlevel analyses of certain categories of data (e.g., ceramics, lithics); (3) individual synthetic and analytic studies which either address specific questions in the Research Design or develop methods (e.g., cermaic seriation) instrumental in addressing a variety of questions; and (4) explanatory models of culture history and process which are both applicable to the Dolores area and testable with program data. The results of these conceptual design efforts, as expressed in written form, provide the basis for the development of program plans.

Planning. Responsibility for planning is shared by both Reclamation and the contractor. The approved research designs provide the basis for the evaluation of appropriate levels of effort. The contractor provides Reclamation with these evaluations, and Reclamation then determines the levels of contractor fieldwork, laboratory analysis, and reporting. Agency decisions are generally based on the level of funding available, the schedule of construction activities, and the mitigative responsibilities of Reclamation. As part

[1] Portions of this chapter have previously appeared in Knudson et al. (n.d.) and Kane (1981a).

of the planning process, a number of documents have been prepared. These include (1) the Work and Study Management Plans prepared annually; (2) various task group guides and manuals (e.g., Editorial Style Guide, Survey Field Manual); and (3) periodic time-personnel-task management plans.

Performance. This function includes fieldwork, analysis, and reporting and is the responsibility of the contractor. Specific outputs include artifacts and samples, field and laboratory documentation, descriptive site and survey reports, and synthetic and analytic reports addressed to specific problems and categories of data. Field and laboratory work are monitored by Reclamation and all outputs are subject to Reclamation review and acceptance decisions.

Returning to the category of conceptual design, the DAP Mitigation Design is the general outline of program conceptual management, and hence, serves as a conceptual basis for the planning of work that will satisfy the scholarly research and public interest considerations implied by a data recovery approach to mitigation. The Research Design was developed early in the program's history, but the Implementation Design, which attempts to answer the question "how much data recovery is enough?" is still being developed. This is the contractor's design for how to approach the question of determining data sufficiency with respect to research design goals. It is not a plan that specifies how much work effort is legally "adequate." This determination is the responsibility of the Bureau of Reclamation. The methods proposed in the Implementation Design may, however, assist Reclamation in making this determination, by making various options of effort versus results more explicit.

The Research Design

The main features of the Research Design were sketched in the initial DAP proposal accepted by the Bureau of Reclamation in June 1978 (Breternitz 1978). The presentation was organized around five problem domains: (1) economy and adaptation; (2) paleodemography; (3) social organization; (4) extraregional relationships; and (5) cultural process. During late 1978 and early 1979, this framework was elaborated by the DAP Senior Staff into a document most recently presented as a key part of the DAP Mitigation Design (Knudson et al. n.d.).

In the current version, the first four problem domains have been broken down into a series of smaller questions, and the general kinds of data needs for addressing each question are indicated. If all these subquestions were answered, a relatively complete (by archaeological standards) reconstruction of Dolores area culture would be achieved at each of several time periods. The fifth problem domain (cultural process) is to be addressed by comparing the results of inquiry into the first four domains and hence arriving at statements about cultural continuity and change. The presentation of the fifth problem domain also states that explanatory models should be developed to address more abstractly stated cultural processes and that these models be tested during the life of the DAP. A question of even greater generality is also outlined in Domain 5 — what can the Dolores results tell us about the role of plant domestication in the development of cultural systems in general?

The Research Design has guided the development and implementation of field and laboratory data recording formats, which are designed to ensure the collection of data at least potentially applicable to a large number of the specific subquestions. It was never anticipated that all the individual subquestions presented in the Research Design would be addressed at the same level of intensity, and it was expected that it might not be possible to address some of them at any level. Nevertheless, it was believed that field and laboratory data recording procedures should be designed with a broad range of anticipated data use in mind — that relevant data categories abundant in the project area should not be excluded simply because no one thought to include them in the field or laboratory manuals or data-recording forms. In this sense, the elaborated Research Design requires the investigators, from senior staff to field research assistants, to recognize and keep in mind the possibilities for cultural inference that are presented by the archaeological remains that occur in the project area.

In addition to providing a systematic coverage of the possibilities for inference and serving as a guide for development of generally useful data-recording formats, the Research Design sets forth some guidelines for research method. It presents a set of logical rules or research steps that structure the approach to each question posed in each problem domain.

During the nearly 3 years that the DAP has been in existence, most of the effort has been devoted to fieldwork, preliminary analysis of recovered materials, and preparation of descriptive reports of excavations and surveys. The organization of these reports, and the categories of data presented in them, reflect the structure of the Research Design. It is hoped that the comparability thus introduced makes this body of descriptive reports more useful for the development of systematically documented generalizations than has ordinarily been characteristic of such archaeological presentations.

A more direct approach to synthesis is envisioned for the DAP, however. With the aid of the program's data processing system, an integrated data base is being built which can be used to apply data from many sites to problems stated in the Research Design. As the DAP "turns the corner" toward synthesis, the feasibility of addressing the specific questions stated in the Research Design is being assessed. Dolores-specific research designs are being developed

around questions which seem most promising, using the data bases that are becoming available; this work is reported in chapters 3 and 5 of this report. Selection and focusing of specific questions, from among the many posed in the Research Design, will be an important component of DAP effort as the program moves toward its conclusion. Initial work on explanatory models of the sort envisioned in Problem Domain 5 is also being done; a trial formulation is presented in appendix F.

The Implementation Design

In the "good old days" of "normative" archaeology, it was presumed that past cultures could be characterized adequately by defining their "types" of culture pattern — house types, pottery types, and the like. The underlying premises were that cultures, like languages (Aberle 1960), were composed of a set of norms that were widely shared within the societies to which they were attached. The archaeologists' primary task, then, was to identify these normative patterns by describing their typical expression in "material culture." To the extent that such norms were indeed widely shared, one or a few "rich" sites could be expected to yield a full inventory of material culture items and hence serve as the basis for defining the archaeological culture's typical patterns.

In the last 20 years, however, this model has given way to, and eventually been replaced by, a model in which cultures are viewed as dynamic systems of articulating components, or subsystems. With this perspective the archaeologist must come to understand how the information embodied in material culture is translated into the dynamics of social organization and adaptation to the environment (cf. Binford 1962, 1964; Struever 1968a). It is not denied that some cultural norms are widely shared, but it is expected that most are tied to particular roles and institutions within sociocultural systems. The data which archaeology addresses are seen to be inferred from populations of artifacts, ecofacts, features, and spatial configurations in which these are arranged. These populations of archaeological entities are seen as the result of instances of behavior guided by cultural norms and expressed in social and adaptive contexts. These entities must ordinarily be studied by means of samples representing the variability within their respective populations.

Whereas, the older normative models treated variability as departure from a cultural norm viewed as an ideal type, contemporary anthropology and archaeology view variability as an expectable property of populations of phenomena, and, in fact, as a primary source of information about the characteristics of the system under study. If one is to determine whether status differences within society are being expressed in cultural materials, one must be able, for example, to examine the variability (1) in populations of burials to determine if there are differential distributions of grave goods among the deceased; (2) in dwelling space and household equipment among a population of dwellings; or (3) in emblematic items such as pectorals and labrets from one time or location to the next. Likewise, if intraregional exchange in, say, ceramics is to be examined, it must be done by mapping and studying the variability in distributions of raw material source areas, locations at which ceramics were manufactured, and locations at which ceramics were used.

The problem confronting DAP, then, as it does any contemporary archaeological study attempting to examine the operation of whole sociocultural systems within a regional context, is "how many data are enough" to characterize the variability in and among the populations of artifacts, ecofacts, features, and distributional configurations of the same that constitute our sources of knowledge about the past. The Implementation Design is an attempt by the contractor to develop a sound approach to answering this difficult question on the basis of the current requirements of anthropological archaeology. It is recognized that Reclamation is proceeding toward the same end of determining data recovery adequacy, but that its starting point must necessarily be principles encoded in statements of Federal law, policy, and procedure. It is anticipated that these efforts can be made to mesh, but perhaps not without some compromise in one or both modes of determination. The contractor feels obligated, however, to make explicit his reasoning from accepted anthropological and archaeological principles, to promote clarity and objectivity in discussions of and negotiations about the level of data recovery that is eventually to be required.

The Implementation Design, then, is a developing, anthropologically based approach to determining the level of work needed to achieve a particular degree of sample adequacy. As such, it has several key conceptual components:

1. Sample confidence level. It is assumed that for a given question, confidence in the adequacy of a given sample to address that question can be assessed. This can be done by a variety of approaches ranging from statistically rigorous quantitative techniques (Hackenberger and Kohler 1981) to informed professional judgment. No arbitrary level of confidence is set as a minimum. The point is that whatever the nature of the sample, it is essential that we be able to state, on explicit and, it is hoped, objective grounds, the degree of confidence we have in the ability of that sample to satisfy the data requirements of the question or questions being addressed to it. This approach will provide a basis for discussion between Bureau of Reclamation and contractor over what levels of confidence are desired and can be afforded, and upon which the scientific community can evaluate the strength of our proffered research results.

2. Intensity of onsite information recovery procedures. A series of "tracks" of data recovery intensity is currently in

use and is well adapted to the Implementation Design's need for flexibility in allocating a given total work effort over a number of sites with a range of data recovery needs. The tracks range from level 4, which is basically a surface reconnaissance investigation, to level 1, which implies intensive investigation. There is actually a continuum of intensity from levels 1 through 4, but this simple classification yields manageable units for purposes of program-level planning and discussion. Most sites in the project area will, of course, receive only surficial examination at the Track 3 or 4 level.

3. Onsite effort required to extract full samples of archaeological phenomena. Archaeological sites are the physical locations at which are found portions of the populations of artifacts, ecofacts, features, and intrasite distributional structures which we must sample in our data recovery program. How large is this resource base; in other words, how large is the aggregate totality of these populations of archaeological phenomena which have been preserved as part of the archaeological record as it exists today? And when specific levels of fieldwork for the program as a whole are discussed, what proportion of this total resource base is being targeted by any given level of work? These are questions that must be addressed at the most basic level of planning, yet they are difficult questions to answer.

Ideally, one would wish to have a direct estimate of the size of each of the populations of interest, but such estimates are only beginning to emerge from analysis of current data. Estimates of populations of sites as such are much more readily available, both from inventory and sampling surveys. Numbers of sites tell us relatively little about the size of the resource base, however, because quantities of artifacts, features, etc., contained in sites may vary by factors of at least several thousand. Furthermore, even at the level of gross site type, sites vary greatly in their characteristics and hence are difficult to compare as undifferentiated entities.

Experience in fieldwork gained over the past three field seasons indicates that it is possible to estimate fairly accurately the crew-weeks (a crew-week is one 10-person crew working for one 40-hour week) required to complete Track 1 excavations at sites of particular types and sizes. Although Track 1 (intensive) excavation by no means results in collection of all artifacts and ecofacts at a site, it does represent a high level of recovery of the site's data content. Consequently, estimates of effort required to carry out Track 1 excavations can serve as a proxy for estimates of the total content of archaeological phenomena of interest at the site. In aggregate, such FSE (full site excavation) estimates can serve as a rough indicator of the size of the total resource base. The FSE measure also allows different proposed levels of work, as derived from differing sampling designs, to be evaluated more accurately in terms of fieldwork costs and percent of total resource base addressed. If these designs were to be expressed only in terms of site numbers, as in "excavate 1 percent of the affected sites," the size of the actual work effort might differ by a factor of several hundred, dependent on whether 1 percent was composed of small sites or large sites.

4. Archaeological populations and sample adequacy. In an ideal world, one would draw samples appropriate for each problem being investigated and determine the levels of confidence associated with a range of sample sizes for each problem. Given the complexity of the DAP resource base, the number of questions of interest, and the constraints on funds budgeted for design and planning activities, this comprehensive approach is a difficult undertaking and has not yet been attempted.

Because there will be a good deal of overlap among many of the data sets required for addressing research design questions, and because certain characteristics of the cultural phenomena under study can be considered as primary variables, it is possible to address questions of sample adequacy in ways that lack the rigor of the comprehensive approach, yet promise to be informative and much less time consuming to implement. Two approaches are currently being carried out by DAP, as described below.

a. *Temporal-functional site matrix:* Because the data sets of interest are derived from investigations at sites, and because temporal and socioeconomic variability are major dimensions considered in the Research Design, any overall DAP sampling scheme must necessarily specify a site sample stratified along these dimensions. Using survey data from the project full pool area (i.e., the Dolores River valley), and from Reach I of the Dove Creek Canal, known sites and their FSE estimates have been placed in a matrix of functional types and time periods. A summary of this information for the full pool area is presented in table 1 of the Mitigation Design. In the more detailed presentation (Knudson et al. n.d.), functional subtypes are shown, as well as the main categories of limited activity, seasonal, and habitation sites given here. Although these data are not amenable to the development of levels of confidence for the treatment of specific problems, the matrix does show the gross magnitude of the full pool resource base at a number of points in time, and controls for main kinds of functional variation among sites. Consequently, it can serve as a check against undue bias in the selection of sites for subsurface data recovery, and can provide a basis for selection of a judgmental sample representing the main kinds of temporal and gross functional variation in the full pool area.

b. *Indicator data sets:* We can move closer to our goal of being able to relate sample size to confidence in research results if we can identify and examine the adequacy of our samples of several data sets that appear to be repre-

sentative of important kinds of variability in the resource base. Several such "indicator data sets" have been selected for further study by the DAP. These include ceramics and lithic tools from tightly dated contexts; well-dated clusters of associated features; habitation floors complete enough to permit estimation of size; deep, well-preserved middens; all materials from probability samples in sites sampled in this manner; and all data from probabilistic sampling survey in the area between full pool and takeline (Knudson et al. n.d.).

Enough information about these data sets is already available from survey and excavation to allow us to ask to what extent existing samples reliably represent the variability of these data categories in the total resource base. Sample sizes required to achieve varying degrees of confidence in the population estimates can be calculated. The association of these data sets with site types and time periods is also well enough known that the sample sizes can be translated into estimates of amounts of additional fieldwork needed at particular types of sites and of amounts of work effort required to accomplish the fieldwork.

To the extent that each of these data sets is useful in addressing several research questions, and to the extent that each is distributed across a wide range of periods and functional site types, the survey/excavation required to obtain and augment these samples should also yield data useful for a large number of additional research questions.

SPECIFIC RESEARCH EFFORTS AND METHODS

Applying the Research Design

As noted in the preceding section, the Research Design is a broad, overarching structure of inquiry, which spells out a set of research questions and conceptual approaches that systematically cover the design's five broad problem domains. It was never anticipated that all the questions listed in the Research Design would be given equal time, but that research emphases would be developed, and specific questions operationalized as the program continued.

After nearly 3 years of existence, the program is moving from a heavy preoccupation with fieldwork, preliminary artifact analysis, and preparation of descriptive fieldwork reports to an increasing emphasis on analysis and synthesis. These efforts are conditioned by our emerging knowledge of the Dolores area data base and prehistory and by the capabilities and limitations of our present staff, data processing system, and budgetary resources.

One of the principal objectives of the 1981 Synthetic Report is to review progress that has been made on questions posed by the Research Design; hence, treatment here will be brief. Basically, aspects of the Research Design are being operationalized and addressed in five ways:

First, the descriptive site and survey reports which have occupied much of the program's time over the past 3 years attempt to address Research Design questions on a site-by-site basis. That is, writers of these reports familiar with the Research Design point out the relevance of data from their sites to Research Design questions insofar as they can. Since the data were collected in formats designed to be compatible with Research Design aims, and since the site data are assembled in systematic categories also developed to address these aims, it is often possible for the authors of these reports to make contributions to the resolution of particular questions. To address Research Design questions adequately requires, however, a comparative approach and a data base broad enough to include a substantial amount of spatial and temporal variability. The authors of the individual site reports are contributing to the development of this data through their ordering of the data concurrent with writing of the fieldwork report. To the extent that they can comment on specific questions, they contribute to the resolution of these questions and draw attention to questions for which relevant data exist.

Second, the task specialists in reductive technology, additive technology, biotic studies, and survey are beginning to use their particular data bases, which extend across the full range of sites that have been investigated, to address particular Research Design questions. One example is the development of specific research designs and research results regarding ceramic exchange systems; this work comes out of the Additive Technologies Laboratory and is reported by Travis in chapter 5 (this report). Several other special studies, that have been done or are being done under the direction of task specialists, are summarized in chapter 5 or are referred to in the task specialists' appendixes at the end of this report.

A third means of addressing Research Design concerns has been by special studies, in which particular staff members (some of them part-time or students) have been commissioned to develop specific research designs and address specific questions. Some of these studies (e.g., the activity area group) cut across several kinds of data base. Some are instrumental in that they examine the utility of a particular construct (e.g., activity areas again) or test a method for dating, estimate duration of site occupation, etc.

Fourth, senior staff, task specialists, and in some cases several crew chiefs met on several occasions in late winter and early spring to discuss modeling of processes of culture change and continuity, as directed in Research Design Problem Domain 5. Basing his work on these discussions, plus his own reading and interests, Lipe has developed a trial formulation of such a model and has circulated it for

discussion. It is presented as an appendix to this report (appendix F).

Finally, Kane's treatment (chapter 3, this report) represents the first major attempt at overall synthesis to come out of the DAP so far. It relies on information and approaches developed in the four modes summarized above, as well as on Kane's overall familiarity with DAP data. This chapter in particular, and this report in general, will serve as a point of departure for the Senior Staff and the Bureau of Reclamation in (1) assessing where we stand now in relation to the goals expressed in the Research Design, and (2) selecting those aspects of the Research Design which can most profitably be pursued, and arranging staff and budgetary priorities so that these aspects can be effectively operationalized and addressed.

Analysis of Materials: Midlevel Research Designs

Stone, bone, ceramic, and vegetal items abound in the DAP sites. Analyses of these materials provide quantitatively manipulable data bases which can be applied to a large number of DAP research concerns. These analyses are conducted within three laboratory units, each headed by an appropriately trained task specialist. The three units are (1) Reductive Technologies Analysis (lithic and bone tools and their respective waste products), (2) Additive Technologies Analysis (primarily ceramics), and (3) Biotic Analysis (macro- and microfloral remains, pollen, and nonworked bone). Unlike the other two, the Biotic Analysis unit "farms out" some materials — pollen and bone — to specialists located away from the Dolores laboratory.

Because of the pervasive distribution of these materials and the frequency of their use in cultural inference, midlevel research designs have been developed in each area. These designs determine what kinds of data are to be abstracted from the specimens during analysis and provide rationales for and approaches to linking these data to a variety of Research Design questions. The most detailed of these analytical research designs addresses the lithic artifacts component of Reductive Analysis. A detailed summary of the analytic approach employed for lithic artifacts by the Reductive Technologies unit is presented below as an example of the type of research design and research activity employed in the laboratory portion of the DAP.

A midlevel analytic approach: lithic analysis. The Lithic Research Design (Knudson 1978), in response to the requirements of the general DAP Research Design, structures the analysis of lithic materials at two levels, or intensities: (1) preliminary descriptive analysis of all materials, designed to provide a basic description of the entire DAP assemblage, information for preliminary cultural interpretation, and parameters for sampling and intensive analysis of selected subpopulations, and (2) intensive technological, functional, and stylistic analysis and interpretation of these selected subpopulations of artifacts, such as projectile points, flakes, manos, and metates.

The Lithic Research Design appropriately separates preliminary analysis into two distinct kinds of analytic systems on the basis of manufacturing technique: one for tools manufactured by flaking (flaked lithic tools), and another for those made by pecking, grinding, and abrading (nonflaked lithic tools). The Lithic Research Design further specifies that both preliminary and intensive analysis systems will observe and record *attributes* of artifacts rather than complete items only.

In response to the Lithic Research Design, Reductive Technology Task Specialists since 1978 have developed four preliminary analysis systems (flaked lithic tools, flaked lithic debitage, nonflaked lithic tools, and undifferentiated nonflaked lithic items) and five intensive systems (manos, metates, flakes, projectile points, and flaked lithic tool functional analysis).

Each of the analytic systems mentioned has an explicitly outlined rationale, reasons for the selection of particular attributes and attribute states, and at least a general cultural framework within which the attributes can be interpreted. The attribute orientation of the analytic systems results in maximum flexibility to independently examine different kinds of variability (technological, functional, stylistic) across a wide range of culturally or administratively defined data groupings, including several levels of temporal or spatial units. Attributes can be interpreted either individually, as small groups of related attributes, or displayed as complete lithic profiles which represent the functional or technological activity of corresponding cultural groupings.

Lithic variability in the archaeological record is, like all classes of variability, logically separable into such major components as technological, functional, or stylistic aspects, though such separation may be extremely difficult or complex in acutal analytic practice. The DAP preliminary lithic analysis programs have been structured to provide, in addition to basic morphologic and raw material descriptions, more detailed information concerning the technology of tool production. This analytic focus on production technology was selected for several reasons. First, "style" has not been well defined in archaeological literature, especially in lithic assemblages. Such high-input items as projectile points may well display significant stylistic variability, but its identification and interpretation is sufficiently detailed to require intensive analysis. In addition, identifying tool function is increasingly recognized as best managed by incorporating both macroscopically and microscopically observed attributes in an intensive analytic routine directed toward very specific questions and well-selected data subsets.

Variability in production technology, however, is theoretically and definitionally well supported in archaeological literature, readily observable at macroscopic levels, and interpretable as either single attributes or small groups of related attributes. This is particularly true of flaked lithic tool production systems, although the DAP is developing a very promising theoretical model within which nonflaked lithic tool production can also be identified and interpreted.

Because lithic artifacts are usually either tools or the byproducts of producing those tools, their analysis and interpretation best focuses on these two cultural subsystems: the technology of tool production and the uses of those tools in behavioral response to the environment. The first is rather directly observed in the tools and in the debitage of their production. The second depends much more heavily on intermediate arguments from analogy or from expected behavior (modeling), which bridge the gap between the tools themselves and the human behavior for which they were used. The DAP lithic data are well structured for response to both of these cultural subsystems. Analysis and interpretation of production technology is largely an independent activity of the Reductive Technology Group and is being conducted in this manner. Analysis directed toward implications of tool use in systems of human adaptation depends on close coordination with other data sets and on the formulation and testing of behavioral models to structure data groupings and interpretation.

The technology of lithic tool production is a relatively stable subsystem in prehistoric culture. Slow change is the expected pattern, and relationships among its constituent elements are gradually developing interactions rather than sudden, all-encompassing leaps. When abrupt changes do occur in tool production patterns, they should mark major cultural change in an area, usually some significant external influence. This implies that systems of lithic production technology are best suited for response to questions that involve, within or among broadly contemporaneous and homogeneous cultural situations, spatially patterned variability. Only within longer temporal sequences should overall lithic variability be expected to demonstrate significant cultural patterning, as for example, the variability between Archaic and Anasazi Traditions.

The DAP lithic data structure has recently been carefully reviewed for its adequacy and responsiveness to the project Research Design. These data will be most useful in responding to Problem Domains 1 (Economy and Adaptation), 3 (Social Organization), 4 (Extraregional Relationships), and 5 (Cultural Process). More specific topics particularly appropriate for examination with the lithic data include:

- changing patterns of lithic resource use
- definition and changing patterns of site function
- changing patterns of trade or indirect procurement of nonlocal lithic resources
- changing patterns of relative dependence on agricultural products
- organizational, activity, and settlement patterns as they are reflected in the lithic component of various assemblages
- stylistic or production technology patterns as reflected in several classes of high-input lithic items
- spatial (and temporal?) patterns of tool production and function, with regional, site or subsite cultural implications.

Project Systematics

The DAP has developed three complementary sets of classificatory units for referencing: (1) archaeological manifestations of social entities (the Spatial Series); (2) cultural subdivisions (the Chronological or Formal Series); and (3) the principal functions attributed to whole sites (the Functional Series or Site Typology). The Spatial Series owes much to concepts presented in Flannery (1976) and is specifically designed to help DAP archaeologists organize their data for application to questions raised in Problem Domain 3 (Social Organization) of the Research Design. Use of this terminology according to standard definitions presented in Kane (1981a) will also provide greater comparability among descriptive reports and will facilitate use of these reports in comparative studies by archaeologists outside DAP in years to come. The Formal (Chronological) Series uses concepts derived largely from Willey and Phillips (1958) and for the most part will be generally understood by the profession without recourse to DAP literature. The lowest units in the hierarchical series — episode and element — are DAP innovations and enable DAP archaeologists to systematically label periods of time marked by changes that affected communities or community segments. The higher levels of the system are also systematically related to units in the Spatial Series. Thus, although most of the units in the series are generally compatible with temporal designators used generally in North American archaeology, the definitions developed for use here, and the lower order units not used elsewhere, make the series specifically adapted for organizing and presenting DAP data on cultural change. The DAP Functional Series is a site typology with basic categories which are in general use, but with subtypes which are specific to the DAP. Furthermore, the definitions of the site types are in part based on recognition of units from the spatial systematics at the sites in question.

More detail concerning the history of development of the DAP systematics and formal definitions of each unit can be

found in Kane (1981a). The units within the three series are listed in table 3.

The Spatial Series. The Research Design of the Dolores Archaeological Program emphasizes the definition and explanation of regional relationships. To effectively investigate regional aspects of the five major problem domains, a systematic and well-conceived scheme of spatial study units is critical. The focal point of the Research Design is the Anasazi community; consequently, the basic unit for this spatial system reflects the physical manifestations of the community: this unit is the community cluster. Ideally, the division in the spatial hierarchy should reflect cultural reality; however, this may not be feasible when defining large spatial units because of uncertainty in describing the nature of intercommunity and long distance Anasazi relationships. It must be emphasized that the series in its present form is really a "model" based on ethnographic and archaeological analogies, inferences from excavation and survey data available from previous work in southwestern Colorado, and logic. As such, the construct serves to draw the researcher's attention to certain intra- and intersite phenomena and to structure his inferences and notes in a standard way. The series is not primarily predicated on locally derived, inductive formulations.

The Formal (Chronological) Series. Regional relationships and cultural process are primary orientations of the Research Design; cultural process is also integrated into the Research Design as a major problem domain. A comprehensive and well-designed set of temporal controls is necessary in investigating variability in cultural phenomena; spatial elements should be included in control systems so that cultural similarities and diversities can be described as multidimensional units.

At the outset of the DAP investigations, the widely applied Pecos Classification was used as a temporal classification device. As more intensive operations progressed, it became apparent that the Pecos scheme was not a good reflector of cultural stability and change in the initial-year study area, and that it could not accommodate spatial variability; hence a more rigorous system with finer units was developed.

The Dolores Archaeological Program Formal Series is based largely upon units originally proposed by several well-known archaeologists (refer to McKern [1939]; Kidder [1962]) and then combined by Willey and Phillips (1958: 11-44) into a single integrated system. The units adopted by DAP personnel have stipulated spatial and temporal connotations; therefore, the system should be regarded as one consisting of hierarchical archaeological units (Willey and Phillips 1958:21), rather than merely temporal divisions. A more detailed discussion of the chronological series is presented by Kane (chapter 3, this report).

The Functional Series: a Site Typology. A system of site classification based on formal attributes is a necessary adjunct to describing settlement patterns and implementing sampling programs. The updated project system employs primary divisions based on intensity of occupation, with subcategories based on visible characteristics and inferred function. A detailed presentation of the DAP Site Typology, or system of site classification, follows.

Limited activity loci: Limited activity loci are archaeological sites where a minimal range of activities took place; they are similar to activity areas as defined for the DAP Spatial Series. However, limited activity loci are in isolated locations and are separated from centralized areas of prehistoric activity. Limited activity loci are

Table 3. Dolores Archaeological Program systematics*

Spatial Series	Formal (Chronological) Series	Functional Series
Activity areas	Episodes/elements	Limited activity
Use areas	Component/subphase	Seasonal
Household clusters	Phase	Habitation
Ward clusters	Sector sequence/subtradition	
Habitations	Tradition	
Community clusters		
Localities		
Sectors		
Districts		
Regions		
Areas		

*Each column is an independent dimension; do not read across rows. In the first two columns, the progression is hierarchically arranged from the specific to the general. In the right-hand column, the system is nonhierarchical and classificatory (mutually exclusive and exhaustive categories). Distinctions between terms occurring on the same level of the hierarchy in the Formal Series can be found in Kane (1981a).

believed to have been integral settlement pattern components during both the Archaic and Anasazi periods, but individual sites may be difficult or impossible to date because they usually lack datable artifacts or features. Limited activity loci can be subdivided based upon functional interpretations. (Note that in some cases it may be necessary to combine these subtypes at a single site; for example, a kill site/butchering station or a petroglyph panel/storage cist. However, as long as the activities performed at the site were limited and the occupation transitory in nature, it should be classified as a limited activity locus.)

Seasonally occupied sites: Seasonal areas or sites were occupied on a short-term basis, usually by small social groups. The occupation of these sites was typically seasonal and periodic. "Seasonal," as used here, is not limited to climatic seasons, but also may refer to economic seasons such as "growing season," "harvest season," or "deer season."

Activities performed at seasonal loci were diversified, but such sites would be established with a definite purpose (usually economic or social) in mind. The number and range of activities were less than those performed at a habitation; in this sense, at least for the Anasazi period, seasonal sites were similar in concept to use areas and in many cases can be considered isolated examples of such spatial units. Seasonal sites may contain architecturally bounded spaces that are similar to houses at habitations and are considered as such. The distinction is that living rooms at seasonal sites were occupied for shorter periods and were generally used for fewer activities; therefore, they generally can be expected to be architecturally less complex. A distinction can be made between seasonal camps or sites that contain no substantial domestic architecture and seasonal loci that incorporate living quarters (often called field houses).

Most commonly, the seasonal locus can be considered a central location where a household, or members of a household, performed activities that were more conveniently accomplished at certain times of the year at that place. Therefore, in many instances, the seasonal locus can be considered a secondary habitation or centralized area of activity; occupations at seasonal loci were often more directed toward a specific activity or activity set and were less intensive when compared to habitations.

Habitations: Habitations are archaeological sites where a wide range of activities were performed; they were occupied continuously or at least for a major portion of the year. Habitations in the DAP typology are congruent to habitations as defined in the spatial systematics section. They consist of one or more household clusters in a centralized location; as such, substantial architectural remains such as rooms, pitstructures, and outside work areas are usually present. Habitations represent the locations where most community activities took place, and they represent the home base of the community. Divisions of this category are based on architecture and number of social units, as well as function, rather than primarily on function, as was done with the other two major site categories. Types of habitations include base camps, hamlets, large hamlets, and villages.

Building the Data Base

The data base being compiled, edited, and maintained by the program should be one of its most enduring contributions. This data base is currently undergoing a transformation from a series of separate, sequential files in which there is limited ability to associate one kind of information with another, to a more complexly cross-referenced system in which almost any kind of information can be assessed with almost any other kind of information.

The independent data files served the project adequately when primary emphasis was on excavation. Not surprisingly, the first linkages achieved between files were between the provenience file — which contains most of the information on the Field Provenience Form — and each of the principal data files — preliminary ceramics analysis, nonflaked lithic tools, and so forth. This makes it possible to key in on any of the variables (either singly or in any combination) in the provenience file and retrieve the materials, one file at a time, associated with the requested types of proveniences. It is currently quite simple, for example, to find out all about the ceramics from pithouse floors which appear to be nonlocal in origin in all Sagehen Flats Locality sites.

This in itself is an achievement surpassing many major mitigation programs. However, it is recognized that certain combinations of information are still difficult to obtain, particularly information concerning the materials associated with various levels of the spatial/temporal hierarchy (described above). Many questions which we would like to pose of the data base look like "compare the ceramics from pre-A.D. 850 activity areas in village surface rooms with those from pre-A.D. 850 activity areas in small hamlet pithouses" — or worse. Linkages now under development across material types to information on temporal, spatial, and (proposed) dating forms will make such inquiries feasible for the first time, and will free investigators to ask the questions they need to ask, rather than the ones which can be conveniently answered.

This flexibility is made possible partly by the program's new commitment to the microcomputer, but also by the use of custom-written FORTRAN and COBOL programs which perform the actual linkages across files using variables held in common by the files to be linked. Then selected data are passed to the Statistical Package for the Social Sciences (Nie et al. 1975), a large package capable of

performing a wide range of descriptive and inferential statistics. This combination of custom-written software for utility procedures and "off-the-shelf" software for more complex statistical analyses is now providing the program with a relatively flexible data base, whose full potential we are now beginning to discover.

ACQUISITION OF FIELD DATA

Surficial Studies

Data acquisition has been structured along a track system. Track 4 and Track 3 are the least intensive and entail various sorts of surface examination (refer to Knudson et al. [n.d.] for distinctions between these two tracks).

Surface information is extremely important in a project area containing over 1,000 sites, only a small number of which can be intensively excavated or even sampled. A good deal of effort is being spent to consider what kinds of information can be extracted from surface collections of various types (for example, Kohler and Schlanger [1980:29-32]; Schlanger and Kohler, this report). Tentatively, it appears that some information about site duration, average momentary population size, and quite specific dates can be recognized in the collections by using innovative techniques which focus on use-lives of artifacts (chapter 5, section 3, this report) and on certain ratio-level attributes of common neck-banded ceramics (Blinman, chapter 5, section 5, this report). These approaches, once refined, will constitute major methodological contributions to northern Anasazi archaeology.

The data base to which these procedures can be applied has been collected using several different techniques over a period of almost a decade. The inventory survey (administered first by the Bureau of Reclamation and later by the DAP) is now complete for several project features, and completion of the full pool, the Glade/Williams Draw/Lone Dome roads, and the Ormiston Point road construction is scheduled for summer 1981. The varying collection procedures used by the Dolores Project (early 1970's), the Bureau of Reclamation/YACC (Young Adult Conservation Corps) surveys, the CU/DAP survey, and the WSU/DAP surveys pose problems of comparability. It will only be possible to see how serious these problems are when the survey data base computerization is complete — by the end of summer 1981. Since all the surveys except the early Dolores Project efforts contained a systematic collection component, it is hoped these problems will be minimal. Current procedures used for collection on the inventory survey can be found in the new survey field manual (Bohnenkamp et al. n.d.).

The inventory survey is designed to provide 100 percent coverage of direct-impact zones meeting or exceeding the Bureau of Reclamation Class III survey standards while collecting environmental and cultural information germane to the DAP Research Design. Another surface survey, conducted by WSU during the 1979 (Schlanger 1979) and 1980 (Harden 1980) field seasons used probabilistic procedures to select quadrats for survey to obtain additional information about localities where portions of these localities fell outside the full pool (or, in some cases, outside the takeline). In these two field seasons, the samples selected for the Cline Crest, Grass Mesa, Hoppe Point, Beaver Point, and Trimble Point Localities were completed using systematic collection techniques similar to those of the present inventory survey. One result of these efforts is a north-south transect of survey across a portion of the river valley, crossing the major environmental zones. There is a clear distinction between types and dates of sites found on the northeast and southwest rims of the canyon which appears to be due in part to the differences in elevation between the two areas. Further comparisons and population estimates for sites along this transect of localities can be found in the forthcoming report by Schlanger and Harden (1981).

Limited magnetometer survey of selected sites has been undertaken to complement the inventory survey and to aid in location of subsurface features prior to excavation. Such information can be used to stratify sites for later excavation or to pinpoint anomalies to make later feature-oriented excavation more cost effective. The report on the 15 sites sampled in 1978 (Huggins and Weymouth 1980) indicated that several types of modern contamination and geological features made identification of prehistoric anomalies difficult, but that careful consideration of the individual characteristics of each anomaly usually allowed a plausible interpretation for the features noted. Later reports (chapter 5, this report) compare these preliminary identifications with later excavation results and suggest improved strategies for anomaly interpretation.

Survey of biotic and abiotic resources and live-trapping of fauna for comparative collections are also included in Tracks 3 and 4. These activities are essential to locate sources of lithic and ceramic raw materials, to map present-day distributions of floral and faunal resources, and to complete various synthetic studies such as the wood resource depletion simulation. Models for interpreting prehistoric land use and colonization/abandonment processes (appendix F, this report) depend on the extent to which DAP can reconstruct past environments; to study past environments, in turn, the present environments must be well documented.

Excavations

Data acquisition beyond surface collection has been done on a selective basis. In theory, sites have been selected for excavation according to their potential for contributing

information relevant to the DAP Research Design. In practice, this goal has often been modified by practical considerations, especially Bureau of Reclamation construction priorities, consideration of land ownership, and extent of inventory survey.

The resultant sample of excavated sites is thus a compromise among several priorities. This selection procedure has resulted in a fairly satisfactory middle ground between the intensive excavation of a high percentage of the sites in a delimited area, as demanded by research questions dealing with social organization, and the sampling at a lower level of larger numbers of different types of sites across all environmental zones and time periods, as required by questions concerning exchange, subsistence, paleodemography, and change through time.

The track system extends to excavation. Track 2 is a sampling mode, including probability sampling and partial judgmental excavation, as well as special techniques like blading. Track 1 is intensive excavation and may include near total site excavation for small sites, or exposure of large blocks beyond a Track 2 level of sampling for larger sites. Once again, the decision whether to use Track 2 or Track 1 techniques at any particular site has been influenced by both research potential and practical considerations, particularly amount of time available versus estimated information recoverable toward research goals.

Two special techniques sometimes used in Track 2 excavation warrant further explanation. The first is the blading program, which has proved to be a successful, rapid, and relatively inexpensive method of stripping the plow zone off previously disturbed sites to expose the intact levels and features below. The usefulness of this program is of course limited to sites which can be reached by the grader. This program is discussed in detail by Greenwald (1980) in a paper prepared for the 1980 Pecos Conference at Mesa Verde National Park. The second technique occasionally applied is probability sampling. The effectiveness of this option is evaluated elsewhere in this report (chapter 5, section 2). Although they have not generally been applied to the same site, it would seem that these two techniques might complement each other quite well. The probability sampling program would guarantee a representative sample of artifacts, while the blading program would quickly expose all or most of the surviving population of structures and features.

The goals of intensive excavation (Track 1) vary from site to site. Typically, however, excavations are conducted in such a manner as to maximize exposure of structures and features, including intact activity areas, without unduly compromising effective recovery of economic plant and animal remains and artifacts. Excavation is accompanied by completion in the field of forms designed to direct the attention of excavators along similar lines and to aid in the computerization of the data base. Each form has two components — a verbal summary, where the notetaker can enter any relevant observation, and a series of boxes in which coded values for selected variables are entered. After being screened in the lab for project-wide comparability, these codes can be entered directly into the data base without the need for an intermediate transfer of data to a loading sheet or a translation of the verbal summaries to variable values. These forms allow for general observations concerning provenience and character of the matrix, but place special emphasis on a series of observations on features, surfaces, activity areas, and structures.

These observations are also documented with field maps, drawn to specified standards, and black-and-white and color photographs. The subjects in each photo are also recorded on computerized forms to aid later recovery. A field recording technique implemented by the DAP Photography Section that has proved useful in documenting architectural complexes involves the use of photomosaics made from photos taken by a bipod-supported camera. The bipod suspends the camera at a known height over predetermined points. This allows a number of prints to be combined into a photogrammetrically accurate mosaic map. The fact that a number of photos are used means that the entire complex does not have to be exposed at once; the mosaic can be built over a whole summer, if necessary.

Most excavated matrix is not screened because of the time and expense which screening would require, and because of the awkwardly large collection of artifacts which would be returned to the lab. Mode of collection (e.g., screened, nonscreened shovel excavation, nonscreened troweling) is recorded for each specimen bag, however. The policy is for "total" artifact recovery only from certain sensitive proveniences. The probability samples, for example, are all screened to get a representative collection of artifacts from the site without having to attempt total artifact recovery. Features and surfaces are also regularly screened, since the materials recovered from them often have the additional advantage of being in an interpretable context. Sampling schemes for macrobotanical remains and pollen are keyed to the inferred circumstances of the abandonment of the structure in which they are located. Little time is now spent sampling surfaces where the context is not interpretable or where the preservation of these materials is likely to be poor. Instead, effort is concentrated in structures where it is most likely to be rewarded. Strategies for biotic sampling keyed to the abandonment mode concept are discussed in more detail in a paper prepared for the 1980 Pecos Conference (Kane and Robinson 1980).

Dating of proveniences is a crucial concern of the program, since success in explaining culture change must be based on ability to document it accurately. The primary chronometric tool of the program has been tree-ring dating. All suitable structural and nonstructural materials are submitted to

the Tree-Ring Laboratory, University of Arizona, for dating and speciation. Specimans deemed too small for dating are retained for species identification at the DAP laboratory. Dendrochronology has not been as helpful as had been hoped, since many of the samples are from species which do not date well or are from young or complacent individuals. Archaeomagnetic samples, especially from hearths and burned walls of pitstructures, are also collected in the field according to a priority system based on the success with which various features with different degrees of burning have been dated in the first field seasons. So far, this technique has been only partially satisfactory, although the development of a local calibration (chapter 5, section 2, this report) promises to improve the results considerably. Artifactual materials, particularly ceramics, are of course chronologically sensitive and are routinely collected. Dating of sites and structures through occurrence seriation of ceramics is possible and has been helpful, but the time ranges provided — although better than those from radiocarbon dating — are too wide to be useful for more than general phase or subphase assignments. Attribute analysis of neckbanded ceramics (chapter 5, section 5, this report) may provide some help in the near future. Radiocarbon dating is now reserved for situations where no other form of dating is likely to be possible (as in the case of some assemblages thought to be Archaic, for example). Radiocarbon samples are still routinely collected in the field from contexts where they might be useful, and are curated for possible future use.

More details on all field procedures can be found in Kane, Hewitt et al. (1981).

Chapter 3

THE PREHISTORY OF THE DOLORES PROJECT AREA

Chapter 3

THE PREHISTORY OF THE DOLORES PROJECT AREA

by Allen E. Kane

INTRODUCTION

> West of the Mesa Verde and extending as far as the Colorado River, there is a great stretch of upland covered by cedar and pinyon, drained by the following northern tributaries of the San Juan: the McElmo, Montezuma Creek, Recapture, and Cottonwood Canyons, and Grand Gulch. These tributaries and the mesas lying between them are literally crowded with ruins of all sorts; there are probably more archaeological sites to the square mile in this district than in any other equal area in the entire Southwest. Unfortunately the study of the antiquities of the district is still very incomplete; and were it not for the work of Prudden and Fewkes we should know next to nothing about it. A certain number of ruins, however, may safely be classed as of Mesa Verde type, and many others are of a type somewhat less well marked but which may nevertheless be considered as bearing a close relationship to the Mesa Verde culture. (Kidder 1962:205-206)

The upland area referred to by Kidder as potentially constituting the largest archaeological resource in the Southwest (at least as far as total number of sites) consists of approximately 8000 km^2 of land in extreme southwestern Colorado and southeastern Utah. Gillespie and other archaeologists working in the Four Corners refer to the area in question as the Yellowjacket and Western Districts of the Mesa Verde Region (Gillespie 1976; Kane 1981a; Nickens 1977).

What is the current status of this resource as far as knowledge and preservation are concerned? Is the study of the district still very incomplete, as stated by Kidder? In the 50-odd years since Kidder's summation, a multitude of archaeological investigations have been initiated within the two districts; however, the quality of most recovered data—given modern methods—is questionable, and the production and dissemination of pertinent reports have been spotty at best. There are as yet no accurate estimates of the total number and cultural affiliation of the sites in the area, although agencies of the Federal Government have been active in recording that portion of the resource owned by the United States or affected by government developments (Breternitz 1974; Martin et al. 1971; Reed et al. 1979).

There have been several large-scale institutional investigations over the last half-century; probably the most prominent are the Peabody Museum's work at Alkali Ridge (Brew 1946) and Martin's work in the Ackmen-Lowry area, first sponsored by the State Historical Society of Colorado and then by the Field Museum (Martin 1929, 1930; Martin el al. 1938; Martin and Rinaldo 1939; Martin et al. 1936). These investigations are currently limited in value because of advances in field and analytical techniques and changes in the direction of anthropological thought; they remain useful, however, for comparative purposes. More recent investigations have been smaller in scale; notable are the efforts of San Jose State University (Winter 1975, 1976, 1977), University of Illinois at Urbana and Wichita State University (Rohn 1974, 1975), the University of Colorado Museum (Brown 1975; Wheat 1955), and the University of Colorado (Hallasi 1979; Reed 1979; White and Breternitz 1976). Archaeologists are aware that this unique resource is being destroyed at a rapid rate. Development of agricultural land and natural resources is expanding at an ever-increasing pace in Montezuma County, Colorado, and San Juan County, Utah, the heartland of the archaeological resource. Vandalism is all too common and the destruction affects public sites as well as private (Nickens et al. 1980); the current condition of the Alkali Ridge complex is a sad commentary on this phenomenon (Louthan 1981). The DAP (Dolores Archaeological Program) is regarded as perhaps the last large-scale attempt to study this resource given the ever more costly nature of archaeological investigation and the continued degradation of the total data base. It is intended that the reports generated by the program will form the primary reference base for the resource and will aid in regional overviews of prehistoric lifeways and cultural processes when combined with other data bases such as Mesa Verde National Park and Ute Mountain Ute tribal lands in the Mancos Canyon.

The DAP staff has developed a Mitigation Design to serve as the basic planning guide for program operations (Knudson et al. [n.d.]; see also discussion in previous section). This

document consists of two parts: the Research Design, which structures field and analytical investigations, and the Implementation Design, which defines adequacy of investigations (Knudson et al. n.d.). In this section, the current results of program fieldwork and analysis will be summarized; the presentation is organized according to these main topics: (1) a presentation of the program's Formal Series or phase scheme, including a summary of the gross temporal patterns evident in the archaeological record; (2) a succinct statement of the status of the domains incorporated in the program's Research Design; and (3) a short comparison of the local prehistoric cultures with other reported descriptions in the Mesa Verde Region. To aid the reader in digesting the discussions, a short glossary of specialized program terminology has been included here.

GLOSSARY

Central impact area - the area incorporating the aggregate of project features centered on the Dolores River canyon northwest of the town of Dolores in which there will be maximum impact on cultural resources. The project features included in the area are the damsite, main pool area, borrow areas, the Great Cut Dike and Pumping Plant, Dolores Dike and Landfill, Dolores Tunnel, recreation areas, wildlife management lands, and access roads.

Escalante Sector - a spatial division of the Yellowjacket District. It is defined as the extent of the local Anasazi subsistence-settlement system centered on the Dolores River canyon and is viewed as a prehistoric geographic unit. The extent of the settlement system fluctuated through time; for consistency, rigid boundaries, which are believed to approximate the extent of the system during the late Pueblo I period, have been assigned (figs. 2 and 3). The sector encompasses the central impact area and the project takeline; Escalante Sector and "Dolores area" are used as synonymous terms.

Habitation - a settlement that served as the abode and center of activities for prehistoric groups. Habitations are composed of one or more "household clusters" and associated specialized structures and can be categorized as small hamlets (one to three household clusters), large hamlets (three to seven household clusters), or villages (eight or more household clusters).

Household cluster - the space at a habitation used by a household (Flannery 1976:5). For DAP purposes, the household cluster includes a pithouse and surface structures for the early portion of the Anasazi sequence, and a three-room "apartment" and surrounding space for the later portion.

Locality - divisions of the Escalante Sector that serve to partition the sector into administrative units useful for

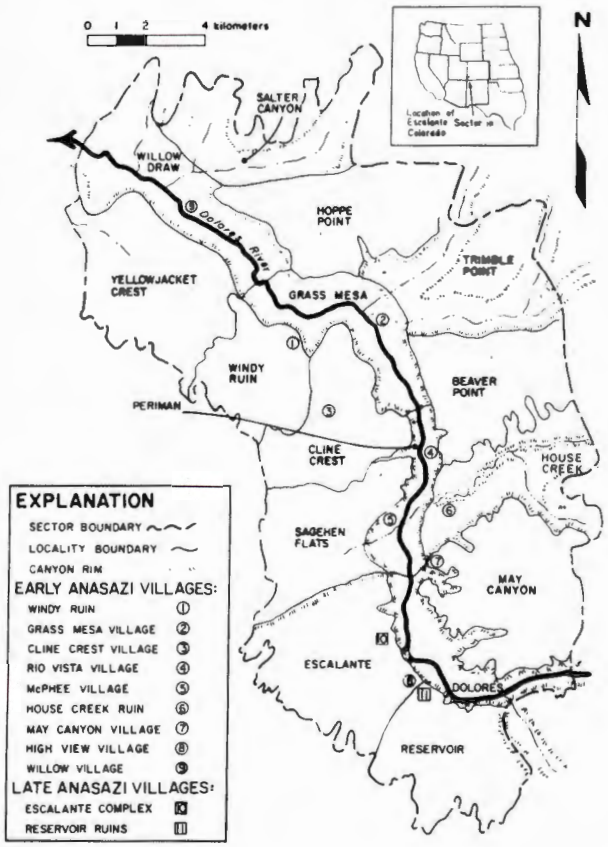


Figure 2. The Escalante Sector.

spatial comparisons. They provide a consistent terminology at this level for program staff.

Mesa Verde Region - a prehistoric geographic unit used by archaeologists to refer to that portion of the San Juan Culture Area in southwestern Colorado and southeastern Utah. The region has been formally defined by Gillespie (1976:12) to include the Western, Yellowjacket, Mesa Verde, La Plata, and Durango Districts.

Main pool area - the area to be inundated by the McPhee Reservoir. The main pool line is established at the maximum elevational extent of the reservoir, or 2110 m.

Project features - areas of construction or other activities defined by the Bureau of Reclamation. They include the McPhee dam site, main pool area, other features in the central impact area, and construction aspects of the water distribution system. The program staff uses the terms "impact area" and "project feature" interchangeably.

Takeline - the boundary of lands to be acquired by the government in establishing a buffer around the main

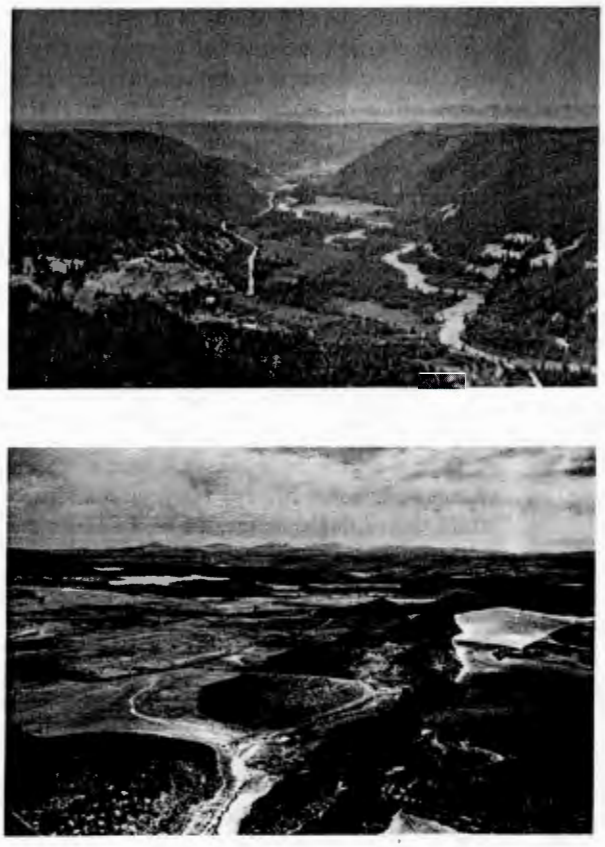


Figure 3. Aerial views of the Escalante Sector. Top, looking south (upstream at the Dolores River canyon. Note upland plateaus on east and west sides of canyon; the Grass Mesa Site is located on low mesa jutting into canyon from east slope (lower left in picture) (DAP 071932); bottom, looking northeast at southwestern portion of sector. Lowlands (Sagehen Flats) west of river shown in left part of photo, plateau in Escalante Sector to right (DAP 076014).

pool area and other project features included in the central impact area.

Yellowjacket District - a geographic division of the Mesa Verde Region; the district encompasses portions of Montezuma and Dolores Counties north and west of Mesa Verde National Park and reflects the maximum extent of Anasazi settlement. As currently defined (Gillespie 1976; Kane 1981a), the district contains major portions of the McElmo Creek, Montezuma Creek, and Dolores River drainages.

THE DAP PHASE SCHEME: A TEMPORAL SUMMARY OF DOLORES PREHISTORY

The rationale for developing project-specific sets of temporal, spatial, and site type units is to provide a logical framework for description and explanation of prehistoric Dolores lifeways and processes (Kane 1981a). After reviewing chronological systems developed by other archaeologists for prehistoric cultures of the Mesa Verde Region, it was decided to develop an independent system. The Pecos Classification (Kidder 1927; Watson 1954), while serving ably as a tool for the archaeology of the 1930's and 1940's, is inappropriate for most modern research. It is useful, however, for general description and temporal placement, and is employed for these purposes by the project staff. In essence, the Pecos Classification is a "stage scheme" based on architectural and artifactual trends identified across a large proportion of the entire Southwest; it therefore is unsuitable for measuring local variability and change (Cordell and Plog 1979:406; Hayes 1964:86). Archaeologists studying the Mesa Verde Region have recognized this deficiency and developed their own schemes with varying success (Brew 1946; Gladwin and Gladwin 1934; Hayes 1964; O'Bryan 1950; Reed 1958; Rohn 1977). These local phase systems have two major faults: first, the spatial extent to which the temporal scheme can be applied is often poorly defined; and second, the authors have adopted most of the definitional criteria of the Pecos Classification in their systems, thereby creating mirrors of the Pecos series. For example, in Hayes' (1964) Wetherill Mesa series, the "La Plata Phase" is similar to Basketmaker III, the "Piedra Phase" is Pueblo I, the "Ackmen Phase" is early Pueblo II, etc. Such formulations therefore utilize the same interregional trends in trying to reconstruct lifeways and processes.

The DAP Formal Series has been formulated with these difficulties in mind. The series has been limited to the Escalante Sector (defined as the extent of the local Anasazi subsistence-settlement system centered on the Dolores River canyon). Definitional criteria which are believed to be more reflective of local variability have been adopted: the perception is that local culture systems exhibit varying patterns of growth, stability, or decline at differing points in time, and that each period can be characterized by dispersed, aggregated, or nucleated settlement strategies (Irwin-Williams 1981). The DAP phase system has therefore been designed to reflect these phenomena and uses settlement pattern characteristics at the intersite (site diversity, spacing, composition of the utilized site set, environmental selection) and intrasite (number of household units, spacing between units, presence or absence of specialized structures) levels as primary definitional criteria (Kane 1981a). Of course, the system units will have their architectural and artifactual correlates. But the primary utility of architectural and artifactual characteristics is in assigning individual sites to the proper unit rather than as definitional criteria for the system. It should be noted that by employing these criteria, the program staff has been able to categorize local cotemporal variation within the Escalante Sector. The late McPhee Phase, for example, is divided into the Cline Subphase (A.D. 900-975) and the Grass

Mesa Subphase (A.D. 880-925); the series does not consist wholly of sequential temporal periods.

The DAP Formal Series (phase system) consists of three major periods, each of which would ideally consist of traditions, phases, and subphases (and the intracommunity units defined for the series, refer to Kane [1981a] and previous section). However, a breakdown into finer units beyond the tradition level is only presented for the Pueblo Period because of limitations in the present data base. The series is intended for program use only and may or may not have wider application. The specific defined units are summarized in the following outline.

I. **Pre-Pueblo Period** (prior to A.D. 600)

A. Paleoindian Tradition (prior to 5000 B.C. ?) - Prehistoric occupation of the Dolores area (Escalante Sector) is believed to have been initiated prior to 5000 B.C. Evidence for Paleoindian use of the Dolores area and southwestern Colorado is slight, but present (Hayes 1964; Winter 1977). One fragment of a parallel-flaked projectile point was recovered by a DAP survey crew in 1979; of course, this may be a curated item. With such slight evidence one cannot draw any conclusions regarding the local manifestation of the tradition.

B. Archaic or Desert Tradition (5000 B.C.-A.D. 500) - The same lack of evidence is also true for the early part of the Archaic Tradition, and thus no phase or subphase assignments have been made. There is more substantial evidence for use of the area beginning about 2000 B.C.

1. *Great Cut Phase* (2000 B.C.-A.D. 500) - There is certain evidence that prehistoric groups with an Archaic or Desert Tradition lifestyle were in the Dolores area after 3000 B.C. Three radiocarbon dates of 5680 ± 2350 B.P. (before present) (Site 5MT2199, Lab No. TX-3872), 3710 ± 90 B.P. (Site 5MT2242, Lab No. TX-3876), and 1400 ± 60 B.P. (Site 5MT4797, Lab No. BETA-1930), recovered from suspected Archaic deposits, support this conclusion. (These radiocarbon dates were calculated using the Libby half-life of 5568 years, and 95 percent of the activity of the NBS Oxalic Acid as the modern standard. The errors are one standard deviation calculated from the random nature of the radioactive disintegration process.) It is suspected that 14 recorded site components within the pool line (the area to be ultimately inundated by the filling of the reservoir) represent cultural activity during this period; these include eight components at open sites in the flats and uplands west of the river canyon, two components at sites on terraces bordering the river flood plain, and four components at rockshelters on the east talus of the canyon (Knudson et al. n.d.: table 1). Other sites assigned Great Cut components have been recorded within the takeline[1] Investigations at sites within the pool suggest that the local area served as a source of seasonal resources for Archaic peoples. The sites are small and material remains consist of shallow, informally constructed hearths and scattered artifacts such as milling stones, hand stones, and flaked stone tools. The sites appear to have been established in or adjacent to local areas containing harvestable resources (Kane 1981b); for example, there appears to be a concentration of sites in the Sagehen Flats area (fig. 4). A speculation is that the river canyon and adjacent highlands were one station for a group or groups practicing a seasonal round type of existence; it is suspected by the project staff that larger camps might be located to the south and west in the McElmo Creek and San Juan River systems. It is believed that the cultural characteristics of these groups were similar to those described by Jennings (1964:149-174) for the Desert Tradition.

II. **Pueblo Period** (A.D. 600-1200)

A. Anasazi Tradition - Anasazi groups practicing horticulture as a primary subsistence strategy are identified in the area soon after A.D. 600. A tree-ring date of A.D. 598 (DAR-149) obtained from a specimen at Tres Bobos Hamlet (Site 5MT4545) is thought to represent the beginning of Anasazi occupation. This is a "vv"[2] date; it can be assumed that the true cutting date is in the early 600's. Cutting dates in the 600's have been obtained from other structures. The Anasazi Tradition is the only culture recognized in the Dolores area during the Pueblo Period. There is no evidence of any transition between indigenous Archaic peoples and the Anasazi; it is suspected that the sector was colonized by groups already possessing the technology necessary to initiate a subsistence strategy based on horticulture in a frontier area. Three phases and eight subphases have been defined for the Anasazi occupation.

1. *Sagehen Phase* (A.D. 600-850) - The Sagehen Phase is the initial Anasazi period of colonization and growth in the Dolores area. Settlements were dispersed and were located on lands with good agricultural potential. Sagehen Phase settlement patterns incorporated a limited number of site types, and habitations can be described as small "hamlets"; that is, farmsteads with one to three households. The West Sagehen Neighborhood,

[1]Doug Goulding, DAP, Dolores, Colo., personal communication.

[2]There is no way of estimating how far the last ring is from the true outside.

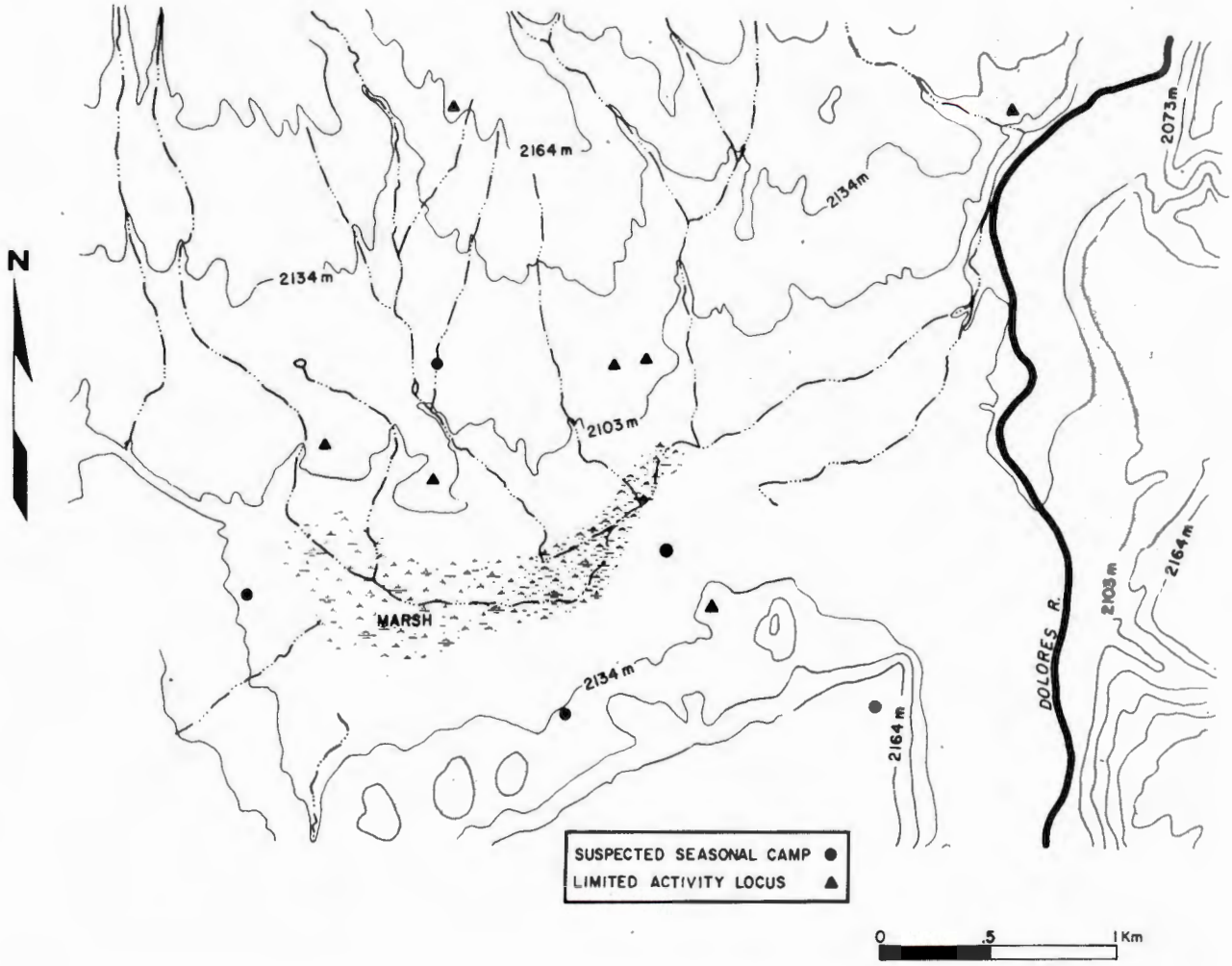


Figure 4. Great Cut Phase settlement patterns in the Sagehen Flats area.

as described by Kane (1981b:36-39), was a dispersed Sagehen Phase community located in the Sagehen Flats area west of the river canyon. Physically, the community consisted of approximately 40 components at 30 hamlet settlements; momentary population levels (Flannery 1976:80) for the total group were perhaps four to seven households (15 to 35 individuals) at A.D. 700 (fig. 5). All individual settlements were located on arable soils and exhibited a tendency toward equal spacing, perhaps indicating some competition among hamlets for farmland. For a more thorough treatment of Sagehen lifestyles, refer to Kane (1981a).

(a) *Tres Bobos Subphase* (A.D. 600-700) - Definition of this period is intended to reflect initial colonization and "settling-in" of the Escalante Sector by Anasazi groups. All settlements appear to have been of the "unit hamlet" type, that is, one household homesteading in a pithouse. The pithouses were dispersed with a minimum distance of 100 to 500 m between each small settlement; no clusters of pithouse units such as the examples described by Wheat (1955) and Rohn (1975) for the canyon and mesa area to the west of the sector have been recorded. Unit hamlet settlements have been found on terraces within the river canyon, in the Sagehen Flats area to the west of the canyon, and on the higher plateaus within the takeline area. Individual hamlets were probably affiliated with other settlement units to form dispersed communities or "neighborhoods." Architecture and material culture correspond generally to the regional Basketmaker III pattern (Birkedal 1976; Hayes and Lancaster 1975).

(b) *Sagehill Subphase* (A.D. 700-780) - This temporal unit is defined as a growth period

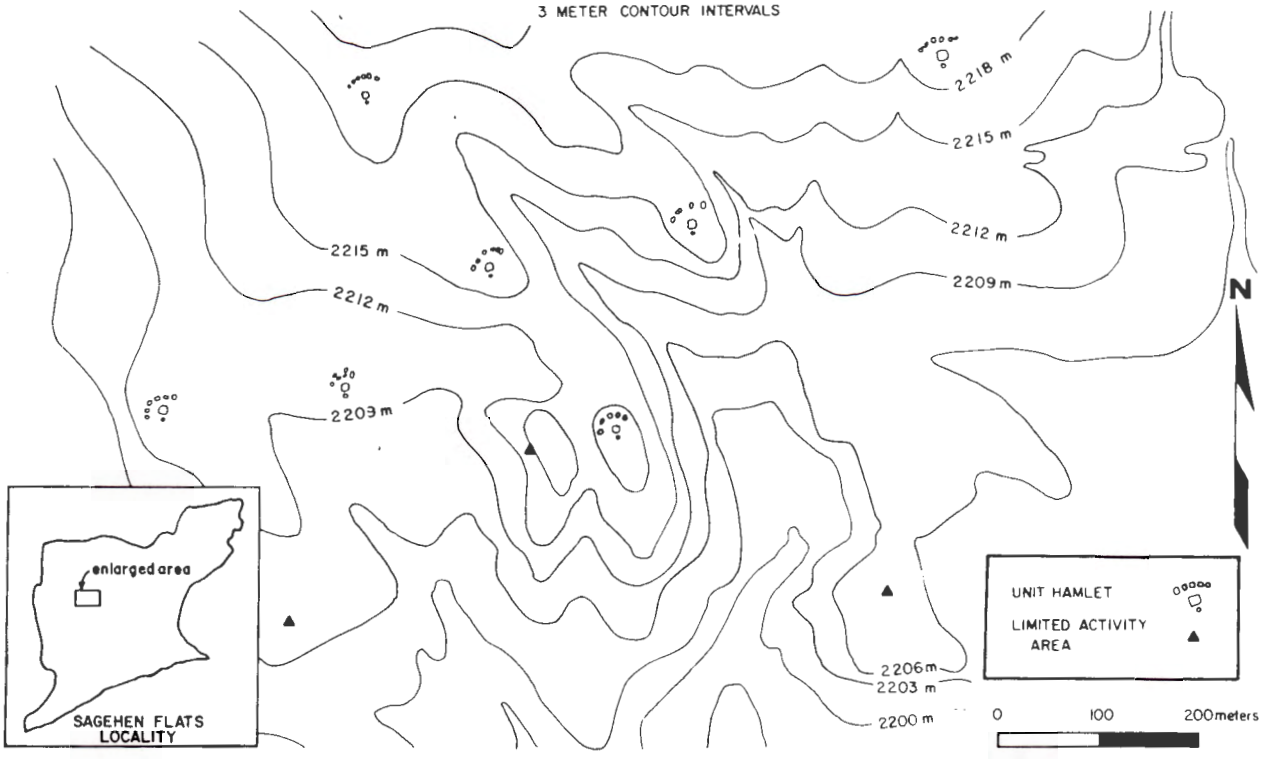


Figure 5. Sagehen Phase settlement patterns: the West Sagehen Neighborhood at A.D. 700.

with the local communities practicing a dispersed settlement strategy. It is theorized that the Sagehill Subphase represents the start of internal population growth that ultimately led to the population maximum evident during the McPhee Phase; however, population levels for the period have not yet been quantified due to incomplete analysis of survey data. The communities maintained the dispersed habitation strategy of their Tres Bobos predecessors; unit household hamlets are found in the Sagehen Flats area and on the high plateau to the west of the canyon. One pithouse assigned to the Sagehill Subphase was investigated at LeMoc Shelter, a multicomponent site located near the damsite on the north slope of the main canyon. A major shift evident in intrasite patterning is the increasing role of surface structures as the center for multiple activities rather than as storage facilities; during this period they are larger than during the Tres Bobos period and contain more internal features, such as hearths and grinding stations. Artifact assemblages and styles correspond closely to those described for the late Basketmaker III period in other parts of the Mesa Verde Region (Birkedal 1976; Hayes and Lancaster 1975). There is some temporal overlap between this subphase and the subsequent Dos Casas Subphase, as some groups were apparently practicing the unit hamlet settlement strategy after other groups had begun aggregating into larger habitations.

(c) *Dos Casas Subphase* (A.D. 760-850). - Beginning in the middle of the eighth century, the prevalent dispersed pattern of habitation units was gradually replaced by an aggregated form. The Dos Casas Subphase was defined to reflect the period of initial aggregation and associated population growth. The aggregation phenomenon was not a sudden shift, but was rather a gradual process over a 40- to 60-year period. Habitation sites with two and three household units have been identified during the last half of the ninth century A.D. After A.D. 800, the transition was complete and habitation units consisted solely of small pueblos with three to six household clusters. It is important to note that the aggregated units appear to be fairly evenly spread over the landscape, thereby retaining some features of the earlier settlement strategy. Households

were apparently centered in three-room surface apartments (one front living room and two rear storage rooms in a double row). The apartments were arranged in a straight line or in a crescent, fronted by a pitstructure centered on the roomblock. The pitstructures appear to have been shared by multiple households and probably can be considered "protokivas," as described by Morris (1939) and Hayes and Lancaster (1975:183). Other architectural characteristics and material culture were similar to those of the early Pueblo I period as described by archaeologists working in the Mesa Verde Region (Farmer 1977; Hayes and Lancaster 1975; Martin et al. 1938).

2. *McPhee Phase* (A.D. 850-975) - The culmination of the growth/aggregation trajectory initiated during the Sagehen Phase is reflected in the subsequent period, the McPhee Phase. A population maximum is evident in the Escalante Sector during the early portion of the period (A.D. 850-900). A demographic collapse swiftly followed in the first decades of the 10th century and the northern and eastern three-quarters of the sector were virtually abandoned by the end of the phase (only the Escalante and Reservoir Localities remained permanently inhabited after A.D. 975) (fig. 2). Settlements exhibit an aggregated or nucleated pattern and appear to have been evenly distributed along the flood plain of the river valley and on the highlands to the east and west. Habitation sites are termed "villages" and usually consist of a minimum of 10 to over 100 household clusters. McPhee settlement patterns incorporate a more complex site set, apparently in response to shifts in agricultural methods and technology (fig. 6).

(a) *Periman Subphase* (A.D. 850 to 890/900) - This unit represents the time of maximum population levels and adoption of a nucleated/aggregated settlement strategy by local Anasazi groups. Nine villages (20+ household clusters) have been identified in the Escalante Sector; these plus outlying settlement units (8 to

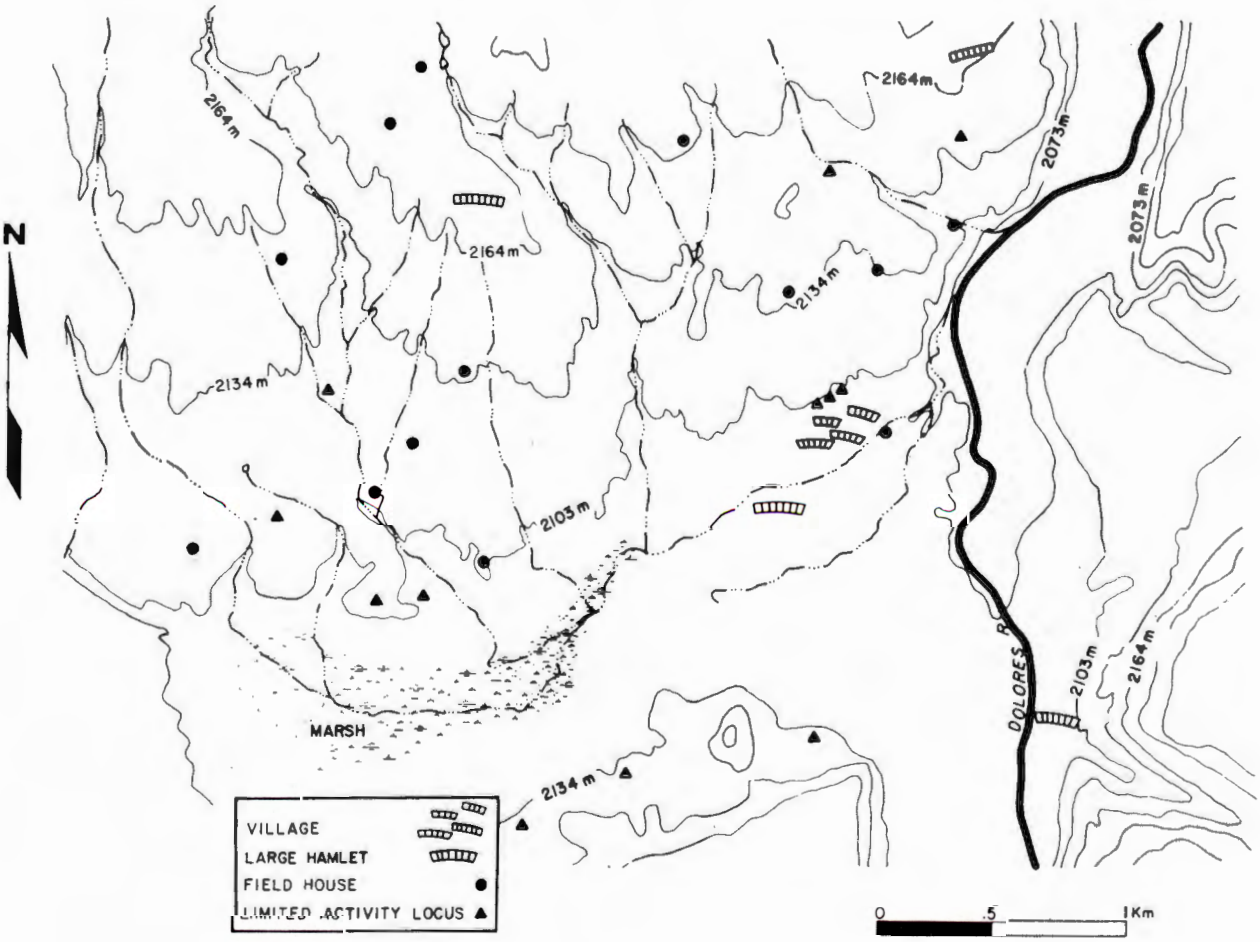


Figure 6. McPhee Phase settlement patterns: the McPhee Village Community at A.D. 875.

20 household clusters and seasonal agricultural sites) are the basis for definition of nine nucleated Periman Subphase communities. The gross distribution of the central villages suggests equidistant spacing. Perhaps each community maintained its own territory; the overall Escalante settlement system particular to the Periman Subphase may bear some resemblance to simple central place models. The village settlements consist of aggregates of Dos Casas-type roomblocks or pueblos arranged linearly or in a column, or as at McPhee Village, in a horseshoe shape, apparently reflecting different local topography. The three-room apartment as the basic household facility is maintained and most pitstructures can probably be considered "protokivas." These exhibit a greater variation in size and internal features than during the Sagehen Phase; the variation may reflect functional differences. Other architectural characteristics and material culture are similar to the late Pueblo I period in the Mesa Verde Region as described by other archaeologists (Farmer 1977; Hayes 1964; Hayes and Lancaster 1975).

(b) *Cline Subphase* (A.D. 900-975) - As mentioned in the introductory discussion for the McPhee Phase, there is a clear indication of a massive demographic collapse and probable exodus of most Anasazi groups from the sector at approximately A.D. 900. There is no certain explanation for this sudden change, but it is noted that population movements at this time seem to be a regional phenomenon (Hayes 1964; Hayes and Lancaster 1975; Martin et al. 1938). It is speculated that stress was brought to bear on local subsistence systems, perhaps centered on agricultural production, and that local communities may have reacted in different ways to the problem. Preliminary indications based on incomplete data are that four of the communities defined for the preceding Periman Subphase were abandoned by A.D. 900, four others persevered (but with radically altered lifestyles and lesser population levels), and one (on the south extremity of the sector) was affected to a lesser degree. The Cline Subphase is intended to classify one type of response — that shared by the inhabitants of McPhee Village and two other communities on the west side of the main canyon. Cline settlement patterns can be characterized as aggregated, but not nucleated, as satellite pueblos located away from the central villages were abandoned. Agricultural organization and practices apparently remained similar to the preceding Periman Subphase, as post-A.D. 900 field houses at a distance of 2 to 3 km from the central villages have been identified. At McPhee Village itself, 12 of the 15 recorded individual roomblock units were abandoned and population had shrunk from an estimated 100 to 150 household units to 30 to 50. The surviving roomblocks exhibit complete reconstruction of all household clusters, and protokivas are replaced by true kivas. Interpretation of ceramic materials recovered from McPhee suggests that the community was participating in an intensified regional trade network (see chapter 5, section 5, this report). It is suggested that this may have been an adopted strategy for coping with stressful conditions. Architecture and material culture approximate descriptions provided by other archaeologists for the early Pueblo II period in the Mesa Verde Region (Hayes 1964; Lancaster et al. 1954; Morris 1939; Rohn 1977).

(c) *Grass Mesa Subphase* (A.D. 880-925) - A different response to this stress period is exhibited at Grass Mesa Village. Here, the Periman Subphase is similar to that at McPhee Village, but post-A.D. 880/890 settlement patterns and architecture are radically different. The Grass Mesa Subphase was established to classify this different response. Grass Mesa settlement patterns can be considered aggregated, as all identified household units are clustered at Grass Mesa Village. However, the central village/field house agricultural system appears to have been replaced by a simpler strategy; no outlying agricultural sites have been identified in the vicinity. Rather than maintaining the roomsuite/kiva architectural pattern, Grass Mesa households lived in small pitstructures; no larger integrative structures have been identified. This shift in settlement and architectural patterns implies that there was probably a dramatic change in social structure as well. The Grass Mesa Subphase is a classic example of exceptions to the Pecos Classification discussed by Hayes (1964:86); that is, groups assignable to the Pueblo II time period (A.D. 900-1100) were living in pithouses rather than masonry surface rooms.

3. *Sundial Phase* (A.D. 1050-1200) - Prehistoric use of the pool area and most of the Escalante Sector for the time span A.D. 975-1050 has not,

based on present data, been verified, although seasonal use is suspected. The Sundial Phase has therefore been defined as beginning at A.D. 1050. Use of the area, excluding the south extremity, was probably seasonal and specialized in nature during this period (refer to discussion by Orcutt in appendix A). Sites were apparently established with very specific purposes in mind and hence exhibit definite locational preferences for certain topographic and environmental zones. Thus, settlement patterns cannot be characterized as dispersed or aggregated. In essence, what is perceived in the local areas are peripheral portions of settlement patterns with population centers to the south and west (fig. 7).

(a) *Marshview Subphase* (A.D. 1050-1125) - This period has been defined to reflect use of most of the sector for specialized purposes and a short-term attempt to resettle a portion of the area in the late 11th century. Most sites assigned to the period are categorized as seasonal or limited activity loci (Knudson et al. n.d.:table 1), and site locations were chosen with a specific purpose in mind. For example, a Marshview component has been assigned to architecture and cultural deposits at LeMoc Shelter near the damsite. The shelter provides easy access to modern wintering grounds for elk and deer, and the site is hypothesized to have functioned as a hunting camp during the Marshview Subphase. Other sites are located on prominent topographic locations with excellent lines of sight and as a unit may have functioned as a communications network. Several Marshview sites located in the Sagehen Flats area are believed to have been small hamlets and may represent an attempted resettlement; the distribution of these suspected habitations seems to suggest a return to a

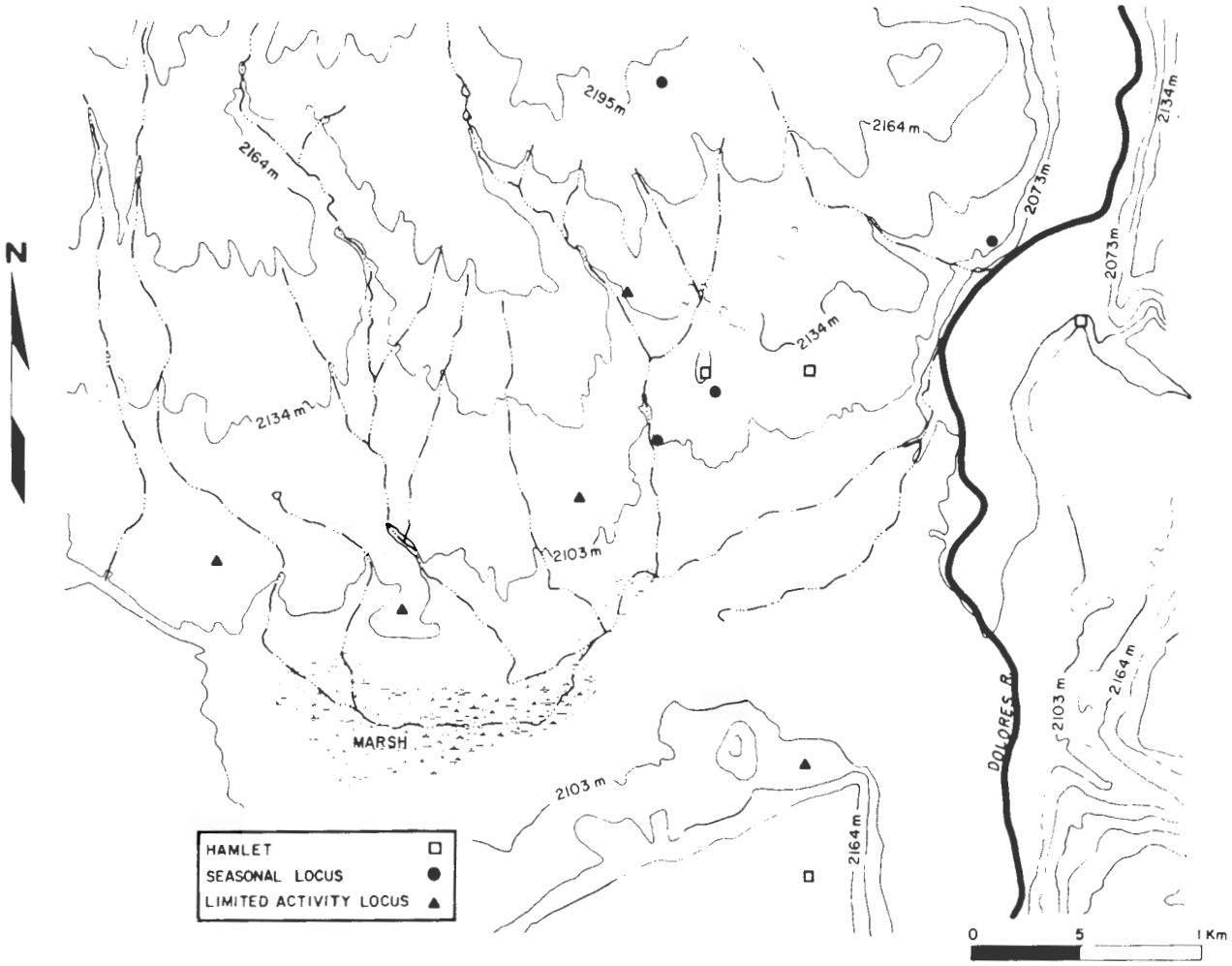


Figure 7. Sundial Phase settlement patterns in the Sagehen Flats area.

dispersed settlement pattern strategy. Architectural remains at one of the suspected settlements excavated in 1978 (Site 5MT2235) consisted of a small oval unlined pithouse, apparently serving as a domicile, and a surface structure constructed of adobe and rock rubble. This architectural mode is much different from that described for other Pueblo II-early Pueblo III settlements in the Mesa Verde Region (Hayes 1964; Hayes and Lancaster 1975; Lister 1964, 1966; Nordby 1974; Swannack 1969). Permanent settlements apparently were maintained in the southernmost two localities of the sector (in the upland area south and southwest of the river canyon), but survey or other data for this area are very incomplete.

(b) *Escalante Subphase* (A.D. 1125-1200) - Assignment of this subphase reflects use of the sector by suspected special purpose communities such as those centered at the Escalante Ruin and Reservoir Ruin (located south of the river canyon about 12 km upstream from the damsite). The Escalante community has been described by Hallasi (1979) and Reed (1979). The Escalante Ruin itself consists of an E-shaped roomblock and a large kiva in the central plaza. Tree-ring dates suggest major construction episodes in the late 1120's and early 1130's. This central Pueblo is surrounded by a loose aggregation of small hamlets, certainly an atypical pattern for the period. Hallasi (1979:399-403) and Reed (1979:113-137) hypothesize that the Escalante Complex is a Chaco outlier; the architecture and material remains lend support to this theory. The DAP staff has speculated about the function of such a complex; one recurring idea is that Escalante served as a trading or resource gathering center and that the inhabitants assembled and processed resources from the unsettled area to the north and the west (the Dolores River canyon and adjacent highlands) before transportation to villages located to the south. Construction of a surface room-kiva complex at Site 5MT2215, 6 km north of Escalante, may represent an abortive effort to expand the system. Less is known about the Reservoir Ruin complex, located about 1.5 km east of Escalante; however, the presence of a tri-wall structure (Eddy and Kane 1981) suggests that this complex as well may have been established with a specialized purpose in mind.

The Escalante and Reservoir communities represent the last verified Anasazi occupation in the Escalante Sector; by A.D. 1200 the local area was apparently permanently abandoned by the Pueblo peoples.

III. **The Post-Pueblo Period** (A.D. 1200-1870) - The presence of post-Anasazi prehistoric and protohistoric groups in the Dolores area has been verified, but descriptions of settlement patterns, other lifeways, and processes are not possible because sites thus far investigated have only provided a minimal amount of information.

A. Shoshonean Tradition (A.D. 1500?-1800) - Pottery fragments and lithic artifacts from a few sites within the sector that correspond to descriptions of Shoshonean (Ute) material culture (Huscher and Huscher 1943; Opler 1939) have been recovered. None of these sites has been investigated, however, because they are outside the boundary of project impact features. It is speculated that Shoshonean peoples were in the area after the Anasazi occupation and that their use of the area appears to have been sporadic and seasonal.

B. Protohistoric Tradition (A.D. 1775-1870) - The period reflects changes in the culture of local indigenous peoples brought about by historic contact. Two sites (Site 5MT5399 and Site 5MT5380) with Protohistoric components have been excavated; the pertinent deposits, which consist of single burials with associated historic artifacts, suggest that the remains date before or during the first few years of Euro-American settlement (A.D. 1870). There are no other excavation or survey-derived data relating to this period.

PHASE SCHEME: DISCUSSION

How well have the concepts used to develop the phase scheme and the integral units themselves held up, given the additional data recovered from survey and excavation since initial formulation of the system in winter of 1978-79? It is believed that they have held up very well and that the phase scheme is an important tool for categorizing recovered data. The basic units (phases) are essentially unmodified since their initial formulation and the original definitional criteria remain valid. It should be stressed, however, that the phase scheme is a flexible tool, and changes will be made if they are warranted by the data. Proposed changes are considered during biannual meetings of the DAP Senior Staff. Modifications in the phase scheme since 1978 (and presented in this report) include the development of more specific definitional criteria and of finer temporal units (subphases). These changes are viewed as reflective of the additional data recovered since the 1978 field season. It is anticipated that use of the DAP phase scheme will avoid the pitfalls inherent in the Pecos Classification and its

made use of Data Processing standardized output (raw data from the ceramics, lithics, and portions of the biotic analyses programs system) as it was available. The standard output was organized according to a temporal-functional outline (table 4) employing the units of the DAP Formal Series (phase system) and site typology (refer to previous section and Kane [1981a]). The organization of the output is flexible and is amenable to separation into subcategories for analysis; for example, analyses of functional types such as limited activity areas, villages, or a combination of temporal units. The task specialists have, to varying degrees, exploited this inherent flexibility.

Domain 1: Economy and Adaptation

This domain addresses the strategies, organization, and activities employed by prehistoric Dolores cultures as integral portions of subsistence systems. As such, reconstruction of the prehistoric resource base and tracking of the use history (such as procurement, processing, storage distribution, consumption, discard) of particular resources are viewed as vital areas of study. The internal structure of the domain reflects two primary concerns: Questions 1 and 2 directly address reconstruction of the resource base, while Questions 3, 4, and 5 are a structure of inquiry for reconstruction of the subsistence system. The status of these two areas are summarized below; in addition, a detailed summary of architectural data as one aspect of prehistoric adaptation is included. This last subject is not addressed by the task specialists' reports.

Resources. It is believed that most of the raw data needed to answer Questions 1 (what resources were available) and 2 (which of the available resources were used) have been acquired, although the necessary analysis is not yet complete. The production of a comprehensive report addressing reconstruction of the resource base is planned by September 1981 (Benz et al. 1981). Most of the pertinent

Table 4. Standard temporal-functional output for the 1981 Synthetic Report*

I. Archaic Tradition

A. Great Cut Phase

1. Limited activity sites (assumed to be procurement and/or processing loci; all proveniences probably contain an unknown proportion of Anasazi Tradition material) - selected proveniences from eight sites.

2. Seasonal sites (assumed to be seasonal camps) - selected proveniences from three sites.

II. Anasazi Tradition

A. Sagehen Phase

1. Limited activity loci (not differentiated by subphase; assumed to be procurement and/or processing loci) - selected proveniences from eight sites.

2. Tres Bobos Subphase habitations - selected proveniences from five hamlets.

3. Sagehill Subphase habitations - selected proveniences from eight hamlets.

4. Dos Casas Subphase habitations - selected proveniences from eight hamlets.

B. McPhee Phase

1. Limited activity loci (not differentiated by subphase; assumed to be procurement and/or processing loci) - selected proveniences from three sites.

2. Seasonal loci (not differentiated by subphase; assumed to be agricultural field houses or seasonal camps) - selected proveniences from nine sites.

3. Periman Subphase habitations - selected proveniences from McPhee, Grass Mesa, Rio Vista, and House Creek Villages.

4. Cline Subphase habitations - selected proveniences from McPhee Village.

5. Grass Mesa Subphase - selected proveniences from Grass Mesa Village.

C. Sundial Phase

1. Limited activity sites (not differentiated by subphase; assumed to be procurement and/or processing loci) - selected proveniences from two sites.

2. Seasonal sites (not differentiated by subphase) - selected proveniences from two sites.

3. Habitations (not differentiated by subphase) - selected proveniences from three sites.

*This output includes all sites for which adequate data had been entered into the DAP data processing system.

studies have been the responsibility of the Environmental Studies Task Specialist, although some base data have been collected by other task groups; for example, the refiring studies and ceramics source materials reconnaissance by the ceramics group, appendix C; and the lithics source materials reconnaisance, appendix D. Two approaches have been adopted for data collection in this area: first, establishing the modern resource base and extrapolating to the prehistoric base; and second, working with materials recovered from prehistoric strata. The first approach requires surveys of the modern environment and linking studies to address the extrapolation. The Environmental Studies staff has implemented the following studies, corresponding to the first approach:

1. Reconnaissances or surveys

A. *Vegetation reconnaissance.* This study was accomplished by the Environmental Studies staff in 1979 and the end product is a preliminary vegetation map. The work is reported by Bye (1981a).

B. *Zoological reconnaissance.* Fieldwork was done by program staff to assess the modern faunal resource base available in the Dolores area. The results are reported by Emslie (1981) and field notes are filed at the Lebanon Laboratory Facility.

C. *Geological reconnaissance.* The fieldwork was done by F. Leonhardy in 1979 to obtain data for preparation of geologic base maps (bedrock geology, land forms, drainage basin and stream orders, and soils). The work is reported by Leonhardy and Clay (1981), and the maps are filed at the Lebanon Laboratory Facility.

2. "Linkage" studies

A. *Ethnobotanical literature search.* The purpose of the study was to assess the botanical resources that might have been exploited by Dolores peoples. A bibliographic report has been prepared by Litzinger (1980a) and Bye (1981a).

B. *Ethnozoological literature search.* The study, accomplished by program staff, estimated the possible range of zoological resources exploited by the Dolores peoples. Notes are filed at the Lebanon Laboratory Facility.

C. *Packrat midden study.* Fieldwork was accomplished in 1979 and the data are currently being analyzed. The study will provide a vital link between the modern and prehistoric resource bases.

D. *Tree-ring reconstruction of past climate.* The study is currently underway by the Laboratory of Tree-Ring Research.

E. *Dolores Archaeological Program comparative garden.* R. Shuster of the Environmental Studies staff supervised a garden study in 1979 and 1980 to investigate local environmental variation in terms of agricultural potential and to determine which crop varieties might have been preferred by the prehistoric peoples. Results have been reported by Shuster (1981a).

The second approach involves compilation of exploited botanical and faunal resources from excavation data. One end product currently envisioned is a set of tables listing exploited biotic resources by temporal and spatial divisions; the Environmental Studies staff is currently involved in this task. B. Benz, the Environmental Studies Task Specialist, has prepared a preliminary listing of verified plant and animal resources (table 5).

To conclude, most of the necessary fieldwork, literature reviews, and analyses needed to address resource availability and use have been accomplished. Some linkage work remains to be accomplished, e.g., site catchment studies.

Subsistence systems. The DAP is less well placed in reconstructing subsistence systems and will rely on the modeling exercise to guide future work in this area. Some necessary preliminary studies have been accomplished or are underway. The concept of "activity areas," or intrasite locations where activities were performed by individuals or task groups (Kane 1981a:34), is vital in this area. Consequently, several studies were commissioned to investigate potential DAP activity areas and to make the approach more rigorous. These studies are summarized in chapter 5, section 7, of this report. Some of the analyses being undertaken by the Reductive Technologies staff have bearing on reconstructing subsistence systems. For example, the intensive flake analysis, the intensive ground stone analysis, and the projectile point study (chapter 5, section 7) all address the functional aspects of stone tools and hence are contributions to this area.

Specific models that address the procurement and use history of resources have been developed. Benz (appendix B) has presented a garden hunting model that stresses the relationship between man-created or modified ecosystems (e.g., planted and fallow agricultural fields) and faunal distributions. The model has implications for reconstruction of prehistoric hunting strategies. Kohler, Lipe, Floyd, and Bye have developed a wood resource depletion model; the authors estimate rates of construction and fire wood consumption for the Grass Mesa Site (Site 5MT23) and suggest that depletion of this resource might have been a factor influencing species selection and locational decisions during the Pueblo period (chapter 5, section 4). Orth and

Table 5. Plant and animal species identified in Dolores prehistoric cultural deposits

Plants:

Yucca sp. (Spanish bayonet)
Amaranthus spp. (amaranth)
Alnus sp. (alder)
Chenopodium spp. (chenopodium)
Artemisia sp. (sagebrush)
Helianthus (sunflower)
Descurainia sp. (tansy mustard)
Juniperus spp. (juniper)
Quercus sp. (oak)
Phragmites sp. (reed grass)
Ribes sp. (currant)
Sphaeralcea sp. (globe mallow)
Pinus edulis (pinyon pine)
Psuedotsuga menziesii (Douglas-fir)
Abies sp. (true fir)
Polygonum sp. (knotweed)
Portulaca sp. (purslane)
Cercocarpus cf. *montanus* (mountain mahogany)
Prunus cf. *virginiana* (chokecherry)
Populus sp. (cottonwood/aspen)
Salix sp. (willow)
Nicotiana sp. (tobacco)
Physalis sp. (groundcherry)
Typha sp. (cattail)

Zea mays (corn)
Cucurbita spp. (squash, pumpkin)
Phaseolus sp. (bean)

Mammals:

Lepus spp. (jackrabbit)
Sylvilagus spp. (cottontail rabbit)
Cynomys spp. (prairie dog)
Marmota flaviventris (yellow-bellied marmot)
Spermophilus spp. (ground squirrel)
Neotoma spp. (woodrat)
Castor canadensis (beaver)
Erethizon dorsatum (porcupine)
Canis latrans (coyote)
Canis lupus (wolf)
Canis familiaris (domestic dog)
Vulpes vulpes (red fox)
Urocyon cinereoargenteus (gray fox)
Mustela frenata (long-tailed weasel)
Lynx rufus (bobcat)
Cervus canadensis (American elk)
Odocoileus hemionus (mull deer)
Antilocapra americana (pronghorn)
Ovis canadensis (bighorn sheep)

Birds:

Branta canadensis (Canadian goose)
Oxyura jamaicensis (ruddy duck)
Aquila chrysaetos (golden eagle)
Falco sparverius (sparrow hawk)
Canachites canadensis (spruce grouse)
Centrocercus urophasianus (sage grouse)
Meleagris gallopavo (turkey)
Grus canadensis (sandhill crane)
Zenaidura macroura (mourning dove)
Otus asio (screech owl)
Bubo virginianus (great horned owl)
Glaucidium gnoma (pygmy owl)
Pica pica (magpie)
Corvus spp. (crow)
Corvus corax (raven)
Sturnella spp. (meadowlark)
Turdus migratorius (robin)

Osteichthyes (fish species)

Phagan are currently conducting a literature search and artifact analysis as the first step in a study of ground stone implements and food processing. One result of this exercise will be the development of a model pertaining to Anasazi domestic food processing practices. A summary of their work to date may also be found in chapter 5, section 6, of this report.

Architecture. One important aspect of human adaption is protection from the elements. Shelter would seem to be a more critical concern for peoples practicing a sedentary lifestyle than for those not tied to a particular place. Rappaport (1969:59), however, has argued that climate is not the determining factor influencing architectural construction. He views architectural form as dependent on many

factors, including climate, available technology and materials, tradition, and presence or lack of an economic surplus. Taking into account the possibility of multiple causality, it is postulated that winter climate would impose basic restraints on architectural form at Dolores. (As a recent example, the winter of 1978-79 was extremely harsh in southwestern Colorado, with more than 1 m of snow on the ground in the Dolores River canyon from January until April. Wildlife species were severely hampered in their movements, and decimation of deer and elk populations was observed. Human populations without the benefits of modern technology would have been subject to the same stresses.) Anasazi groups apparently colonized the Escalante Sector in the seventh century A.D. (see previous section; no architectural forms with the exception of hearths have been recorded for the Pre-Pueblo and Post-Pueblo periods) and were equipped with an architectural form (the pithouse) that was adapted to continental winters. During the subsequent Pueblo period, architectural forms exhibit considerable variability in formal characteristics and function; this variability seems to be the result of several factors, as suggested by Rappaport. Probably most significant are the changes in pitstructure function and the associated development of surface dwelling units. Many of the trends appear to be regional phenomena; similar trends in pitstructure and surface structure architecture are exhibited at Mesa Verde (Hayes and Lancaster 1975) and in the Ackmen-Lowry area (Martin et al. 1938). However, there appear to be some Dolores specializations; these will be pointed out in the regional comparisons discussion.

The remainder of the architecture presentation has been organized under the following subtopics: construction prerequisites, formal and functional variability of pitstructures and surface structures, and intrasite and intersite patterning.

Construction prerequisites. Available materials and labor input affect construction modes and longevity of structures. Dolores groups invariably relied on locally available materials for construction. Early (Sagehen Phase) pithouses were often pits dug into native earth with packed floors and wood, bark, and earth roofs (e.g., Hewitt 1981; Brisbin 1981). McPhee Phase pitstructures exhibit more finished construction and the walls were usually covered with multiple layers of plaster. Walls of surface structures consisted of jacal (poles and adobe), often with base courses of vertical sandstone slabs or adobe mixed with sandstone fragments (during the early Sagehen Phase). Surface rooms dating after A.D. 800 are of more substantial construction and coursed masonry construction is exhibited after A.D. 850. This emphasis on using locally available materials was pervasive; for example, Sagehen Phase sites in the Sagehen Flats area often include borrow pits (Brisbin 1981; Yarnell 1981) which apparently served as sources of native soil for construction. Habitation sites built on terraces in the main canyon often incorporate river cobbles into the walls of surface rooms. Roof construction conforms generally to the four post-and-stringer patterns cited by others for the Mesa Verde Region (Hayes and Lancaster 1975; Farmer 1977). Different wood species were preferred for different construction members, probably because of inherent strengths and weaknesses (appendix B; Hayes and Lancaster 1975). Douglas-fir was preferred for the main posts of very large pitstructures and juniper for small pitstructures. Stringers were most often fashioned from ponderosa pine, and filler layers between the stringers and the earth cap consisted of reeds (*Phragmites* sp.), willows, or juniper bast.

Labor input required for construction of domestic and community structures is of great interest to the program staff due to its implications for social organization. Estimated labor needs vary considerably for individual structures. Construction of the initial pit for a Tres Bobos Subphase (A.D. 600-700) pithouse would have required the removal of 20 to 40 m^3 of earthfill; the work required would be slightly less for Grass Mesa Subphase (A.D. 880-925) pithouses (15 to 30 m^3). These amounts can be contrasted with the estimated amount of earthfill removed from Pitstructure 3 at McPhee Village — 160 m^3. Construction of this oversized facility obviously necessitated a formidable labor investment and implies community cooperation for such endeavors. More formal studies in this area are planned in coming years.

Inferences from stratigraphy and comparisons with tree-ring dates from construction timbers suggest that the lifespans of Dolores Anasazi structures varied between 10 and 30 years. Some pitstructures apparently burned accidentally 10 to 20 years after construction. All structures were rebuilt or abandoned after a maximum of 30 years, perhaps because of roof or wall deterioration.

Formal variability. Formal variability in construction characteristics is associated with the passage of time. Formal characteristics of pitstructures (such as size, shape, construction of the ventilator or antechamber, depth, bench construction, wingwall construction, and placement and size of features) have been employed by the DAP staff in a seriational approach to project chronologies (Hewitt et al. 1981; also refer to Domain 5 discussion). It is suspected that surface room architecture exhibits a similar pattern of variability, but formal studies have not been initiated. Architectural variability in pitstructures is illustrated in figures 8 through 11.

Functional variability. The association between formal variability and temporal placement can probably be extended to functional variability as well. The functional sequence first proposed by Morris (1939) for Mesa Verde Region pitstructures (pithouse, protokiva, kiva) seems generally applicable to the Dolores area, with the exception of

post-A.D. 900 structures. The shift from pithouse to protokiva seems to correspond to the shift in surface room function from storage to general domestic. That is, the appearance of surface rooms with domestic features (central hearths, grinding stations, storage bins) is closely followed by the aggregation of households into room suite-protokiva habitation units (surface living rooms are first recorded between A.D. 725 and 750 in the Sagehen Flats area and multiple-household room complexes are recorded between A.D. 750 and 775). This trend seems to correspond closely to the sequence at Mesa Verde National Park (Hayes and Lancaster 1975). Dolores protokivas may have been functionally subdivided during the Periman Subphase A.D. 850-880/900. Floor area estimates collected by Hewitt and Kane for the pitstructure seriation study (Hewitt et al. 1981) suggest that three size groupings might be present, since the figures cluster within these ranges: "small" (17-22 m²), "large" (30-40 m²), and "oversized" (greater than 60 m²). The groupings also reflect the presence or absence of floor vaults and "ceremonial boxes," (phrase initiated by DAP excavation staff). "Ceremonial boxes" are square, slab-lined pits, 0.5 m² in area, located north of the central hearth on a north-south axis (fig. 9, Pitstructure A). They apparently were roofed and are surrounded by small marks apparently made by sharp sticks on the floor of the structure (these are inferred to be "paho" marks by the field

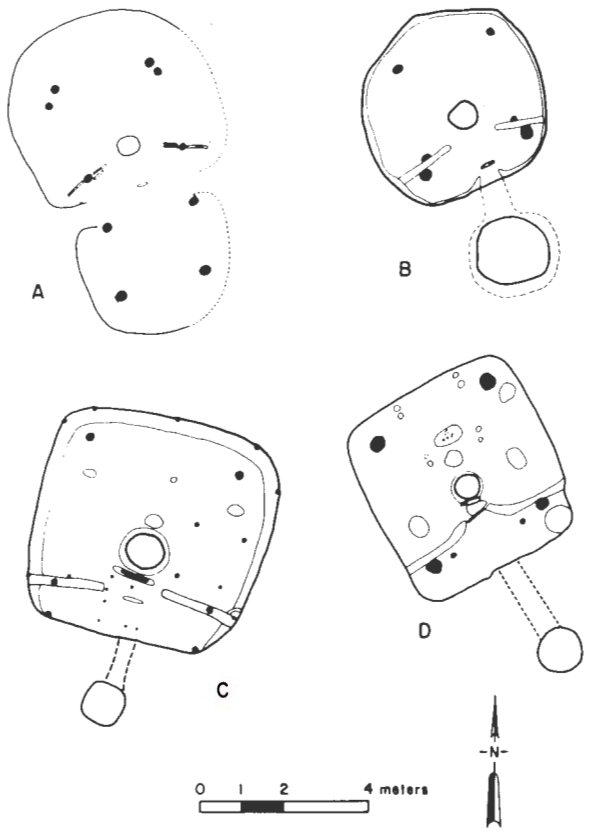


Figure 8. Dolores pithouse architecture, A.D. 600-1200, Sagehen and McPhee Phases: (A) Tres Bobos Subphase pithouse at Site 5MT4545 (A.D. 625-650). Note main chamber and antechamber, bench, slab wingwalls, and position of deflector; (B) Sagehill Subphase pithouse at Site 5MT2198 (A.D. 700-725). Antechamber has been replaced by ventilator system; the bench has disappeared; wingwalls are adobe; (C) Dos Casas Subphase protokiva at Site 5MT4644 (A.D. 775-800). Gross outline is more square; ventilator is smaller; southern main posts are incorporated into wingwall; deflector is immediately south of central hearth; (D) Periman Subphase protokiva at McPhee Village, Site 5MT4479 (A.D. 875). Bench has disappeared; ceremonial pit is north of hearth; deflector is incorporated into wingwall; wingwall is constructed of masonry.

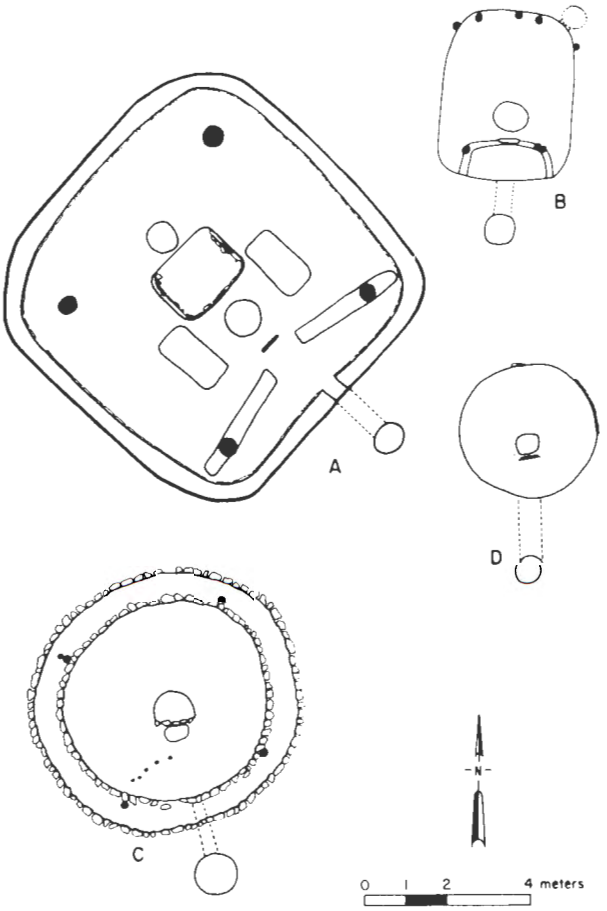


Figure 9. Dolores pithouse architecture, A.D. 600-1200, McPhee and Sundial Phases: (A) McPhee Phase communal pitstructure at McPhee Village, Site 5MT4475 (A.D. 875). Note large size, floor vaults, roofed "ceremonial box" to north of central hearth; (B) Grass Mesa Subphase pithouse at Grass Mesa Village, Site 5MT23 (A.D. 900). Structure is very small; unusual post and wingwall patterns are present; (C) Cline Subphase kiva at McPhee Village, Site 5MT4475 (A.D. 975). Note round outline, masonry lining of outside wall and bench, absence of wingwall; (D) Sundial Phase pithouse at Marshview Hamlet, Site 5MT2235 (A.D. 1100). Note lack of features and roof supports (leaners probably footed on outside of structure); architecture differs considerably from "typical" patterns observed in Mesa Verde Region for this period.

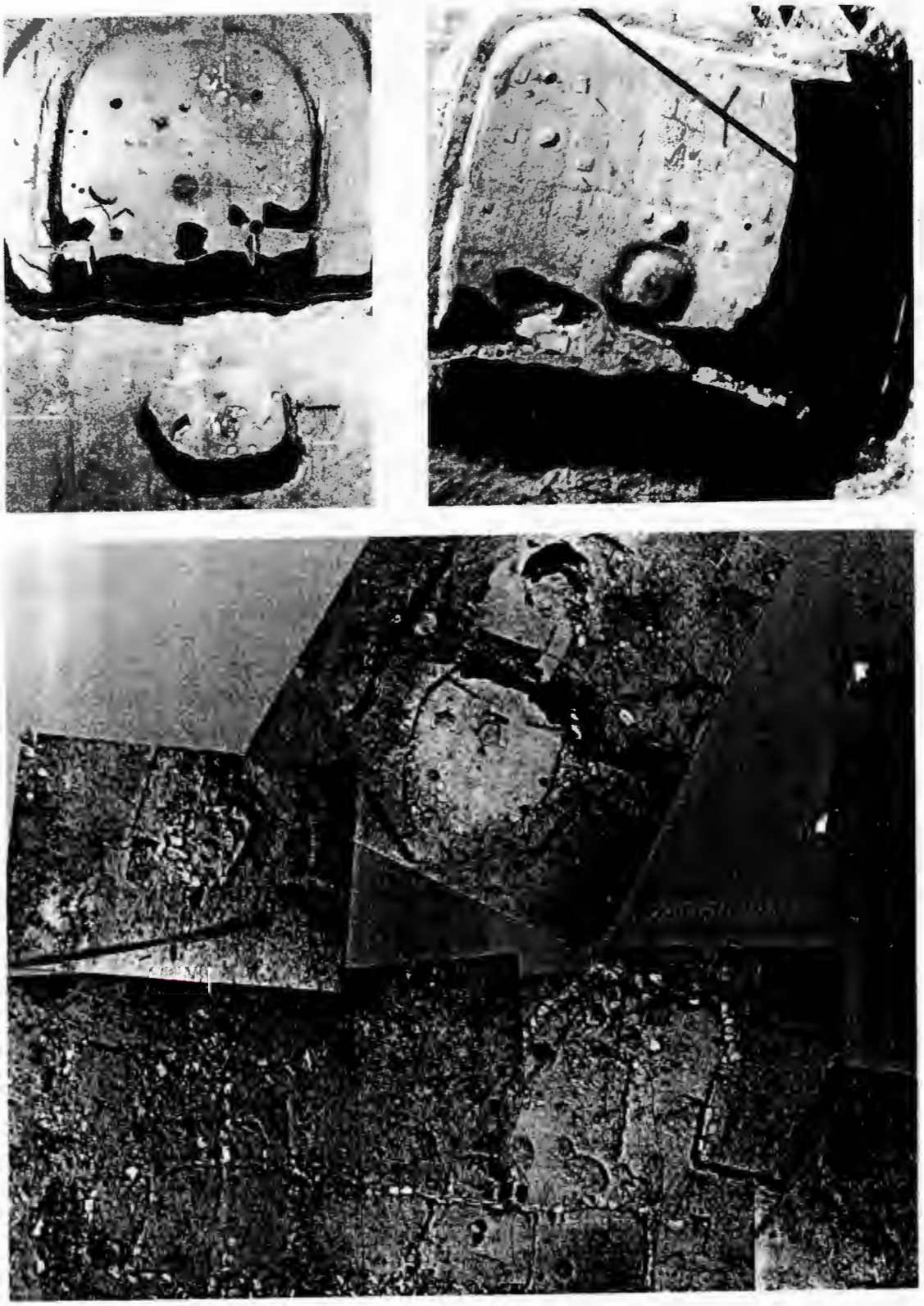


Figure 10. Views of Dolores Sagehen Phase architecture: Top left, Tres Bobos Subphase pithouse at Site 5MT2858 (surface rooms were destroyed by plowing) (DAP 077831); top right, Dos Casas Subphase protokiva at Site 5MT4644 (surface rooms were destroyed by plowing) (DAP 032514); bottom, Dos Casas Subphase site plan at Site 5MT4671 (DAP 077819).

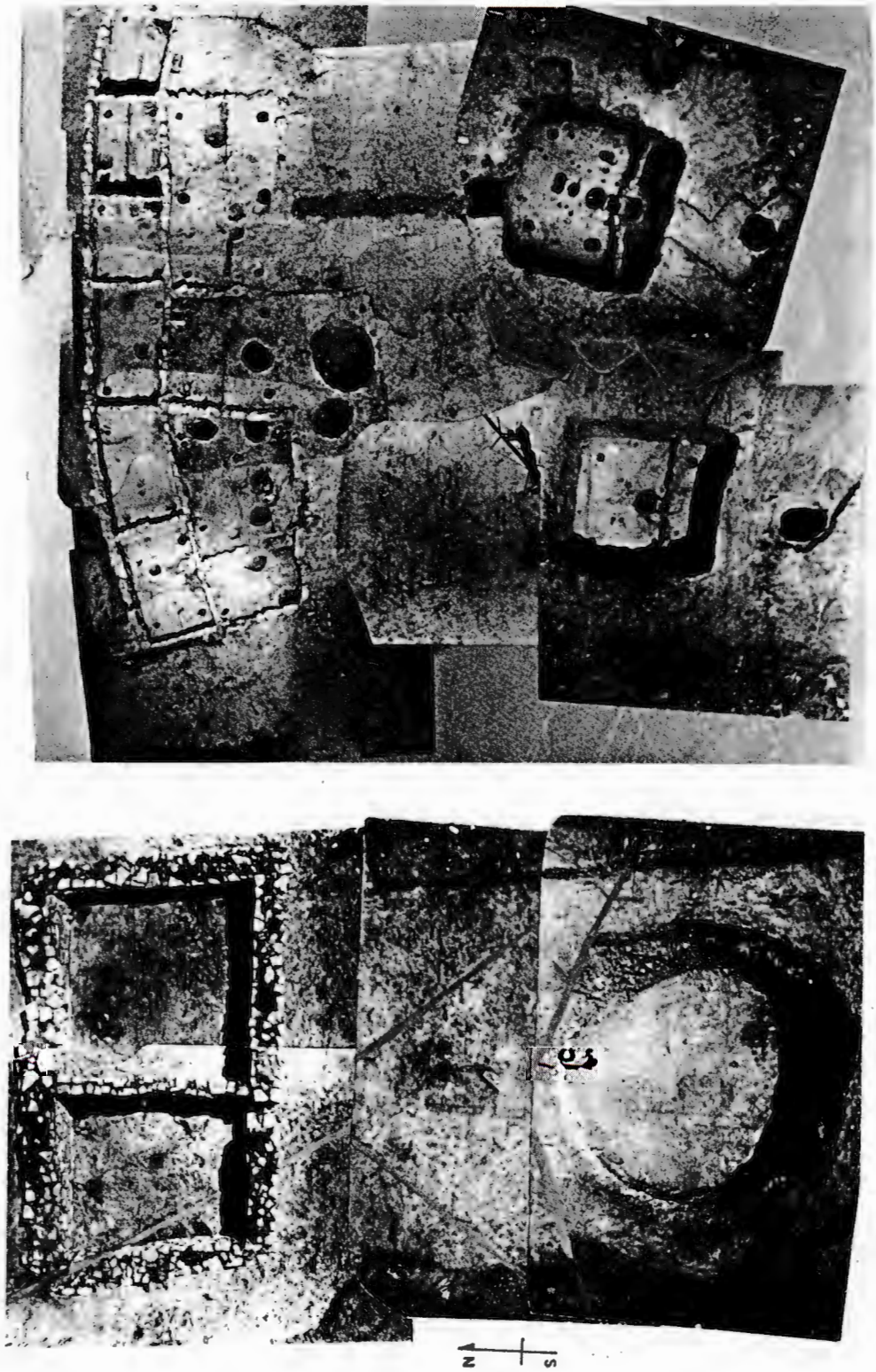


Figure 11. Views of Dolores McPhee Phase and Sundial Phase architecture: Top, McPhee Phase site plan (Site 5MT4479, an architectural unit at McPhee Village) (DAP 077825); bottom, Sundial Phase site plan (Site 5MT2215) (DAP 077820).

staff). Small structures may exhibit paho marks, but no ceremonial boxes or floor vaults; large structures possess all three features. It is speculated that ritual or integrative activities were performed at a greater level of intensity (more participants, greater frequency) in the larger structures. This description is currently only a subjective impression. Because of inadequate sample size, more excavation data are needed to confirm these initial impressions.

As noted previously, most post-A.D. 900 structures do not correspond to other cotemporal patterns in the Mesa Verde Region. Dolores pitstructures can usually be functionally classified as domiciles rather than kivas, except at McPhee Village.

Intrasite patterns. Intrasite settlement patterns at Dolores are generally similar to that reported for Mesa Verde, at least for the pre-A.D. 900 periods. The typical pattern consists of a northern surface room area fronted by a plaza area containing pitstructures, with a sheet-trash or midden area further to the south (Hayes and Lancaster 1975). Figures 12 through 14 illustrate Dolores site plans; the trend resulting in surface roomblocks consisting of three-room apartments fronted by protokivas is evident (fig. 12). Also notable is the "scattered" appearance of the early Tres Bobos and Sagehill subphase habitations when compared to the compact, formally organized Periman villages. This variability is viewed as indicative of a higher order of social organization during the McPhee Phase.

Intersite patterns. Dolores intersite patterns have been described in the phase scheme discussion and additional data are presented by Orcutt (appendix A). A more detailed presentation is available in Kane (1981a). To summarize the patterning identifiable in the available data, the Escalante Sector is believed to have been used as a seasonal stop for resource procurement by Archaic Tradition groups. Site types represented are small camps and limited activity loci; sites may be clustered in certain areas (such as Sagehen Flats), perhaps in response to local resource distribution.

The Anasazi Tradition Dolores communities employed three distinct settlement strategies: dispersed, dispersed/aggregated, and nucleated. The early periods (Tres Bobos and Sagehill Subphases, A.D. 600-780) are characterized by dispersion; unit hamlet settlements are distributed over areas with good farming soil (Kane 1981b). In the succeeding Dos Casas Subphase (A.D. 760-850), an aggregative trend is identified, although the system maintains some aspects of dispersion. Large hamlets with four to six

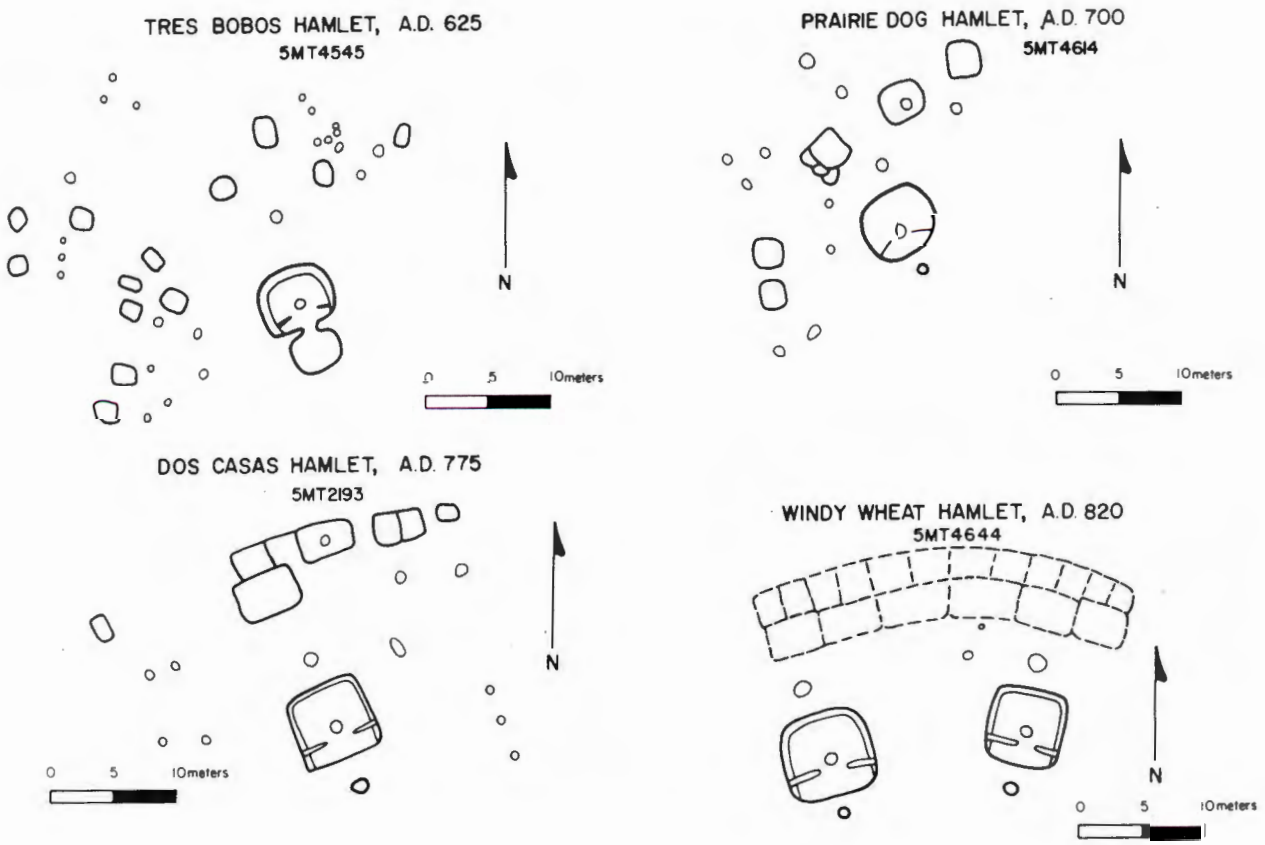


Figure 12. Dolores Sagehen Phase site plans. (Adapted from Lipe and Breternitz 1980.)

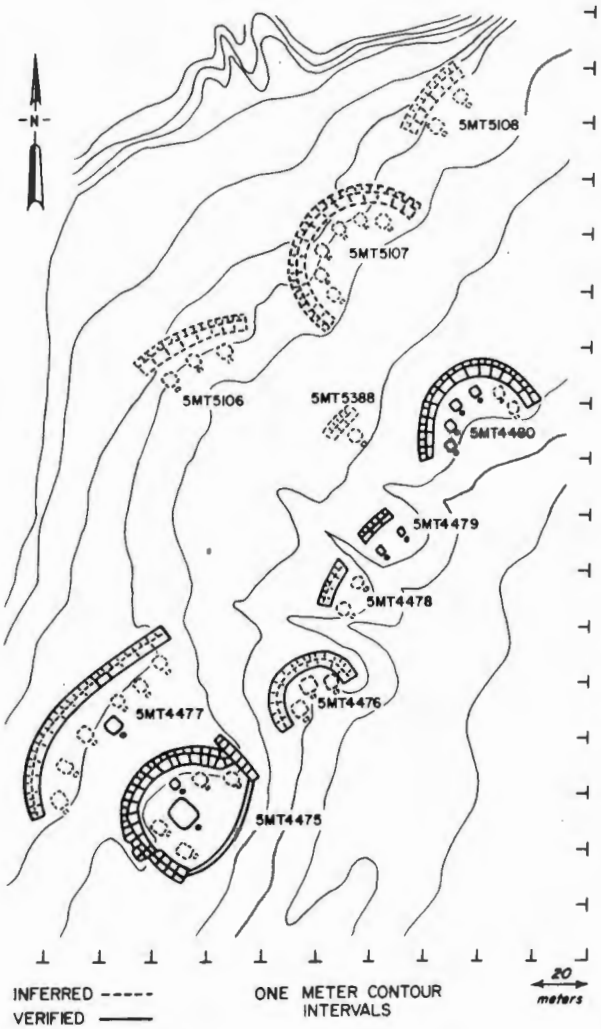


Figure 13. Dolores village plans. McPhee Village at A.D. 880. Only 10 of the 20 estimated roomblocks are depicted (hypothetical reconstruction based on current excavation data; roomblock and pitstructure outlines are probably less regular than indicated).

household clusters are common toward the end of the period. Nucleated patterns characterize the Periman Subphase (A.D. 850-890/900), at least in the river valley and the surrounding highlands. A central village is the nucleus of the community with outlying population units and agricultural sites. A period of stress is identified at A.D. 900 and an exodus from the sector began at this time. Groups at McPhee Village, and perhaps others to the northwest (Cline Subphase), practiced a nuclear settlement strategy well into the 10th century. The groups at Grass Mesa (Grass Mesa Subphase) apparently pursued a less formal organizational strategy. During the Sundial Phase (A.D. 1050-1200), the sector was primarily used for resource exploitation rather than settlement; this is reflected in a striking increase in total limited activity site area (appendix A). The Escalante Complex (Hallasi 1979; Reed 1979) and Reservoir Village were community centers during this period. No settlement patterns have been identified during the post-Pueblo period (A.D. 1200-1870) because of insufficient data.

The locations of population centers and most habitation units for the northern upland and river valley portions of the Escalante Sector have been established. The data base is less complete regarding location and function of limited activity sites and the number and location of habitation sites in the southern and eastern portions of the sector. Additional fieldwork (probability survey and limited excavation) is planned for the remaining field seasons to acquire the information needed to complete the cultural reconstruction.

In summary, the program is fairly well placed in regard to progress in Problem Domain 1. Most of the basic data needed for reconstruction of resource acquisition and use has been acquired, and analytical studies in this area are underway. Benz is currently preparing a comprehensive report on environmental studies. Proposed additional fieldwork in 1982 and 1983 is designed to investigate rock shelter and midden deposits to recover additional ecofactual materials and to enhance the post-A.D. 900 data applicable to resource use. In reconstructing subsistence systems, some specific studies and models have been developed. Further work in this area will be in coordination with the general program model (refer to presentation by Lipe, appendix F). Spatial and temporal patterning in architecture and settlement distributions have been described for most of the sector, with the exception of the southern and eastern portions. Additional data and analyses are needed to verify intrasite and architectural patterns for the Periman Subphase and to establish patterns for the Sundial Phase.

Domain 2: Paleodemography

The presentation of Problem Domain 2 (Kane, Lipe et al. 1981:21-27) is a structure of inquiry for analyzing Dolores paleodemography. The DAP is primarily interested in two broad aspects of prehistoric population studies: first, total population numbers and densities for the sector in each period, spatial and temporal variation in densities, and population movements; second, age, sex, and health characteristics of Dolores populations.

Population numbers and densities. The structured presentation within the domain discussion suggests three types of estimation methods for arriving at absolute population numbers.

1. *The habitation approach.* Since the DAP has defined households in terms of space (the household cluster, [Kane 1981a]), total population can be estimated by determining the number of individuals constituting a

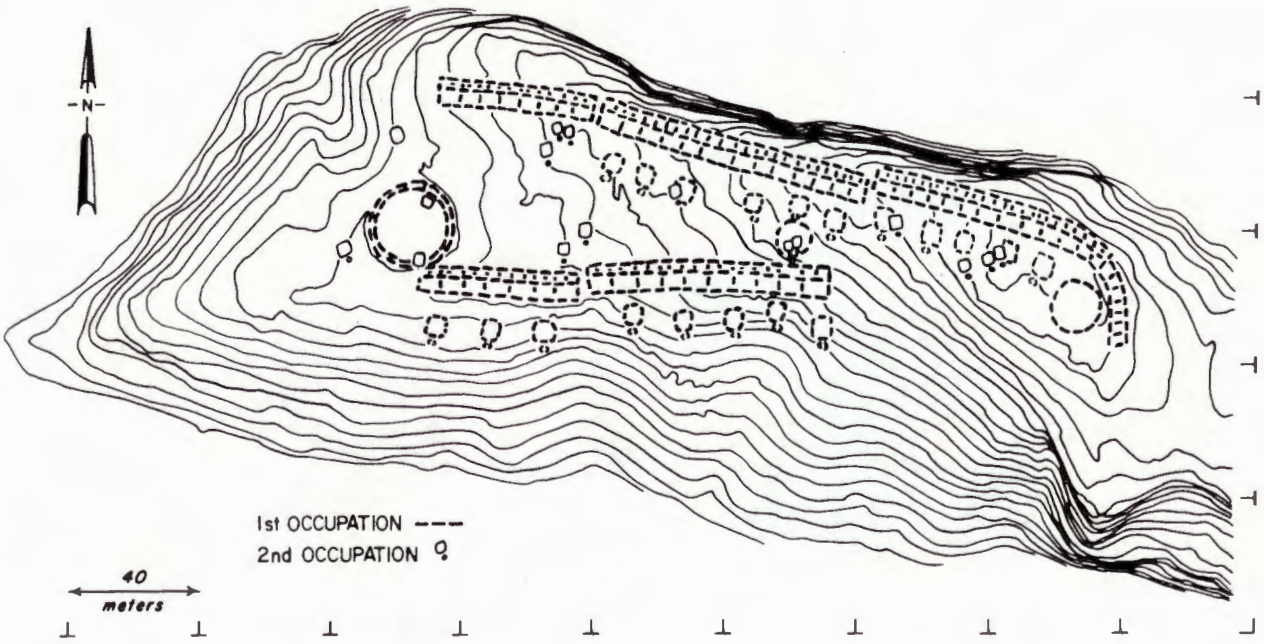


Figure 14. Dolores village plans, Grass Mesa Village at A.D. 860 and A.D. 900; 860 occupation depicted by dotted line; later occupation is solid line (hypothetical reconstruction based on building materials map presented in Kohler and Schlanger (1980); outlines of roomblocks and pitstructures probably less regular than shown).

household and multiplying this figure by the number of households calculated for a given area at a given time. Because of the uncertainty of archaeological dating, and because each household cluster was in use for a limited time span, a corrective constant must be employed to arrive at a true "momentary population" figure (Flannery 1976:88).

2. *The resource limit (carrying capacity) approach.* This technique is patterned on traditional carrying capacity theory (Zubrow 1975) and involves estimating a maximum population limit based on the constraints of the Dolores Anasazi subsistence system and the resource base (Kane, Lipe et al. 1981:23). It is suggested that a number of specific approaches could be adopted for study, including multiple-resource models, indicator (single-resource) models, or decision-based models.

3. *Time-rate studies.* This method is a multistep approach which involves, first, estimating the rate of deposition or discard of various types of archaeological materials remains in relation to human effort and population size. The total amount of the specific type of material in the area and time period under investigation must then be estimated, probably by using a sampling strategy and carefully controlled collection techniques. A population estimate is arrived at using the calculated figures from the first and second steps. This estimate must then be subjected to a correction factor for momentary population and other "hidden" variables, as in the habitation approach. Application of the survivorship model as suggested in the Research Design (Kane, Lipe et al. 1981:25) is not feasible given the realities of the human skeletal material data base.

Several studies that correspond to the recommended approaches have been or are being implemented. Orcutt (appendix A) has employed a habitation approach to estimate population size of the river valley within the Escalante Sector. Rather than using the household as the basic analytical unit, however, she has instead employed rubble area and/or pithouse area in a manner similar to that used by Plog (1974). Orcutt has also adopted Dickson's (1975, 1979) site weight index to compensate for the differing absolute time spans of the phases being investigated. Her results indicate that in the river valley proper, the McPhee Phase population was 42 percent higher than the Sagehen Phase level, and 87 percent higher than during the Sundial Phase.

Kane (1981b) used the habitation and household approach to estimate momentary population densities for the Sagehen Flats Locality, a relatively low and flat area west of the river which includes McPhee Village. Birkedal's (1976) estimate of five to seven persons per household was used as a constant multiplier. Kane (1981b:46) reports calculated momentary population densities of approximately 6 to 9 individuals/km^2 for the Sagehen Phase, 12 to 17 individuals for the McPhee Phase, and 0 to 2 individuals for the Sundial Phase. If these density

figures are extrapolated for the entire Escalante Sector, then an estimate of total population is possible (this is, of course, a preliminary estimate): 980 to 1220 individuals during any one time for the Sagehen Phase, 1800 to 2500 individuals for the McPhee Phase, and 80 to 150 individuals for the Sundial Phase. A temporal population curve for the locality was constructed and has been reproduced for this report (fig. 15). These figures should be regarded with some reservation, first of all because Birkedal's household size estimate (obtained from Mesa Verde Basketmaker III data) was used for all periods, rather than restricting its use to the Tres Bobos and Sagehill Subphases; and second, because more habitation sites have been recorded in the locality since the study. Even with these caveats, the same gross results were obtained from both habitation approach studies: maximum population levels during the McPhee Phase, lesser levels during the Sagehen Phase, and minimum levels of resident population during the Sundial Phase.

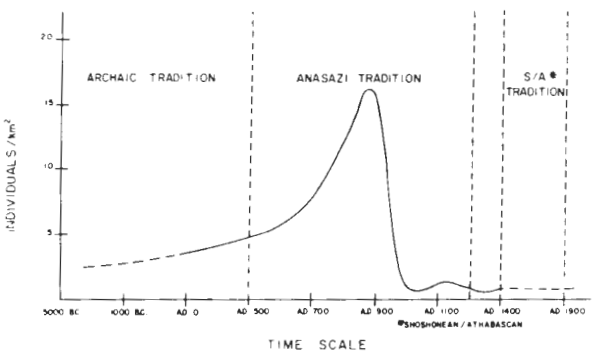


Figure 15. Prehistoric population densities in the Sagehen Flats Locality, Escalante Sector. (Adapted from Kane 1981b.)

Schlanger and Kohler (refer to summation, chapter 5, section 3) are making a study that can be classified as a time-rate approach. Their method tests for correlations between measurements that have been used directly for estimating population size (site area, pithouse floor area) and absolute numbers of common artifact types found in site surface collections (flaked lithic debitage, lithic tools, jar sherds, bowl sherds, metates). The authors' analysis revealed a number of significant correlations, and they suggest (along with other recommendations for further study) that counts of bowl sherds and metates from systematic surface collections might prove to be reliable estimators of site-specific population levels.

In conclusion, the results of the studies indicate that the habitation approach to population estimates is the most profitable. Application of this technique has been hampered during the preceding years of the project because of incomplete survey coverage of critical areas and poor data comparability. It is believed that both of these problems will be effectively solved in 1981. The resource limit approach has not yet been implemented, although the wood depletion study (chapter 5, section 4, this report) is a step in this direction. The study by Schlanger and Kohler (chapter 5, section 3) suggests that systematic surface collection of "long uselife items" (e.g., bowl sherds, metates) might provide a valuable complement to the habitation approaches.

Population characteristics. The structure of inquiry in the domain presentation (Kane, Lipe et al. 1981:26) acknowledges that a large body of skeletal data is necessary to achieve acceptable levels of statistical significance.

The skeletal material data base after 3 years of excavation is grossly inadequate for statistical manipulation. Pursuant to DAP requests, A.L. Wiener has recently completed a study of the available material and has prepared an appendix to this report (appendix E). It is felt that she has succeeded admirably, considering the circumstances, and the reader is directed to her contribution for further substantive discussion in this area. It is recognized that this is a critically deficient portion of the program's data base and specific recovery strategies are planned during the remaining field seasons to alleviate the problem.

Domain 3: Social Organization

Domain 3, Social Organization, is a complex discussion as presented by Kane, Lipe et al. (1981:28). The presentation is organized according to four subdomains: social, economic, political, and ideological/ceremonial organization. Subdomain 1, Question 1a, is the foundation on which the remainder of the presentation rests, since it posits identification of residential groups and can be addressed directly from the archaeological record. Less progress has been made with the other questions and no formal studies have been initiated. The prime difficulty encountered in reconstruction of prehistoric economic, political, and ideological groups is the transition from archaeological data to group identification. Residence groups can be recognized by analyzing intrasite and intersite settlement patterns, but the economic, political, and ideological implications of residence groups are not known. Developing appropriate models from the anthropological and ethnographic literature is proving to be a difficult task, but progress is hoped for in this area during the coming year. The problems inherent in the study of social organization are also discussed by Phagan (appendix D), who presents a number of possible approaches using the lithic data set.

Dolores residence groups have not, as yet, been formally studied. Spatial correlates for these groups are defined in the DAP Spatial Series (Kane 1981a) and a summary of that discussion by spatial unit is included as pertinent to this report.

Household cluster. The household cluster is the space and facilities used by a household (those individuals who share meals and other domestic and economic activities). At Dolores, household clusters are defined as pithouses and associated exterior work areas during the Tres Bobos, Sagehill, Grass Mesa, and Marshview Subphases, and correspond to surface room suites during the Dos Casas, Periman, and Cline Subphases. The relationship between household and kin groups has not been formally assessed, but other archaeologists (Birkedal 1976; Rohn 1977) have suggested that a household is equivalent to a nuclear or extended family.

Interhousehold cluster. The term refers to spatially related groupings of household clusters identifiable in the archaeological record. Thus far, interhousehold clusters have been assigned on the basis of identification of contiguous household clusters in a roomblock sharing a "small" protokiva (refer to previous architecture discussion). The basis for this assignment is only applicable to the Dos Casas, Periman, and Cline Subphases, and there are no guidelines for assignment when studying dispersed communities. Again, the significance of an "interhousehold group" in terms of kinship or other social groups is uncertain.

Ward cluster. This unit has been added to the system since development of the original construct and has been applied to Periman Subphase villages. Briefly, it refers to spatially related interhousehold groups or, for the Periman villages, those sharing a roomblock (pueblo) and a "large" protokiva. The latter criterion is important, because some small roomblocks appear to be "annexes" to parent ward clusters.

Community cluster. According to Kane (1981a:25) this is the "space, facilities and architecture . . . used by a community." The DAP definition of community is based on the discussion by Murdock (1949:79) and includes three subtypes: (1) dispersed community clusters (termed "neighborhoods" and identified in the Dolores area during the Tres Bobos, Sagehill, and Marshview Subphases); (2) dispersed/aggregated communities (used in referring to Dos Casas communities); and (3) nucleated communities (termed villages and used in referring to Periman communities).

Maximum subsistence-settlement unit. This term is adopted from Struever (1969) and refers to the space which "includes all people integrated at one or more intervals in the functioning of a subsistence-settlement system." Flannery (1976:6) considers all of the villages in a single valley to constitute a maximum subsistence-settlement unit, and this practice has been followed in assigning all Periman Subphase villages (fig. 2) to the Escalante Settlement Unit.

In summary, little progress has been achieved in this domain. The first question has been informally addressed, but a formal study is needed to assess the social significance of residence units, and the units summarized in this report must be verified or modified through collection of a more adequate excavation sample. Appropriate models to address the remaining questions must be developed; this will depend on the final form of the modeling exercise currently underway (see discussion in chapter 2 and appendix F). Additional Track 1 excavation is needed at the McPhee and Grass Mesa villages to better understand the composition of residence groups and the social implications of small, large, and oversized pitstructures. Track 2 investigations should be conducted at other McPhee Phase settlements to establish spatial similarities or variability.

Domain 4: Extraregional Relationships

The presentation of extraregional relationships (Kane, Lipe et al. 1981:40) is similar to that for the other domains: the first question addresses identification and analysis of pertinent data and the succeeding questions use the first as a base for reconstructing the relevant system. Again, the preliminary data base needed to address the first question is available, but formal studies have not been accomplished. Two methods have been adopted in obtaining the requisite data base: first, through resource identification surveys materials and/or items which are local have been identified; hence, unrecognized items are assumed to be foreign (this is the general approach adopted thus far by the Lithics Task Group); second, through item, or "type," collections obtained from extrasector or extraregional areas, foreign items can be directly identified (this approach is employed by the Ceramics Task Group). Of course, some items (such as shell, obsidian, or turquoise) are de facto foreign materials. C. Phagan, the Reductive Technologies Task Specialist, is implementing an obsidian source study (appendix D) and this should provide the first formal report addressing Question 1.

Travis (report summarized in chapter 5, section 5) has addressed the higher level questions in the domain by employing analyses of ceramic attributes and ceramic raw material source studies to estimate the characteristics of Dolores exchange systems. Based on these analyses and studies, he has developed a model of Dolores exchange systems which incorporates three levels: first , a localized exchange network, or one that operated within the Escalante Sector and involved local kin groups; second, an intraregional exchange network operating within the Mesa Verde Region and characterized by redistribution of resources from ecologically diverse areas, sociopolitical alliances, and kin-based alliances; and third, an interregional network operating within the northern Southwest and potentially controlled by political, economic, or religious functionaries. Travis views the Dolores system as organizationally less complex than the later Chacoan network, but possessing characteristics similar to those of other Formative level exchange networks as described by Pires-Ferreira and Flannery (1976).

In summary, significant progress has been made in addressing this domain and several formal studies are in progress or in the planning stage. Future directions in approaching the domain will again depend on the ultimate result of the modeling exercise.

Domain 5: Cultural Process

The Domain 5 presentation (Kane, Lipe et al. 1981:44) is a diachronic perspective rather than the period-by-period approach adopted for Domains 1 through 4. The general structure, however, is similar to that of the others; that is, first the relevant data must be acquired and arrayed in a useful format, then models must be developed and test implications formulated to address the higher level questions.

A problem encountered by the DAP staff that necessitated preliminary studies was the unsuspected inadequacy of original program dating methods. It was assumed, before implementation of program operations, that tree-ring dating complemented by archaeomagnetic dating would constitute a basic analytical framework that would address most dating problems (Kane 1981a). This assumption has proven to be erroneous and indeed there are problems with both dating techniques (discussed in chapter 2). A number of studies have therefore been commissioned to alleviate these deficiencies:

1. *Pithouse seriation study*. This study was carried out in the spring of 1981 by N. Hewitt and A. Kane, and results were reported at the 1981 SAA (Society for American Archaeology) meeting (Hewitt et al. 1981). The temporal variability inherent in the architecture data base was employed in a seriational study with moderately successful results. Five pitstructure "types" were defined, each with a time span of 40 to 80 years.

2. *Archaeomagnetic calibration study*. This study was performed by J. Eighmy and H. Hathaway, and a draft report has been prepared (a summary is included in chapter 5, section 2). The object of the study was to refine the existing archaemagnetic pole curve to better reflect the Dolores data. To this end, corrected polar plots were obtained by calibrating archaeomagnetic samples with associated tree-ring dates. The implementation of the new curve is imminent.

3. *Ceramic seriation study*. This study was performed by E. Blinman and was reported at the 1981 SAA meeting (Blinman, [1981]; also refer to chapter 5, section 5, this report). Blinman employed temporally correlated attributes of neckbanded ceramic types (coil width and thickness) and independently derived dates to develop a regression curve. This has proved to be a promising approach with potential for a high degree of dating accuracy.

4. *Lithic task group studies*. C. Phagan has organized and implemented two studies that address the dating problem. The first was the development of a projectile point typology for the Dolores area; the resultant construct has temporal and functional implications. The second study addresses recognition of local Archaic site components through development of recognizable "profiles" in lithic artifact assemblages (chapter 5, section 6).

Question 1 of the domain deals with the identification and description of temporal variation. It is believed that the phase scheme and architecture presentations in this section and in the appendixes serve as a formal answer to this question.

As stated previously, Questions 3a and 3b are currently being addressed, and the end product will be used as a general model to approach the higher level questions in the Research Design, including the other questions (2, 4, and 5) in Domain 5. A pilot form of this model is included as appendix F.

In summary, the dating problem identified after the first seasons of fieldwork is on the verge of being solved. Much of Question 1 (establishment and description of temporal patterning) has been adequately addressed. Additional field data are needed to confirm impressions regarding the nature and direction of culture change in the A.D. 880-920 time span, especially at the large village complexes and in the southern portion of the sector. In addressing Question 3, a general model that will be used as a framework for future problem domain studies is being developed.

REGIONAL COMPARISONS

To place Dolores archaeology in a better regional perspective, comparisons have been made between the Dolores data base and other data bases within the Mesa Verde Region. In most data categories the comparison is restricted to Dolores and Mesa Verde National Park because of the relative lack of quantitative data relating to the relevant periods in other intraregional areas. A word of caution is appropriate at this point. There are many similarities between the Dolores and Mesa Verde cultural systems, especially when comparing architectural styles and ceramic and lithic artifacts. Indeed, many of these characteristics have been shown to be similar over the entire northern Southwest and are the basis for normative temporal classification schemes such as the Pecos Classification. Under no circumstances must assumptions of normality be extended to other data categories with a corresponding subjective determination of "redundant data." Such normative modes of thought impede the production of scientifically valid syntheses (Cordell and Plog 1979). The Dolores data base is regarded as a unique resource; it is a vital component in understanding the patterns and processes integral to the prehistoric cultures of the northern Southwest.

The regional comparison presentation which follows is organized according to DAP Research Design topics. A discussion of the pre-Pueblo and post-Pueblo periods has been omitted because of the inadequacies of the relevant data bases.

Economy and Adaptation

One serendipitous result of the placement of the Dolores Project was the opportunity afforded to study cultures on the northern periphery of the Anasazi culture area. The Escalante Sector is a frontier; therefore, the prehistoric inhabitants were probably faced with a unique adaptive situation with built-in advantages and disadvantages. A complicating factor is the Dolores River canyon itself, which constitutes one of the largest total acreages of riparian ecosystems in the Mesa Verde Region north of the San Juan River. Hence, the Dolores Anasazi had the advantage of easy access to several ecological systems, but were also faced with frontier-related problems such as marginal climate for agriculture (Kane 1981b; Shuster 1981a) and potential conflicts with non-Anasazi groups. Did the Anasazi subsistence system reflect these local environmental parameters, a natural setting obviously in contrast to Mesa Verde National Park (Erdman et al. 1969), the Montezuma Valley, and the Hovenweep area (Winter 1975)? The impression (necessarily subjective at this point, given the states of the data bases) is that to a certain extent it did, but that, generally speaking, the Dolores Anasazi employed the same subsistence strategy as their counterparts in the Mesa Verde Region; i.e., horticulture or agriculture with a primary emphasis on maize, beans, and squash. This similarity probably indicates that Dolores and Mesa Verde groups also shared local hunting strategies, or garden hunting (appendix B). The archaeological record at Dolores does indicate, however, that the local inhabitants apparently were exploiting boreal species to a greater extent than Mesa Verde communities. Benz (appendix B) lists elk, snowshoe hare, pine marten, and pygmy owl as either more frequent in the archaeological record at Dolores when compared to Mesa Verde (cf. Hayes and Lancaster 1975; Swannack 1969; Cattanach 1980) or present at Dolores and absent at Mesa Verde. Other demonstrable differences in patterns of faunal exploitation are noted in the archaeological record; for example, there are higher frequencies of grouse at Dolores and lower frequencies of turkey. Bison remains are present at Mesa Verde, but absent at Dolores; fish bones and beaver are fairly common at Dolores, but infrequent at Mesa Verde. This last difference suggests greater exploitation of riparian ecosystems at Dolores. Of course, the Mesa Verde groups would have to travel a greater distance to reach significant acreages of riparian environment.

The same pattern is noted when studying the use of wood resources: the archaeological record at Dolores demonstrates that the Dolores Anasazi were exploiting a variety of tree and brush species (Douglas-fir, ponderosa pine, pinyon pine, juniper, cottonwood, sagebrush, and willow are all common in the archaeological record from several different environments, including the boreal and riparian ecosystems). Cottonwood is notably absent from Mesa Verde (appendix B), again emphasizing the more restricted options available to Mesa Verdean peoples.

Ceramics and lithics. Both Phagan (appendix D) and Travis (chapter 5, section 5) emphasize the expedient strategy employed by the Dolores peoples when selecting raw materials used in tool manufacture. Phagan even suggests that the different proportions of lithic raw materials in the assemblages of McPhee Phase villages are the result of local access to suitable materials. There is no way of determining whether this local procurement strategy was employed by Mesa Verde Region groups, but it appears to be a logical assumption. Subjective comparisons of Mesa Verde and Dolores lithic and ceramic artifact types and styles indicate that they are very similar. A quantitative comparison was not attempted because the analytical approaches used by the program task groups are incompatible with those employed to investigate the Mesa Verde assemblages.

Pitstructures and surface room architecture. Architectural comparisons of Dolores and Mesa Verde structures (Birkedal 1976; Cattanach et al. 1980; Hayes and Lancaster 1975; Rohn 1971; Swannack 1969) suggest many similarities in the early part of the sequence, but many differences after A.D. 850. Pitstructures (there are no reported Mesa Verde surface structures available for comparison) in the two areas share many characteristics in the A.D. 600-700 period, and the pitstructure classification developed by Hewitt et al. (1981) can be applied to both data sets. Complex arrangements of surface rooms, plazas, and partitions like those described by Rohn (1975) and Wheat (1955) for the Yellow Jacket area are unknown at Dolores. Dolores pitstructures in the A.D. 700-750 period exhibit changes in formal characteristics (compare fig. 8, Pitstructures 1a and 1b), and surface living rooms are present before A.D. 760 (Yarnell 1981). Such changes are not reported at Mesa Verde, but this is believed to be the result of sampling error. Late eighth century and early-to-middle ninth century architectural characteristics (roomblocks of household suites and protokivas) appear similar in both areas and also in the Ackmen-Lowry area to the west (Martin et al. 1938). No large or oversized protokivas, as described earlier in this section, are reported at Mesa Verde, at least not at Badger House (Hayes and Lancaster 1975). This is an important distinction because of the implication of such structures for social organization. Some structures at Site 13, Alkali Ridge (e.g., Pithouse B, Brew [1946]), might represent the same type of phenomenon, although Pithouse B dates 80 to 100 years earlier than the Dolores structures. A "large" pithouse is present at Site 5MTUMR2347 in Mancos Canyon south of Mesa Verde (Gillespie 1976). After A.D. 880/900, the architectural forms at Dolores and Mesa Verde exhibit divergent patterns. A variety of forms were

employed by Dolores groups, including the "classic" masonry roomblock and kiva, albeit with varying degrees of skill and detail; e.g., compare construction details at Escalante Ruin with the Dominguez Ruin (Hallasi 1979; Reed 1979). Variability at Dolores is exhibited by the reintroduction of pithouses (at Grass Mesa Village and Marshview Hamlet) with mutable internal architecture and features. Surface structures assigned to the Grass Mesa and Marshview Subphases are constructed of jacal or adobe and apparently were not domiciles, but rather were used for storage or other limited functions; only a few examples are recorded for these periods. This is in contrast to the Mesa Verde data which seem to conform more to the classic pattern (Hayes and Lancaster 1975; Rohn 1971; Swannack 1969) of masonry roomblocks and kivas.

Intrasite and intersite patterning. Early Anasazi settlement patterns (A.D. 600-850) for the Dolores and Mesa Verde areas seem similar. The Dolores sequence of dispersal followed by aggregation is replicated at Wetherill Mesa, based on a comparison of the available data (Birkedal 1976; Hayes and Lancaster 1975). Seventh century aggregated settlements such as the Gilliland Site (Rohn 1975) in the Ackmen-Lowry area are unrecorded at Dolores and Wetherill Mesa, although Rohn (1977) suspects that they exist on Chapin Mesa. Intrasite patterns, including the appearance of surface room suites and protokivas, appear to be similar in the two areas.

After A.D. 850, there is evidence for settlement pattern divergence, although some of the suspected differences may be the result of sampling error. Figures 16 and 17 depict aggregated settlement plans for Alkali Ridge Site 13 (Brew 1946), the Badger House Community (Hayes and Lancaster 1975), Site 1 in the Ackmen-Lowry area (Martin et al. 1938), and Mancos Canyon sites (Farmer 1977). These can be compared with Dolores Periman Subphase village plans (figs. 13 and 14); it should be noted that the Alkali Ridge and Ackmen-Lowry villages date 80 to 100 years earlier than the Dolores, Mancos Canyon, and Wetherill Mesa examples. The roomblock aggregations for all areas exhibit many similarities. It appears that the Dolores villages exhibit more internal organization or regularity than the Badger House Community. The "crescent" or "horseshoe" plan of the major roomblocks at McPhee Village (and other contemporary villages in the Escalante Sector) is unduplicated at Badger House, but present at Mancos Canyon and the Ackmen-Lowry area; e.g., Martin's Site 2 (a detailed architectural plan of this site is unavailable). Other Pueblo I villages have been recorded at Mesa Verde (Rohn 1977; Smith[3]) and most seem to correspond to the pattern at Badger House; however, this is a subjective impression based only on survey data. Mesa Verde Pueblo I villages with more regular spatial organizations may be present at the Morfield and Prater Canyon complexes near the east boundary of the park,[3] but later prehistoric construction has rendered the ninth century pattern ambiguous. The total size of the McPhee Village itself seems unequaled in the Mesa Verde record. It is estimated that 120 to 150 total household clusters of 350 to 450 surface rooms are present at McPhee Village, while Rohn (1977:273) estimates 40 to 100 rooms for most contemporary Chapin Mesa settlements. Post-A.D. 900 settlement patterns at Dolores exhibit considerable variability (refer to Domain 1 discussion) and are in contrast with Mesa Verde. Aggregated or nucleated patterns have been recorded at Mesa Verde in the 11th, 12th, and 13th centuries (Lister 1966; Rohn 1977; Swannack 1969).

Demography

Population numbers and densities. Comparable absolute figures are difficult or almost impossible to obtain. Hayes (1964) records 147 sites on Wetherill Mesa (25.5 km^2 surveyed) during the La Plata and Piedra Phases which calculates to a site density of 5.76 sites/km^2 for the period A.D. 600-900. At Dolores, 96 sites have been recorded within the river valley for the Sagehen Phase and Periman Subphase; this yields a density of 5.11 sites/km^2. There are many problems with these figures including nature of momentary populations, site duration, number of habitation sites versus limited activity sites, consistency in site definition, etc. Therefore, perhaps it is better to summarize the data in a nonquantitative fashion. At Dolores, it has been demonstrated (Kane 1981b; appendix A, this report) that the Periman Subphase (A.D. 850-890/900) represents a population maximum. At Mesa Verde the population maximum is represented as the Piedra (A.D. 750-900) or Ackmen (A.D. 900-975) Phases (Hayes 1964; Smith[3]). Thus, subjectively, population trends appear to be similar in both areas until A.D. 900. After A.D. 900, of course, there was a population exodus in the Escalante Sector. There were probably no more than 25 to 50 people living in the river valley and adjacent lowlands at A.D. 1100; abandonment was complete by A.D. 1200. In contrast, at Wetherill Mesa, Hayes (1964:110) estimates 996 total rooms during the period A.D. 975 to 1050, 540 rooms between A.D. 1050 and 1150, and 1512 rooms between A.D. 1200 and 1300. Thus, there was a large population remaining at Mesa Verde after the abandonment at Dolores.

Population characteristics. Some demographic comparisons have been made by Wiener (appendix E); however, the Dolores data base is inadequate for statistical comparison.

Social Organization

Comparisons are difficult to make due to the problems discussed earlier. Residence units (pithouses and room suites, aggregated roomblocks) appear to be similar for the early sequence (A.D. 600-800) at Mesa Verde and Dolores,

[3]Jack E. Smith, National Park Service, personal communication.

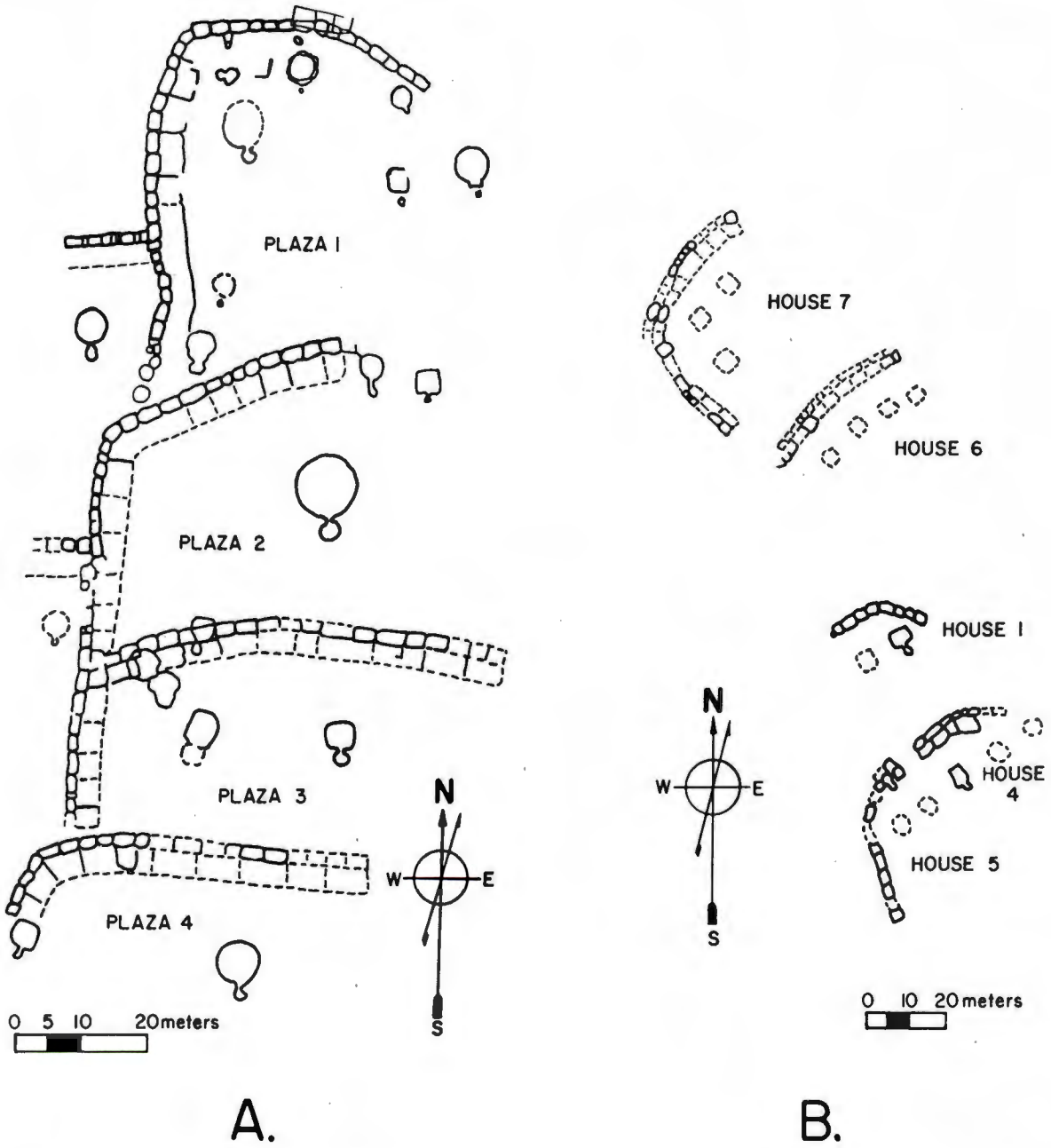


Figure 16. Anasazi village plans of southwestern Colorado: (A) Site 13, Alkali Ridge, A.D. 770 (adapted from Brew 1946); (B) The Badger House Community, Wetherill Mesa; Houses 6 and 7, A.D. 800; Houses 1, 4, and 5, A.D. 860 (adapted from Hayes and Lancaster 1975).

and the inference is made, therefore, that residence groups were very much alike. It is difficult to assess the implications of the apparent lack of Periman-type large and oversized protokivas at Wetherill Mesa. If the absence is real, and not the result of sampling error, then the social organization at Dolores was probably more complex. The more ordered intrasite settlement plans at Dolores may also constitute positive evidence for this assertion. After A.D. 900 the divergences in architecture, settlement patterns, and demography were almost certainly duplicated in social organizations.

Extraregional Relationships

Again, this is a difficult area to assess; it is speculative whether the models proposed by Travis (chapter 5, section 5) are applicable to Mesa Verde groups, although that is a logical assumption. It appears (although "hard" data is

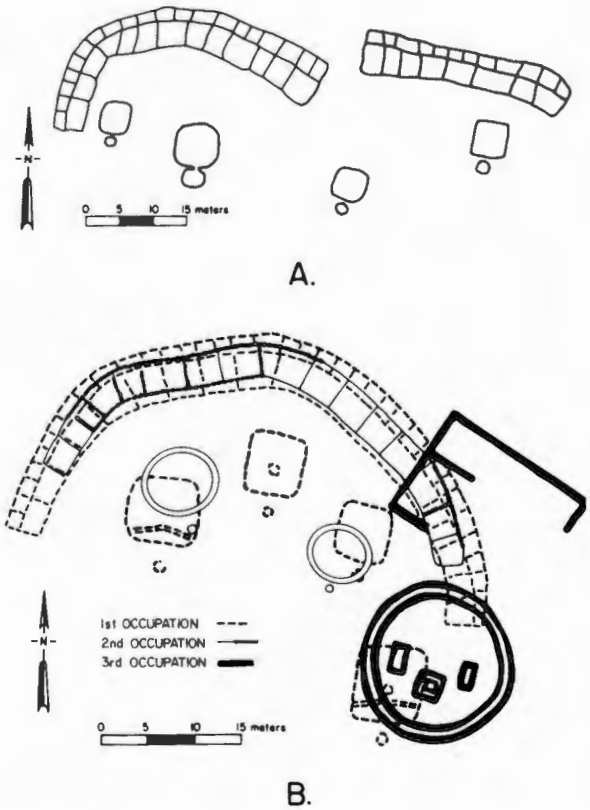


Figure 17. Anasazi village plans of southwestern Colorado: (A) Martin's Site 2, A.D. 750-770 (adapted from Martin and Rinaldo 1939); (B) Site 5MTUMR2350. Thick, solid line represents the latest component (A.D. 980), thin solid line is second component (A.D. 925?), dotted line is earliest component (A.D. 890)(adapted from Farmer 1977).

difficult to find) that contemporary Mesa Verde collections contain the same general classes of "obvious" trade items (obsidian, turquoise, shell) as do Dolores contexts and, therefore, that groups in the two areas may have participated in the same interregional network. Verification of the true parameters of the model requires source studies.

Culture Change

A period-by-period description has been presented according to components of the cultural system, and diachronic trends are implicit in the discussion. In general, the Dolores and Mesa Verde sequences seem similar until about A.D. 850. Comparison of settlement and architectural patterns in the span A.D. 850-900 can be interpreted as indicating a more complex society at Dolores, but sampling error is an unestimated factor in this determination. The patterns indicate sharp divergence after A.D. 900 and the Anasazi sequence at Dolores is 150 to 200 years shorter than at Mesa Verde. This last comparison leaves open a critical question: Why did the Dolores groups leave their settlements before the Mesa Verde groups? There are no positive answers, but it is suggested that the particular environmental parameters of the two areas may have been a contributing cause. The Escalante Sector (especially the river valley and eastern and northern uplands) is regarded as a marginal area for agriculture, especially in terms of growing season (Shuster 1981a). Euler et al. (1979) have proposed an interregional model of climatic cycles and suggest that some areas of the Southwest can be characterized as warm climate optimal areas (those favorable during warm climatic episodes) and some as cold climate optimal areas. It is speculated that Dolores is a "warm climate optimal area" and that a possible shift to cooler conditions about A.D. 900 (Euler et al. 1979; Petersen 1981a) resulted in unfavorable conditions and a population exodus. A cooler climate beginning about A.D. 900 would, of course, have affected the Mesa Verdeans as well, but they may have benefited from more favorable cold-air drainage patterns than the river-bottom Dolores cultivators. There are significant shifts in Mesa Verde settlement patterns around A.D. 900 (Hayes 1964). This is an oversimplified, unicausal view, but may have some merit. Appropriate multicausal models with test implications will be incorporated into modeling activities now underway.

Summary

The previous discussion has presented many similarities and differences between the Dolores, Mesa Verde, and other regional cultures. The salient points are these:

1. The catchment environments at Dolores and Mesa Verde exhibit significant differences. Dolores groups had convenient access to boreal and riparian ecosystems, an advantage not shared by the Mesa Verde Anasazi. Differential access is manifested in contrasting frequencies of certain exploited animal and plants species observable in the archaeological records in the two areas.

2. Both areas shared the same basic subsistence strategy: horticulture or agriculture with reliance on maize, beans, and squash. It cannot at this point be determined whether Dolores access to boreal and riparian environments resulted in a different "mix" of subsistence practices.

3. Dolores and Mesa Verde architectural and artifact forms exhibit close similarities until A.D. 900, when divergence is exhibited in architecture; the Dolores post-A.D. 900 artifact collections are inadequate for comparison.

4. Dolores and Mesa Verde settlement patterns exhibit considerable similarity until A.D. 850 and can be characterized as initially dispersed and then aggregated. Other areas within the region exhibit aggregated patterns while Dolores and Mesa Verde patterns are

dispersed. Post-A.D. 850 Dolores villages appear to exhibit more formal/spatial organization and a more complex architectural complement than Mesa Verde. After A.D. 900, Mesa Verde and Dolores settlement patterns exhibit divergence, a trend related to the partial and then complete abandonment of the Dolores area by A.D. 1200.

5. Absolute population numbers for the two areas are difficult to ascertain. A population maximum is demonstrated at Dolores between A.D. 850 and 900, while at Mesa Verde a maximum is evident at either A.D. 750-900 or A.D. 900-975. It is currently impossible to compare population characteristics due to inadequate sample sizes.

6. Comparisons of social organization and foreign relations for Mesa Verde and Dolores groups are difficult because of inadequate data. It is suggested that residence groups were similar in composition until A.D. 900. The differences identified in intrasite patterning for the period A.D. 850-900 suggest there may be differences in social organization as well.

7. Both areas were inhabited beginning about A.D. 600 by the Anasazi, and similar processes apparently operated in both areas until A.D. 850 or A.D. 900. After A.D. 900, there was considerable divergence. Environmental stress is proposed as one possible contributing factor in this phenomenon.

CHAPTER SUMMARY

In this chapter, three major areas of Dolores prehistory have been addressed: a temporal summary organized according to the DAP phase scheme, a summary of the Dolores cultural systems organized by Research Design problem domains, and a regional comparison. In the review of the phase scheme, the flexibility of the construct is emphasized; it was designed with the description of variability in mind. Different definitional criteria than those employed for the Pecos Classification and its derivatives have been adopted.

While the problem domain summaries point out several deficiencies in the program's data base, in general this base is adequate for most purposes and subsequent fieldwork programs will be designed to acquire the remaining critical basic data sets. All of the initial questions in each domain have been addressed but comprehensive statements have not been prepared. Further development of the remaining questions will be contingent on completion of the program's modeling activities.

The regional comparison addresses similarities and differences between the Dolores and Mesa Verde cultures, to the extent that such comparison can be made, considering the uneven quantities and quality of the data. Considerable variation in intersite and intrasite settlement patterns and population movements is exhibited within the Mesa Verde Region, and the Dolores data base is a vital component in explaining these patterns.

Chapter 4

HISTORIC STUDIES

Chapter 4

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By John Porter Bloom

BACKGROUND

The DAP Historic Studies Program has experienced several changes of direction since its inception. In every instance, to December 1980, the approach has been site oriented, following only a superficial use and appraisal of historic (archival, published, and "oral history") sources. That the results of this approach would be inadequate is suggested by a major conclusion of William H. Adams (1977:150) in his Silcott study: "Most aspects of the twentieth century are probably studied best by means of written documents, oral history, catalogs, and other means toward studying material culture." Almost all DAP historic sites are in or nearly in the 20th century.

Good preliminary work was done by Paul R. Nickens (1977). His use of historical sources was superficial and some of his data and conclusions were incorrect, but he used sources that were apparently overlooked by later investigators.

Pursuant to his general recommendations, a subcontract was negotiated with Centuries Research, Inc. of Montrose, Colorado, for historical studies in 1978-79 as a portion of the Dolores Project Cultural Resources Mitigation Program. The resulting reports were deemed unacceptable for a variety of reasons and it was determined to develop a DAP in-house capability in history. The staff persons hired for this work proved to lack experience and/or capacity and did not provide or maintain adequate records. They seemed to be unable to overcome their impulse to go out and survey and excavate, making judgments in the field which did not stand up well when exposed to historical data. The third startup by the DAP involved bringing in a more senior professional historian with a mixed background, including concern for material resources, to organize and conduct a first-class historic studies program. There was a presumption of its continuance parallel with the archaeological studies, with fieldwork possible through 1983, and final reports due no later than 1985.

The DAP Historic Studies Program, pushed by the urgent need implied in "cultural resource mitigation," and pulled by the ideal of producing authoritative, complete, insightful reports, was then designed to march on three legs: research in written sources, "oral history," and field investigation.

DAP HISTORIC STUDIES FRAMEWORK

The outline of the historic framework or research design was as follows:

I. Hispanic Beginnings
II. Indian Occupation and Relationships
III. Pioneer Euro-American Occupation
IV. Euro-American Occupation since 1920

An ideal program would provide ample time and resources for basic library and archival research, and at least a beginning in oral history, before going beyond the point of surveying in the field. The completed survey then would provide confirmation and elaboration of knowledge acquired through the other two steps, and probably new questions and problems for further work of all kinds. Only then would resources be applied to excavation which would result in confirmation and elaboration of knowledge and problems. The end result, after going back to archival and oral history sources as needed, would ideally be a definitive final product.

Because the history program was not fully rationalized until the winter of 1980-81, fieldwork has been undertaken to date as a tag-along with prehistoric surveying, on the one hand, and on a partially subjective basis for excavating on the other hand. Now priorities have been thought out in terms of the usefulness of all of the various resources in revealing the main cultural features of all groups who occupied the Dolores study area in historic and contact, or protohistoric times.

In terms of the DAP Research Design questions, the long-term focus was put on cultural process (Problem Domain 5). For the most part, the data called for in the preceding problem domains are obtainable by documentary and oral history research. Combining this data base with archaeological research will give the best possible explanations for

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III. Pioneer Euro-American Occupation
IV. Euro-American Occupation since 1920

An ideal program would provide ample time and resources for basic library and archival research, and at least a beginning in oral history, before going beyond the point of surveying in the field. The completed survey then would provide confirmation and elaboration of knowledge acquired through the other two steps, and probably new questions and problems for further work of all kinds. Only then would resources be applied to excavation which would result in confirmation and elaboration of knowledge and problems. The end result, after going back to archival and oral history sources as needed, would ideally be a definitive final product.

Because the history program was not fully rationalized until the winter of 1980-81, fieldwork has been undertaken to date as a tag-along with prehistoric surveying, on the one hand, and on a partially subjective basis for excavating on the other hand. Now priorities have been thought out in terms of the usefulness of all of the various resources in revealing the main cultural features of all groups who occupied the Dolores study area in historic and contact, or protohistoric times.

In terms of the DAP Research Design questions, the long-term focus was put on cultural process (Problem Domain 5). For the most part, the data called for in the preceding problem domains are obtainable by documentary and oral history research. Combining this data base with archaeological research will give the best possible explanations for

the variations of DAP data over time, for patterns of cultural stability and change, for population growth, movement and decline, and so forth.

The plan for FY1981 called for concentrating efforts in all activities of research and fieldwork, with about 50 percent of this effort being directed toward Category III, about 30 percent toward Category IV, and about 10 percent each toward Categories I and II. There is so much overlapping between Categories III and IV that the allocation of effort has been purely arbitrary and may be unrealistic. There is no problem about significance, however, because the population load and cultural changes have clearly been greatest during the Euro-American occupation as compared to the first two categories.

Categories I and II were downgraded largely because it was felt that the likelihood of encountering sites falling primarily in either category was small. Sites, their careful evaluation and possible preservation as a matter of paper and film record, are the first and obvious focus of efforts in cultural resource mitigation. The "downgrading" of the first two categories in the historical framework follows this consideration and does not reflect any lack of interest in contact and contemporary Indian and Hispanic peoples. It is true also that full historic research in these two categories would require a relatively large amount of money for travel. The intent was not to ignore them entirely, of course. They contribute to the understanding of Categories III and IV, and must be addressed in future work plans.

SUMMARY OF SITES BY CATEGORIES

Of sites currently recorded, the following 19 pertain to Category IV, "Euro-American Occupation since 1920": Sites 5MT4561, 5MT4563, 5MT4677, 5MT5059, 5MT5060 5MT5061, 5MT5063, 5MT5065, 5MT5066, 5MT5079, 5MT5081, 5MT5161, 5MT5162, 5MT5166, 5MT5170, 5MT5172, 5MT5176, 5MT5178, and 5MT5179. Of major interest in this group are the CCC (Civilian Conservation Corps) Camp (Site 5MT5066) and the Bean Canyon Ranch (Site 5MT5081).

The following 41 recorded sites overlap Categories IV and III (Pioneer Euro-American Occupation). Those marked by an asterisk* offer remains in Category IV, but there is also evidence in documentation and/or oral history to indicate pre-1920 occupation which has not been tested by archaeology: Sites 5MT4560, 5MT4562, 5MT4564, 5MT4565, 5MT4566, 5MT4567, 5MT4568, 5MT4569, 5MT4570*, 5MT4571*,5MT4572, 5MT5057*, 5MT5058*, 5MT5062, 5MT5064, 5MT5067*,5MT5068*, 5MT5069, 5MT5070*, 5MT5071, 5MT5072, 5MT5073, 5MT5074, 5MT5075, 5MT5076, 5MT5077, 5MT5078, 5MT5080, 5MT5163, 5MT5164, 5MT5165, 5MT5167*, 5MT5168*, 5MT5169, 5MT5171*, 5MT5173*, 5MT5174*, 5MT5175, 5MT5177, 5MT5180*, 5MT5181. Of major interest in this group are the Periman Place (Site 5MT4566), McPhee (Site 5MT4571), Big Bend (Site 5MT4572), Ritter Place (Site 5MT5163), Dickenson Homestead (Site 5MT5165), and the Montezuma Valley Tunnel and Canal System (Site 5MT5181) (fig. 18).

There is no site identified solely with Category III.

For Category II, "Indian Occupation and Relationships," there are indications from archaeological surveys of Ute or Navajo utilization of Sites 5MT4563 and 5MT5161 (overlapping with Category IV) and Site 5MT4564 (overlapping with Categories III and IV). Site 5MT5380 and Site 5MT5399 are two strong indications of Category II. It is strongly felt that, with further research, more (and more substantial) evidence of Indians working and residing in the study area may be found.

There are no recorded sites for Category I, "Hispanic Beginnings," a period which is arbitrarily cut off at the end of the 19th century for present purposes. The text makes it clear, however, that there are important Hispanic components in sites listed under Categories III and IV, including the Lucero Place (Site 5MT4567) and McPhee (Site 5MT4571).

CULTURAL SYNOPSIS

The DAP historic framework has four main categories, as noted previously:

I. Hispanic Beginnings
II. Indian Occupation and Relationships
III. Pioneer Euro-American Occupation
IV. Euro-American Occupation since 1920

Each category has a structure that has been shaped largely by certain events which must be considered in any cultural or comprehensive history of Spanish-speaking peoples in this area. The most significant of these historic events include the following (Chavez and Warner 1976; O'Rourke 1980):

1. The earliest expeditions in the area; these include the 1761-1766 Rivera expedition and the 1776 Dominguez-Escalante Expediton.
2. The United States conquest of New Mexico in 1846.
3. The Ute-settler conflicts of the 1880's.
4. The introduction of cattle to the area in 1879.
5. The coming of the railroad to the area in 1891.
6. The introduction of irrigation in the late 1800's.
7. The establishment in 1924 of the lumber town of McPhee.

The expeditions signified the developing concern by Spanish colonial administrators about existing, presumably growing, relationships between New Mexico settlers and the Ute Indians. The administrative stance was restrictive,

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Figure 18. General view of Big Bend, Site 5MT4572 (DAP 034824).

so that trade and other relationships were informal and extralegal, even illegal, and hence difficult or impossible to document. There will be little to report here by way of documented history, and probably nothing in terms of specific sites.

The 1846 conquest of New Mexico operated to remove the previous restrictiveness and to open the area to new categories of observers such as fur traders, prospectors, official explorers, and scientists, including archaeologists, who were possible documentary sources. However, even if Hispanic settlers were moving closer to the Dolores River, they were clearly not occupying it on a permanent basis. It is well documented that the Southern Utes exhibited considerable intermixture, including intermarriage, with Hispanics during this period. Clearly they ranged through the Dolores Valley (especially Big Bend) in this period, pursuing trade, horse herds, and perhaps other herds, but leaving no clearly defined sites. With the advent of cattle in Euro-American ownership in the late 1870's, and the railroad soon after, it is evident that Spanish-speaking people came in numbers and settled permanently. Most were probably employees of "Yankee" settlers and or of the railroad. Not until the 1920's are Hispanic names found on the list of original land patentees. But it is known that squatting was common, that many persons settled but never patented their land, and that some persons may have occupied land belonging to others, so that it is realistic to anticipate a possibility of Hispanic-related sites pertaining to this period. Finally, there was the influx of Spanish-speaking millworkers who occupied what was referred to at the time as "Mexican Town" in McPhee. No one as yet has accomplished a study of life in McPhee. Little remained for archaeological retrieval and analysis, which has been completed in McPhee, but in fact, numerous structures were removed from there to other areas, including Dolores, and remain for further study and analysis. This investigation will produce, in considerable measure, a study in acculturation. It seems to a casual observer of the 1980's scene that forces including education and intermarriage have now produced a culture in which all elements of the earlier Hispanic life have been almost entirely submerged. Where, for the earliest periods, one might hope for culturally distinctive sites, even though very few of them, one has a much larger number of 20th century sites; however, the ethnic distinctiveness of the latter is relatively low.

It has been found that there is less to go on in regard to Indian occupation and relationships, and much that is

known is bound up with points touched on in the previous paragraphs. Utes and Navajos seem not to have found employment to a significant extent in the lumbering industry or on the railroad, and they did not homestead in the DAP area. Probably the only 20th century site category where they are represented is in that of the shepherd's camp (fig. 19). Indians employed to tend herds moved with the animals on a seasonal basis, and winter pastures were situated in the DAP area. The shepherds often camped at a given site year after year, for (winter) months at a time, and often there were associated features, such as sweat lodges (fig. 20), which are culturally diagnostic. Students of this subject will have to place considerable reliance ultimately, in Categories I and II, upon oral history.

Turning to Categories III and IV, Euro-Americans pre- and post-1920, there is an amplitude of written sources plus oral history, as well as much source material from both below- and aboveground archaeology (bridges provide an example of aboveground historic source material, as seen in figs. 21 and 22). Discussion of a cultural system can have reality here, tied to the DAP study area, but again it hinges to some extent upon particular events. These were: (1) the coming of the railroad to Dolores in 1891; (2) the point when motor vehicles came into general use, about 1920; (3) the creation of McPhee in 1924, revolutionizing of the local lumber industry (late 1920's, early 1930's); and then (4) the failure of McPhee at about the end of World War II.

Public lands in and near the Big Bend of the Dolores River valley were surveyed and opened for homesteading in the latter 1870's but, for lack of transportation, the only practical cash crop had to be one which could transport itself to market: beef cattle (fig. 23). Such farming as was done was largely on a subsistence basis, with a limited sale of grain, etc., possible at nearby mining centers such as Rico. There is some evidence of area farmers, in the longstanding tradition of the American farming pioneer, turning their grain into whiskey, in which form the cost of transportation to market could be overcome and a profit realized. Not much evidence of this business has yet been acquired, however, and no sites are anticipated to illustrate it.

A disproportionate amount of attention has been given by amateur historians, writers, and chroniclers in general to a few incidents in the early pioneer period involving conflict with Indians. Almost every account of an incident in 1881 relates the killing of three cattlemen by Indians in an area west of the Dolores River near the Utah border. DAP research has produced authoritative evidence that only two were killed. The matter has been of special concern to DAP because the two were reportedly given "cowboy burials" in the pool area, although the exact location of the site has never been established. How a third man, named Smith, escaped death in 1881 is also not fully explained in accounts found thus far, but he is known to have been alive at a later date.

Figure 19. Shepherd's wagon on Site 5MT5069 (DAP 020832).

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Figure 20. Sweat lodge, Isolated Find 34 (DAP 026615).

Figure 21. Footbridge at the Lucero Place, Site 5MT4570, about 1942 (DAP 006207).

Figure 22. Stone bridge at Site 5MT5179, about 1937 (USFS photograph; DAP 034703).

Figure 23. Beef cattle in the Dolores River valley (DAP 001904).

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The Utes had legal authority in the 1880's to leave their reservation to hunt. Government rations and Ute farm produce were so inadequate that they had to do so for their own survival. In their hunting (and perhaps other) trips, they often begged food at ranch homes and allegedly killed cattle. Of course some settlers were more alarmed and annoyed than others. Tempers flared against a small group of Utes camped near the mouth of Beaver Creek in June 1885. Six were reported to have been killed, including two children, in a surprise dawn attack by "cowboys." One Indian woman somehow escaped, however, and the settlers over a wide area were fearful of Ute retaliation — and not without reason — for at least one settler was killed soon after in an attack on his home, midway between Cortez and Mancos. The site of the "cowboy massacre" was in an area early and very heavily torn up by dam construction work and was never precisely located, much less excavated, for lack of timely research. Of course, there was never an assurance that it could have been so located. DAP research in military records has shown that the military did respond from Fort Lewis many times in the 1880's to protect the settlers — but not without realization of the typical overreaction syndrome of the Euro-American newcomers and some sympathy for the plight of the often inoffensive Ute and Navajo. After 1890, there was almost no further troublemaking between settlers and Indians in the DAP study area.

The earliest permanent settlers were, in any event, primarily cattle ranchers rather than farmers. Usage of the term has been remarkably persistent, so that even today farmers (who may own no livestock at all) are usually called ranchers. The coming of the railroad in 1891 and mechanized farm equipment (fig. 24) enlarged the scope of ranching activities substantially and also made it possible to market some farm products competitively on a regional, if not national, basis. New cash crops came into being before long, especially apples and pinto beans. Population expanded notably and apparently became more stable. Many DAP sites illustrate this pioneering period, before and especially after the railroad arrived. The completion in 1888 of the irrigation tunnel delivering Dolores River water into the McElmo Creek watershed (and in the 1890's to the town of Cortez) made possible Montezuma Valley's development and the growth of a cultural (economic, political, social) focus or community enveloping the Big Bend plus the Montezuma Valley and the grasslands reaching toward Dove Creek. The point bears emphasizing to a casual visitor or even a resident of the 1980's: in the pioneer period the town of Dolores with its railroad was much more important than Cortez or any other area town, and the DAP portion of the Dolores River valley was much more the focus of regional life than it is now. Documentary sources prove this abundantly, reinforced by evidence derived and expected to be derived from DAP sites.

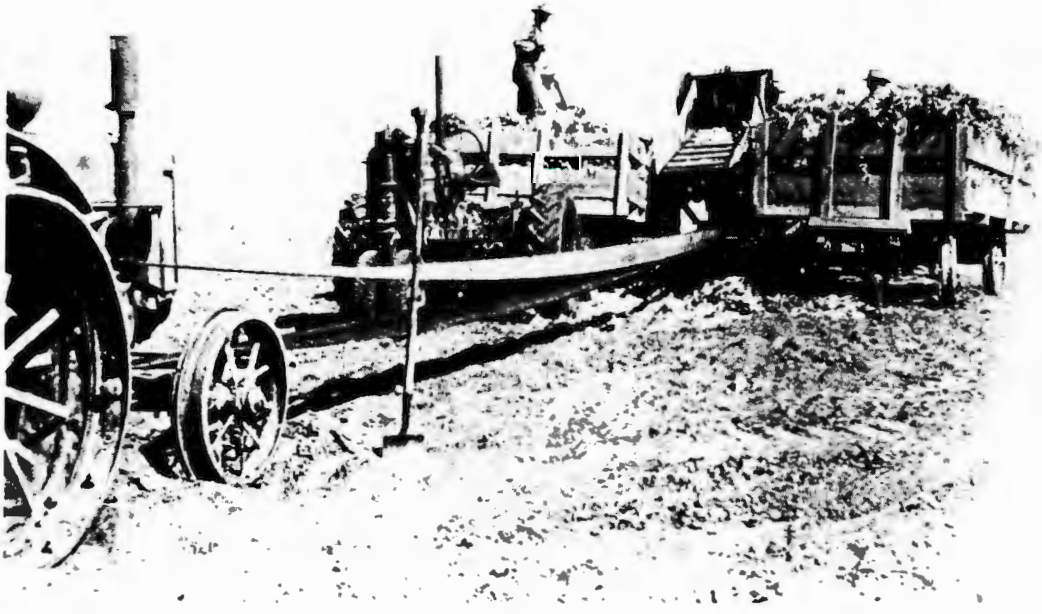

Figure 24. Thresher/tractor hookup (DAP 050924).

The internal-combustion engine marked the transition from the pioneer to the contemporary period. The given transitional date (1920) is arbitrary and somewhat tentative, being selected to indicate the point after which motorcars, trucks, buses, and tractors became common enough to make a significant difference in the everyday life of a majority of residents. There is no question of the change having occurred. DAP studies have been planned to determine the phases of its development, the status of changes in given periods, and the varied cultural ramifications reflecting the spreading uses of electricity, telephones, radio, refrigeration, etc. Documentary sources and oral history will be extremely important in this research, along with site archaeology.

Analysis of the sites that have been surveyed and (in a few cases) excavated to date shows that, as one would expect, the choice valley locations were selected first by settlers and have exhibited great continuity (Categories III and IV of the historical framework) in being occupied and productive through the years. William M. May's homestead (Site 5MT4572) provided the focus for the first town of Dolores — the name fixed on it by the U.S. Post Office, while common usage was "Big Bend." In this immediate neighborhood, believed possibly to include some elements of 1870's-1880's structures, is the Ritter Place (Site 5MT5163). Still occupied by residents of some years' standing, this site has been only partially examined but not excavated. It was a "model farm" earlier in the present century and is still visually impressive for its number and variety of structures (figs. 25 and 26). Research by the DAP in U.S. Post Office records at the National Archives has established the date of appointment of the first Dolores Postmaster (W. May, on 5 April 1878) and the locations of three Dolores post offices up to 1896, after the coming of the railroad in 1891 and the establishment of the present town of Dolores. Greatly conflicting statements on these events can be found in conventional published materials.

Culturally significant sites which reveal a notable continuity are also found down the valley from Big Bend: Periman Place (Site 5MT4566; figs. 27 and 28) and Calvin House Homestead or Cline House (Site 5MT5078). When McPhee was established (Site 5MT4571), it maintained the continuity of occupation, though drastically altering the components of one of the earliest homesteads, whose most noted owner had been "Racehorse" Charlie Johnson. His 14-room adobe house and the stables and appurtenances (fig. 29) where he cared for his thoroughbreds, were entirely obliterated.

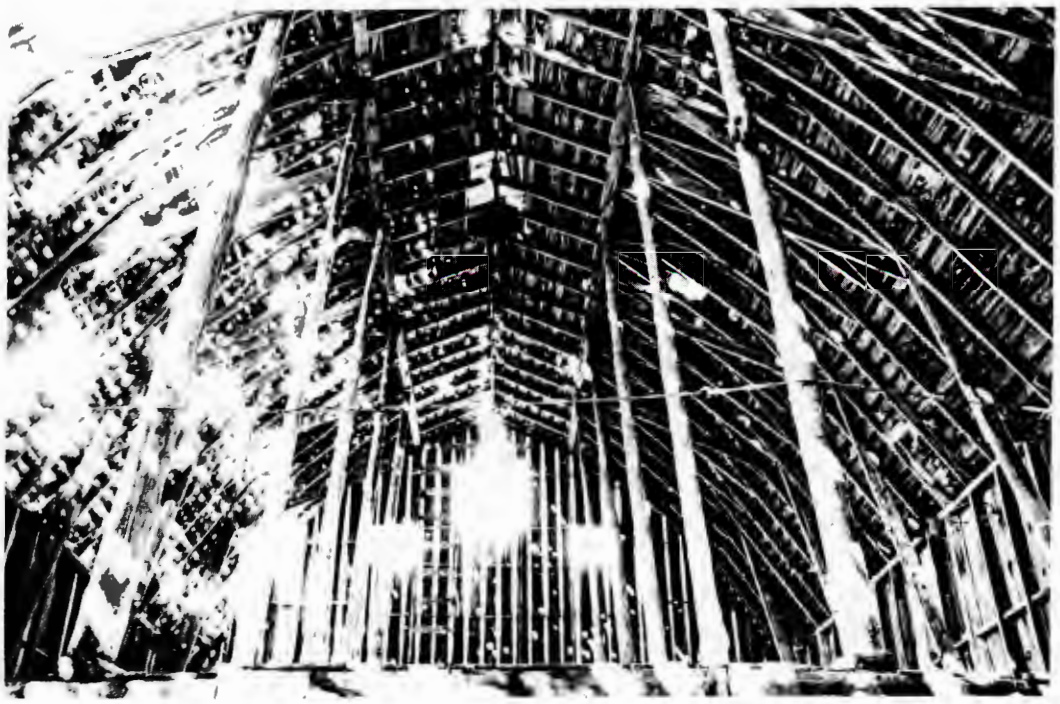

Figure 25. The Ritter Place: barn and roof construction, Site 5MT5164 (DAP 064008).

Figure 26. The Ritter Place: milking stalls, Site 5MT5164 (DAP 064011).

Figure 27. The Periman Place: concrete block construction of 1908, Site 5MT4566 (DAP 029932).

Figure 28. The Periman Place, Site 5MT4566, about 1895 (DAP 029931).

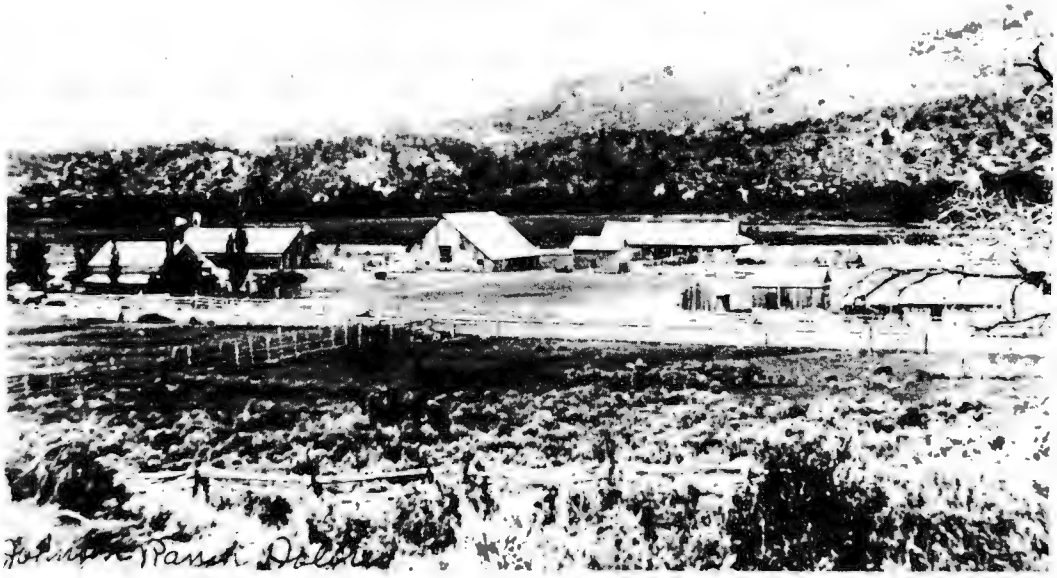

Figure 29. Photograph of the Charles Johnson Ranch (Site 5MT4571, later the location of McPhee), about 1890 (DAP 034925).

McPhee is reputed to have been the largest, most important lumber mill town in Colorado (figs. 30 and 31). It represented the culmination of the genius of several generations of McPhees and their associates in lumbering and milling, wholesale and retail, in Colorado and New Mexico. McPhee's establishment and its failures (under original and later managements) provide an interesting and significant "special case" for DAP history. It may be noted that the McPhee operators made a great investment in rail service with the construction of about 41 miles of a logging railroad of their own to bring logs to their mill. This was done precisely at the time when it is held that motor transportation was attacking the railroad's viability. It has been stated[1] that it was, in fact, a major economic error by the McPhee-McGinnity company to stick with railroading too long, a factor contributing to its failure.

A possibly significant relationship needs to be explored between McPhee and the nearby CCC (Civilian Conservation Corps) Camp (U.S. Forest Service, No. 53-C) in the Depression years. This was reportedly one of Colorado's longest-lived CCC camps, and a start has been made on documenting its administration through government records. During the winter of 1980-81, an apparent dump site was located and excavation of it has been planned. There is reportedly a substantial photographic record of the camp and its activities (figs. 32 and 33), including aerials; and oral history should be possible to obtain with very useful results. Because the site of the camp itself is not in the pool area (though it is close, and of course some CCC works were in the pool area), it has not been given high priority in DAP research to date.

The important relationships of McPhee and the CCC Camp with the existing and always changing ranching-farming life in the DAP study area, are an important topic for research in the cultural resources mitigation program. Various forms of cliometric analysis need to be explored, involving tax structure, vital statistics records of all kinds, utilities extension and consumption (telephone, electricity, water, and perhaps other utilities), employment, social service, and other government-related functions.

The result, if amply researched and thoughtfully interpreted, including, of course, selective site analysis and

[1]J. P. Bloom, conversation with Robert D. McPhee, Denver, 11 March 1981.

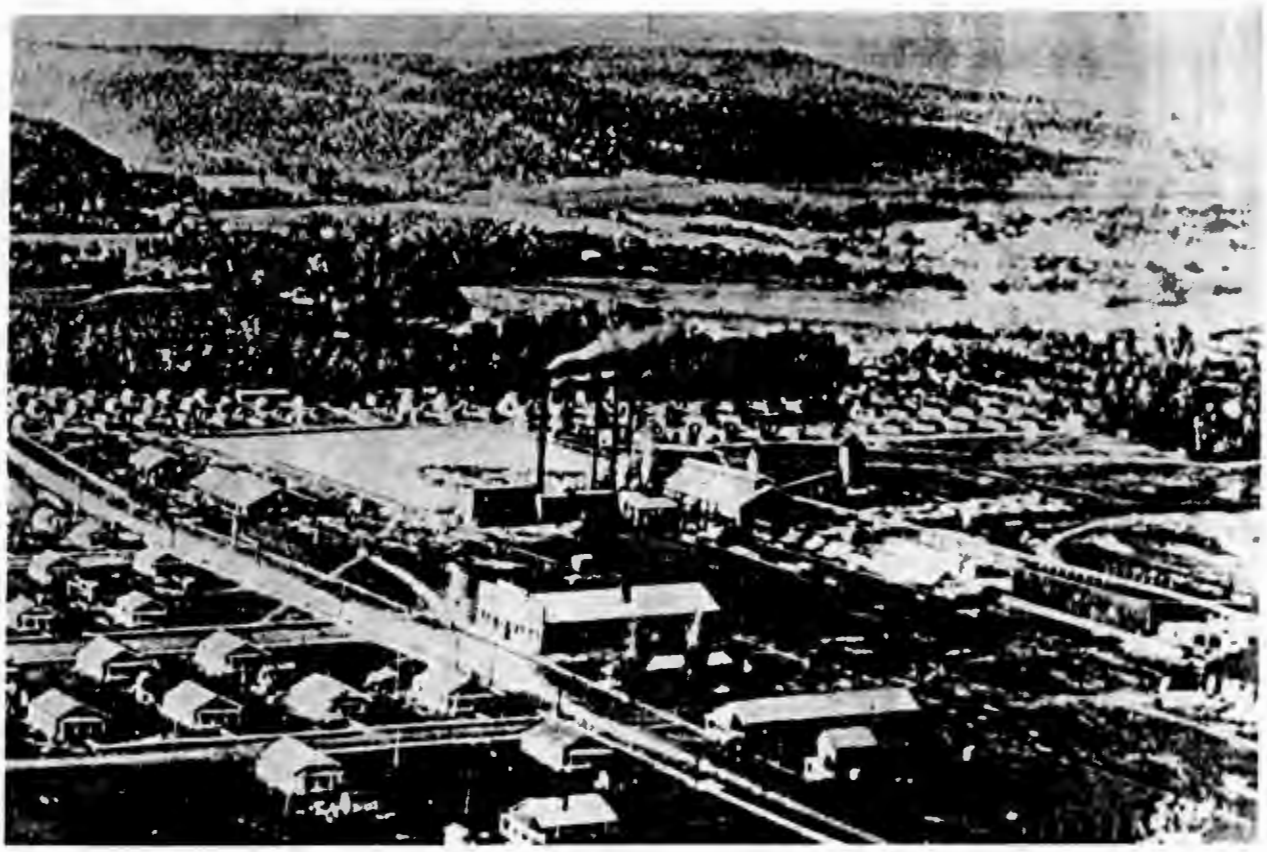

Figure 30. Photograph of McPhee mill town (Site 5MT4571) during the height of operations (DAP 004820).

excavation, will be a uniquely valuable report or series of reports, for they will provide rare insight into the transition from pioneer to modern culture of a specific area — an area, a milieu, scarcely touched to date in historical and/or scientific analysis and interpretations. The area has some claims to special distinction, but not of transcendent importance in the national or international context. The contemplated and possible reporting will have few points of comparison, however, in terms of contributing to the understanding of regional development.

Figure 31. McPhee Church (Site 5MT4571), which was moved to Dove Creek and now stands as St. Jude's Catholic Church (DAP 059703).

Figure 32. CCC Camp, Site 5MT5066 (USFS photograph; DAP 034723).

Figure 33. Boxing at the CCC Camp, Site 5MT5066 (USFS photograph; DAP 034630).

Chapter 5

INTERIM ANALYTICAL RESULTS

Chapter 5

INTERIM ANALYTICAL RESULTS

Contributing authors:

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Section 1
INTRODUCTION TO INTERIM ANALYTICAL STUDIES

by Christine K. Robinson

The following papers are a representative sample of intensive and synthetic studies completed or in progress by the DAP (Dolores Archaeological Program). The studies reported in this section fall under the general headings of sampling, population, paleoenvironment, ceramics, lithics, and activity area investigations. Some of these studies are designed to address or model parts of Problem Domains 1 through 4 beyond the first basic questions. Others, particularly the sampling studies, address Question 1 of Problem Domain 5.

Among the sampling papers, Kohler and Gross report on the probability sampling program. Probability sampling contributes to the DAP paleodemographic data base within the framework of Question 1 of Problem Domain 5. Hathaway and Eighmy report on the progress of the DAP archaeomagnetic dating program. This program has the potential to add substantially to DAP's ability to gain temporal control over the prehistory of the project area; more substantive results should become available over the summer of 1981. Burns, Huggins, and Weymouth present a paper on the correlation of subsurface magnetic anomalies with prehistoric cultural features. This program has a very practical aspect, since it is used as part of Class III inventory procedures and as a tool for planning excavation strategies. It also has implications for paleodemographic investigations as specified in the Research Design.

The paper by Schlanger and Kohler focuses specifically on Problem Domain 2 of the Research Design. Their study is a time-rate approach to the reconstruction of the size and distribution of prehistoric population.

Two papers are presented which deal with paleoenvironmental models critical to Problem Domain 1 (Economy and Adaptation) of the Research Design. Bye and Shuster present a model for contemporary and archaeological agricultural subsistence which has been developed from the DAP comparative gardens. Kohler and others present a preliminary model for wood resource depletion as part of DAP paleoenvironmental investigations.

With respect to ceramic studies, Travis presents a preliminary model of inter- and intraregional exchange in the DAP area to address Problem Domain 4. Blinman provides preliminary results of the neckbanded ceramic dating study to address Question 1 of Problem Domain 5.

Lithic studies are represented by three papers. Phagan and Vierra discuss the results of the projectile point study which has a variety of implications for Problem Domains 1, 3, 4, and 5. Phagan's lithic profile paper is an assessment of the preliminary analysis system in terms of the DAP excavated temporal/function site matrix. Orth and Phagan present a preliminary model formulation for nonflaked lithic tools and food processing activities; this paper is also related to the other activity area papers which follow.

The last four papers in this section are a series of activity area studies which serve as investigations into the nature and interpretability of DAP activity areas (a critical concept for reconstruction of prehistoric subsistence systems). Montgomery provides an overview of the general concept. C. Breternitz focuses on temporal and functional variability among Dolores activity areas. Southward discusses the Southwestern ethnographic resource base and its contribution to the study of DAP food processing activity areas. Finally, Matthews presents the results of analysis of bulk soil samples as they relate to food processing activity areas.

Section 2

SAMPLING INVESTIGATIONS

by Patricia K. Burns, Jeffrey L. Eighmy, G. Timothy Gross, J. Holly Hathaway, Robert Huggins, Timothy A. Kohler, John Weymouth

PROBABILITY SAMPLING IN EXCAVATION: A PROGRAM REVIEW

by Timothy A. Kohler and G. Timothy Gross

INTRODUCTION

A probabilistic sampling approach to site excavation was set forth in the 1978 DAP Research Design Proposal that was submitted by the University of Colorado and accepted by the Bureau of Reclamation. In particular, it was proposed that at a representative sample of sites chosen for intensive investigation, the initial stage of work should involve excavating a sample of 2- by 2-m test pits. A random sample of such pits was to be chosen for small sites, while a stratified, systematic, unalined design was to be used on the larger sites. In keeping with the Research Design's emphasis on obtaining evidence of domestic activities and of past demography, the sampling rate was to be sufficient to determine the rate of occurrence of household units, and sampling units that encountered architectural features were to be expanded if it appeared that these features represented habitations or activity areas.

During the first season's fieldwork, it became clear that judgmental sampling would play a larger role in site excavation than had initially been proposed, because (1) the location of main domestic habitation areas was often clear from surface evidence of architectural features, and (2) time and money constraints of a data recovery mitigation program required that work concentrate on the highest priority information and that this information be obtained as economically as possible. Furthermore, the standardization of artifact and ecofact collection techniques originally envisioned for the site sampling program was forced to give way to more variable means (including use of heavy equipment where appropriate) to reach occupation surfaces where the best evidence of domestic activities was expected to be found.

Although it was clear that an extensive probability sampling design could not be carried out at every site, the DAP Senior Staff felt that many of the advantages of this type of sampling for the program as a whole could be retained by implementing a smaller sampling program at a few sites, in conjunction with the judgmentally selected excavations guided by researchdes ign priorities. Consequently, early in the 1979 field season, the present PSP (Probability Sampling Program) was begun. This is a minimal sampling program that seeks to obtain at least a 1-percent sample, by area, of selected sites (or, in the case of large sites of each designated major site area division). The sample does not generally exceed 5 percent of the site unless this is required to obtain a minimally acceptable number of squares per site or site stratum. From each sampling square, all fill is screened and all artifacts are collected.

The goals of the present Probability Sampling Program are as follows:

1. Calibration. The PSP is designed to provide a baseline against which sites excavated by judgmental sampling can be compared. This comparison determines the degree to which judgmental sampling, often without screening, results in artifact collections which are biased in comparison with collections derived using probabilistic sampling and standard collection techniques.

2. Estimation. The PSP is also designed to provide samples of materials which can be used to estimate the true totals, proportions, and ratios of the various material types at the sampled sites. These estimates, when compared with independently derived data on the occupation history for these sites, may be used to test the assumption that there is a high correlation between the person-years for which a site was occupied and the accumulation of materials at the site.

3. Inference. Because inferential statistics are used in analysis and synthesis, the PSP is expected to provide a sample of sites of various ages and functions with collections resembling, as closely as feasible, the simple random sample collections assumed by nearly all statistical inferential procedures. These collections also allow estimates to be made of the degree to which materials typically cluster across sites, and the seriousness of the "design effect" for DAP cluster samples.

The purpose of this review is to examine how well these goals are being met by the program and to consider whether the DAP's needs have changed since the implementation of the program 2 years ago.

EXTENT OF THE PROGRAM

During the 1978, 1979, and 1980 field seasons, DAP personnel examined 62 sites at Track 2 or greater intensity. Of these, 17 (27 percent) have been partially or completely sampled using PSP procedures. Of the 21,527 field provenience unit (field specimen, or FS) numbers assigned to excavated or bladed sites since the beginning of DAP, 1452 (6.7 percent) are part of the PSP. Considering only the 16 sites at which the PSP has been implemented since the start of the 1979 field season, the PSP proveniences account for

13.9 percent of the 10,481 FS numbers assigned at those sites.

Table 6 summarizes the chronological and functional distribution of the sites in the PSP for which sampling results are available, and includes an estimate of the crew-weeks spent at each site on the PSP. Based on numbers of sites sampled, numbers of FS's assigned in the PSP, and crew-weeks needed to excavate the samples, the PSP appears to have taken up a relatively small portion of the total excavation effort to date. Nevertheless, the PSP is quite time consuming in its demands of the data processing system and on the report writers, considerations not reflected in these statistics.

IS THE SAMPLE WORKING FOR ESTIMATION?

In theory there are two ways to evaluate how "good" an estimate is. The first method is to evaluate the accuracy of the estimate based on the sample; that is, how close is the estimate of the population parameter (for example, number of sherds at the site) to the true population parameter? In practice, of course, the true population parameter is rarely known. Even at sites where there is total excavation of features and structures, field procedures are not (nor should they be) oriented toward collection of all the cultural materials in the site.

The other approach to evaluating the worth of an estimate is to evaluate the precision of the estimate. Precision is different from accuracy in that it reflects how variable the population parameter estimate would be under conditions of repeated sampling. While it is not possible to know, in an absolute sense, how close the estimates are to the true population parameter, it is possible to quantify how variable the population estimate would be under conditions of repeated sampling. Several ways to evaluate precision appear in the archaeological literature.

Here the ratio of the population parameter estimate to the CI (confidence interval) around that estimate is used. If an estimate ($\hat{X}$) of, say, 10 000 g of ceramics at a site is obtained from the PSP, and the CI around that estimate is 10 000 g, it should be intuitively obvious that the estimate is not very precise (the ratio of the two quantities is 1.0). If the population total estimate is 10,000 and the CI is 5,000, the estimate is somewhat more precise, and the ratio takes on a value of 2.0. Tables 7 and 8 display the ratio $\hat{X}$/CI for all the PSP sites for which that information is presently available. An estimate in which the CI is larger in magnitude than the $\hat{X}$ is unsatisfactory; the ratio for these estimates is less than 1.0. A ratio of between 1.0 and 2.0 is regarded as satisfactory, although less precise than would be desired. A ratio of greater than 2.0 is regarded as good and should be the goal of the program.

Table 6. Probability sampling program site inventory

Site No.	Site name	Major phase or subphase	Functional designation*	Season sampled	Sample complete?	Sample proportion	*n* of squares in sample	crew-weeks[1] to excavate PSP
23	Grass Mesa	Periman	village	1979-80	no[2]	0.01	36[2]	2.9[2]
2161	Prince Hamlet	Periman	lrg. hamlet	1979-80	yes	0.05	10	1.8
2182	Rio Vista	Periman	village	1980	no[3]	0.04[4]	32[5]	6.4
2192	Pheasant View	Dos Casas	sm. hamlet	1979	yes	0.09	23	0.7
2194	Casa Bodega	Sagehill	sm. hamlet	1979	yes	0.03	20	0.7
2199	Horse Bone	Archaic/ McPhee	?/limited act.	1979	yes	0.17	20	0.6
2215	Sundance	Sundial	?/limited act. (never occupied)	1980	yes	0.05	12	1.0
2854	Aldea Sierritas	Sagehill(?)	sm. hamlet	1979	yes	0.02	20	1.0
4614	Prairie Dog	Sagehill	sm. hamlet	1979	yes	0.08	35	0.9
4650	Hanging Rock	Periman	lrg. hamlet	1980	yes	0.07	13	5.0
4681	Hawk House	Anasazi-Ind.	?/seasonal	1979	yes	0.07	6	0.2
4789	Quasimodo Cave	Sundial	limited act.	1980	yes (within shelter)	0.50	4	0.8

[1]Based on rough estimates by crew chiefs.
[2]Based on Areas 1-5, and 7 where PSP was completed in 1979 and 1980.
Sampling in Area 2 was begun in 1980 but is not complete; partial results are included in following tables. PSP in Areas 6 and 8 has not yet begun.
[3]Area 1 complete; Areas 2 and 3 more than half complete.
[4]Average across 3 areas.
[5]Areas 1 and 3 only.
*lrg. - large; sm. - small; limited act. - limited activity site
Ind. - Indeterminate

Table 7. Precision of the estimates: flaked lithic items

		Debitage				Tools			
		Count		Weight		Count		Weight	
Site No.	Type of Sample	$\hat{X}$[1]/CI[2]	No. Elem*	$\hat{X}$/CI	No. Elem.	$\hat{X}$/CI	No. Elem.	$\hat{X}$/CI	No. Elem.
5MT23	stratified cluster	2.74	20 462.00	2.49	99 310.00	2.21	1 132.25	2.17	86 546.25
(Areas 1-5, and 7 only)									
5MT2161	stratified cluster	0.83	3 491.75	0.75	31 398.08	0.95	135.00	0.78	11 226.75
5MT2182	simple cluster	1.19	3 332.00	1.46	24 203.00	1.33	169.00	1.30	19 604.00
(Area 1 only)									
5MT2192	stratified cluster	1.71	52.25	1.49	404.75	1.42	6.00	0.93	319.75
5MT2194	simple cluster	1.94	85.25	1.60	278.50	1.36	7.50	1.04	692.50
5MT2199	simple cluster	2.09	732.00	1.79	651.25	2.01	33.75	1.33	322.00
5MT2215	stratified cluster	1.14	94.00	0.68	483.50	0.79	7.00	0.50	1 917.25
5MT2854	simple cluster	1.94	436.25	1.60	2 823.00	1.36	54.75	1.04	1 686.50
5MT4614	simple cluster	2.37	661.50	2.11	4 059.25	2.25	59.50	2.05	2 651.75
5MT4650	stratified cluster	0.96	2 523.00	1.17	16 844.00	1.32	187.50	1.38	16 942.25
5MT4681	simple cluster	4.63	245.25	1.46	338.50	0.99	4.00	0.59	85.75
5MT4789	simple cluster	0.77	192.00	0.61	1 565.00	0.72	10.00	0.81	504.00
	Mean	1.70	1 203.02	1.30	6 676.03	1.30	70.80	1.04	4 610.06
	Standard deviation	1.09	1 693.13	0.98	9 962.67	0.46	94.67	0.41	6 614.73

*Number of elements in sample; in this case, counts and weights (g) of debitage or flaked lithic tools.
[1]$\hat{X}$: Estimated population total.
[2]CI: Confidence interval.

Table 8. Precision of the estimates: nonflaked lithic tools and ceramics

		Nonflaked lithic tools				Ceramics			
		Count		Weight		Count		Weight	
Site No.	Type of Sample	$\hat{X}$[1]/CI[2]	No. Elem*	$\hat{X}$/CI	No. Elem.	$\hat{X}$/CI	No. Elem.	$\hat{X}$/CI	No. Elem.
5MT23	stratified cluster	2.17	255.50	1.82	457 274.25	2.57	31 081.75	2.27	199 014.42
(Areas 1-5, and 7 only)									
5MT2161	stratified cluster	1.04	97.50	0.96	67 693.50	0.79	10 489.25	0.73	56 487.04
5MT2182	simple cluster	1.45	72.00	1.02	63 723.00	1.32	6 394.00	1.14	40 978.80
5MT2192	stratified cluster	1.71	4.50	1.49	1 839.00	2.47	52.50	1.98	253.70
5MT2194	simple cluster	0.67	1.50	0.69	37.50	2.05	142.50	1.91	552.55
5MT2199	simple cluster	—	0.00	—	0.00	0.53	1.00	0.53	2.00
5MT2215	stratified cluster	0.74	3.00	0.64	1 549.50	0.46	1.00	0.46	2.00
5MT2854	simple cluster	1.08	2.50	0.92	768.25	1.81	617.75	1.78	2 326.27
5MT4614	simple cluster	1.47	8.25	1.40	2 178.00	2.59	890.50	2.59	2 584.70
5MT4650	stratified cluster	1.35	29.25	7.20	108 158.00	1.11	4 890.25	1.91	31 853.07
5MT4681	simple cluster	0.51	2.75	0.51	3 042.00	—	0.00	—	0.0
5MT4789	simple cluster	0.44	1.00	0.44	402.00	0.44	6.00	0.44	47.4
	Mean	1.12	18.98	1.54	23 178.14	1.37	2 186.01	1.38	11 711.56
	Standard deviation	0.51	30.04	1.92	38 300.29	0.79	3 496.12	0.74	19 329.59

*Number of elements in sample; in this case, counts and weights (g) of nonflaked lithic tools or ceramics.
[1]$\hat{X}$: Estimated population total.
[2]CI: Confidence interval.

DO THE COLLECTIONS FROM PROBABILITY SAMPLING AND JUDGMENTAL SAMPLING DIFFER?

One argument in favor of the probability sampling design has been that judgmental collections are not representative of total site content. If this is true, then it might be expected that there would be some differences between the probability sampling collections and those from the judgmental collections. There are many ways in which such differences could be examined. One plausible contention is that in judgmental, nonscreened excavations, small, unobtrusive objects might be less likely to be collected than larger or aesthetically appealing objects. Is there any evidence for this effect in the present data base? Somewhat surprisingly, there is only a small difference in the percentage of decorated sherds in the probability samples (4.1 percent) and in the other samples (5.5 percent) from all sites. In flaked lithic tools, one might expect that relatively inconspicuous utilized flakes would be retrieved less often in judgmental than in PSP samples. Indeed, this appears to be the case. In sites with probability samples, the PSP collections contain 26.7 percent utilized flakes (as a percentage of all flaked lithic tools), while other collections from all sites contain only 19.5 percent utilized flakes. (These differences are highly significant when the large sample sizes on which they are based are taken into account.) Relatively inconspicuous items — even those with high labor input — may be passed over in unscreened samples. Thin bifaces and projectile points together constitute 8.3 percent of the flaked lithic tools in the probability samples, but only 4.8 percent of the other samples from all sites, so that these collections differ by a factor of nearly 2 on these items. What about the average size of flaked lithic tools from the two contexts? In the judgmental sample, the mean weight for the flaked lithic implements is 57.4 g; in the PSP, exactly the same. In the ceramics data base, however, the mean sherd weight in the judgmental sample is 8.5 g, while that from the PSP is 6.3 g. The faunal data base was not available for study, but potentially this size effect might result in a different perception of the total species composition of an archaeofauna, depending on which sampling procedure was used. Based on the experience of the other data bases, small animals are very likely to be underrepresented at judgmentally sampled sites.

It might be contended that these are arguments for screening, not for probability sampling. This is of course true. However, screening is one of the most time-consuming portions of the probability sample. If the DAP is going to take the time to screen selected samples to control for these effects, it might be unwise not to spend slightly longer to obtain samples which can also be used for estimation and statistical inference.

ARE ESTIMATES OF MATERIAL POPULATION TOTALS NECESSARY?

The amount of materials at a site is not one of the traditional concerns of archaeology, although no one thinks it unnatural to be concerned with, say, the number of structures at a site. This position is perhaps justified, since there are few studies providing evidence that this information can be used constructively.

However, there are a number of methodological and culture-historical studies which such data make possible, particularly questions of site formation processes. If, for example, it can be shown that total site (material) content is highly correlated with the length of time that a site was occupied, and/or the number of people who lived there, then estimates of material populations can be used to estimate the number of person-years at a site. Moreover, there is considerable reason to believe that some kinds of materials accumulate more rapidly at sites than do other kinds of materials. If this effect is to be studied, such studies must be based on true estimates of population proportions and ratios for these material types. Finally, the sample from which these estimates are derived have considerable potential for revealing unsuspected functional variability within and between sites.

Table 9 presents the data available thus far which address the question of the relationship between material population estimates and person-years at sites. The sample is at present very small. Crew chiefs of sites where the PSP had been used, and where more extensive excavation was undertaken, were asked to estimate the number of person-years of occupation represented at their sites. These estimates were based on guesses, absolute dates when available, and a constant figure of five people per pithouse.

Table 9. Human population indicators and artifact population estimates at five sites

Site No.	Habitation area (m^2)	Person-years	Population total estimates FLD	FLT	NFLT	CER
5MT2161	143.0	2000	72 754	2981	1969	220 768
5MT2215	48.6	5	2 107	167	72	24
5MT2854	48.0	390	24 866	3121	143	35 212
5MT4650	245.0	1125	32 099	2214	324	59 854
5MT4789	0.0	2	384	20	2	12

Table 10 shows the correlations (r) between person-years, square meters of habitation, and each of the four population total estimates based on the PSP:

Even given the small sample sizes and the imperfect methods for estimating person-years used by the crew

chiefs, these correlations are too large to be ignored. Note that the correlations between person-years and material type totals are much higher than between square meters of habitation space and material totals. Whereas, momentary population may be correlated with floor area of habitation, accumulations of material are correlated with both momentary population and length of occupation. It also appears that some materials track person-years better than others: FLD (debitage) and CER (ceramics) are the best; NFL (nonflaked lithics) are next, while FLT (flaked lithic tools) are the least dependable. Could these effects be due to curation behavior? The lifespans of the artifacts? The possibility that in some sites more flaked lithic tools are being lost offsite than any other material category? Without a probability sample we could not ask and pursue these questions, because we would have no evidence for the different correlations of material types with person-years in the first place.

Table 10. Correlations *(r)* between human population indicators and artifact population estimates at five sites

	FLD	FLT	NFLT	CER
Person-years	0.98	0.71	0.91	0.96
Habitation area (m^2)	0.59	0.51	0.40	0.48

ADDITIONAL COMMENTS AND RECOMMENDATIONS

Probability sampling is not helpful to the crew chief writing a descriptive report. It may be important in guaranteeing a certain basic level of control over, and comparability among, the material collections from DAP sites. If material collections are to be used to characterize sites at any time in the future, this is an important consideration. It is not an important consideraton if the major, or only, cross-site comparisons deal with architectural and site-layout variables.

Crew chief labor required by the PSP, if it is continued, might be decreased by not requiring crew chiefs to report material populations in descriptive fieldwork reports. The usefulness of such estimates cannot be appreciated from the perspective of a single site.

The precision of the PSP for estimation can be improved in two ways: more accurate sample stratification to increase the intrastratum homogeneity of the estimated variables, and a larger minimum number of squares. If the PSP is continued, attention should be paid especially to the first of these methods for improving precision. Unfortunately, strata which are homogeneous on one variable may not be so on another; it is impossible to devise a sampling scheme which is optimal for all variables. In future probability sampling, attention should be paid to optimizing the precision of estimation for those variables which will be of maximum interest in addressing the test implications suggested by the DAP-specific models now being developed.

THE ARCHAEOMAGNETIC DATING PROGRAM

by J. Holly Hathaway and Jeffrey L. Eighmy

INTRODUCTION

The Colorado State University archaeomagnetism research group has continued to provide the DAP with archaeomagnetic dates from archaeological samples by reference of sample properties to a standard Southwestern curve of past magnetic polar positions. In addition, the group has in recent months undertaken two projects designed to improve the quality of archaeomagnetic dates furnished to the DAP.

The first of these projects uses DAP data to reexamine the calibration with time of approximately the A.D. 600-1000 portion of the Southwest master curve (DuBois 1975). This portion of the curve had previously been only weakly supported by data points derived from independently dated archaeomagnetic samples. As a consequence of this study, it should be possible to improve the accuracy and reliability of archaeomagnetic dates furnished to the DAP, both in the future, and with regard to samples derived from the 1978-80 field seasons.

The second project involves experimental firing of 12 simulated hearth features, with controlled variation of sediment matrix and temperature. The object of this study is to improve understanding of which types of sediment and which portions of features yield the strongest and most reliable thermoremanent magnetic information, so that field sampling can be made more efficient and effective.

EVALUATION OF THE A.D. 600-1000 PORTION OF THE SOUTHWEST MASTER CURVE

During the past three field seasons, archaeomagnetic samples have been recovered from 31 prehistoric sites in the Dolores Project area. Approximately 40 percent of the samples were from media (hearths, pits, and walls) with remanent magnetisms that consistently produce sample directions with alpha 95 values of less than 2.6, although approximately 65 percent of the samples collected yielded dates. Dating information of comparable precision from independent sources was available for most of the features or structures which produced these samples. A total of 36 samples from 13 sites covering the period of interest was selected as most applicable to the study. The independent dating estimates for the samples were the best approximations of the last prehistoric use of the sampling medium,

based on occupation period of the site and specific reconstruction of the use history of the structures and features sampled. The confidence interval (which ranges from ± 10 to ± 30 years) for each estimate is based on the precision of the dating methods used to arrive at the estimate. Most of the estimates were backed up by dendrochronological dates, but temporal correlations of ceramic and architectural types, stratigraphy, and other methods were used as well.

Each sample consisted of 12 separate 2.5-cm^3 (1-in^3) specimens that had been collected in the field. The natural remanent magnetism of each specimen was measured in the Colorado State University laboratory; specimens were considered "outliers" and excluded from characterization of the sample if they lay more than three angular deviations away from the mean of the remaining specimen set. It was felt that omitting outliers would result in better representation of the true thermoremanent magnetic directon created by the ancient firing.

The results of the above measurements of the Dolores samples indicated that the Dolores data were somewhat different from the Southwest curve described by Wolfman (1979) for the time period of interest. When the Dolores data are compared with the DuBois curve for the Southwest (Weaver 1967), similarities are apparent at two points, but there are also deviations. Compared with the Dolores refinement, the earlier of these (Wolfman 1979) is characterized by a difference in both declination and inclination at approximately A.D. 775-800 and A.D. 865-890, while in the latter (Weaver 1967) there are differences in inclination at approximately A.D. 850-880. Although the Dolores data conform better to the DuBois curve than to the Wolfman curve, some modifications of both are indicated.

The archaeology of the Dolores region is providing one of the better contexts in Southwestern archaeology for temporal control of archaeomagnetic samples. The result is a broadened data base from which to document and refine current estimates of the secular variation in paleopolar position in the Southwest. This should result in better archaeomagnetic dates not only for the Dolores sites, but for other Southwestern sites falling in the latter half of the first millenium A.D.

HEARTH-FIRING RESULTS

Twelve features were constructed to resemble prehistoric hearths. They were placed in several different areas of the Dolores Project to ensure that a geographic range of typical sediment matrices would be represented. Sediment samples taken in advance indicated that significant variation in clay, silt, and sand proportions was also represented. It was predicted that quantities of ferromagnetic particles would be greatest in clay and least in sand. It was therefore expected that thermoremanent magnetization would be greatest in sediments having the highest proportions of clay. If this prediction could be verified, then the proportion of clay in a prehistoric hearth matrix could be used as an indicator of the probability of a good dating context, and hence as a factor in decisions about whether to sample a particular hearth.

Fires were built in the constructed features and were monitored for temperature intensity and duration. Temperature gradients from bottom to rim of hearth were measured, as were gradients from rim surface to several centimeters into the matrix. It was expected that these measurements would provide a better understanding of the effects of varying intensities and durations of fire on typical sediments of the Dolores Project area and would also provide indications of which portions of features achieved the highest thermoremanent magnetization. The latter information would help make field sampling more effective.

Four of the hearths were intensely burned, while the remaining eight reached maximum temperatures (between 400 and 450 °C) below that of the Curie temperatures of ferromagnetic minerals. Temperature gradients from the outside of the upper rim to points in the sediment matrix tended to drop approximately 150 to 200 °C/cm; depths greater than 2 cm were not measured. These data indicate that the rim of the hearth is the best place for archaeomagnetic sampling, and that the thermoremanent magnetism is likely to be confined to the outermost 1 to 2 cm of the sample.

Sediment analysis conducted at the Colorado State University soils laboratory indicated that the postfiring soils displayed considerable variation in sand-silt-clay proportions. Samples from the same part of the project area resembled one another more than they did samples from different areas. The total ferric content percentage was high for samples with very high clay proportions, but did not necessarily drop proportionately with a decline in clay percentage. Some hearths with a high sand content in the sediment matrix contained as much ferrous material as other hearths with medium clay and silt proportions. Microscopic analysis of ferric minerals is planned to determine what type of minerals are occurring in post- and prefiring soils, and whether a chemical alteration is taking place during firing at certain hearths. Chemical alteration can be an important factor in that it can cause remanent magnetization at temperatures below Curie temperatures. Magnetization thus maintained is reflective of the first firing occurrence, not later ones (unless these attain temperatures of 570 to 670 °C). There is growing evidence that temperatures this hot are generally not being attained in the central hearths of pitstructures. Thus, we may be measuring magnetization attained during the original alteration of the ferromagnetic minerals, probably during the first burning of the hearth. In such instances, a structure

might actually not be abandoned until 10 to 20 years after the date indicated by the archaeomagnetic samples from the hearth.

Five of the twelve samples — two from one DAP locality and three from another — have been measured on the magnetometer and their alpha 95, magnetic direction, and magnetic intensity determined. One hearth from each locality was heated above Curie temperature; in both cases, intensity values were higher and alpha 95 values lower (better) for these samples than for the other sample(s) from the same locality which were heated to lower temperatures. However, the intensity value of one of the high temperature samples, from a predominantly sandy matrix, was 10 times greater than the intensity values of the other high-temperature hearth, which had a clayey matrix but was from a different locality. This relationship is the opposite of the one expected. It implies that sediments of low clay content may be sufficient for recording remanent magnetization, and that those of high clay content may need to be fired at higher temperatures to obtain results similar to the ones from the sandier situations. Alternately, there may be sufficient variation in ferric mineral content from locality to locality to override, in some cases, the tendency for finer grained sediments to have better archaeomagnetic success.

Two samples from each of four localities were fired at low temperatures for 3-hour increments, one hearth from each locality on one firing occasion and one hearth on five separate occasions. The repeatedly fired hearths showed slightly greater intensity values and lower alpha 95 values than did their single-fired locality counterparts. This indicates that additional low temperature firings may improve the remanent magnetization attained.

CONCLUSION

Questions raised and results achieved by the archaeomagnetic analyses reported above will be further explored as the remaining samples are studied. Although it does not appear that all results are as predicted, it is clear that the study will produce information useful both in field sampling and in interpretation of results achieved from archaeomagnetic analysis.

CORRELATION OF MAGNETIC ANOMALIES WITH SUBSURFACE CULTURAL FEATURES

by Patricia K. Burns, Robert Huggins, and John Weymouth

INTRODUCTION

In September 1978, a magnetic reconnaissance program was initiated for the DAP. The magnetic program was continued throughout the 1979 field season, by which time 26 selected prehistoric sites had been magnetically surveyed. The raw data obtained by these surveys was sent to the NEBCAR (Nebraska Center for Archaeophysical Research) to be analyzed by Rob Huggins under the direction of Dr. John Weymouth.

Magnetic surveying is an aid to locating subsurface features and is therefore capable of indicating the presence of specific, buried archaeological features such as subterranean domiciles and hearths. The magnetic survey may also indicate site boundaries and outline the overall occupation pattern of a site. These results of magnetic survey can help archaeologists design efficient sampling strategies for excavation. Furthermore, if sound correlations between particular kinds of magnetic anomalies and particular kinds of buried cultural features can be established, magnetic survey can serve as an information-gathering tool in its own right, in complement to excavation and archaeological survey techniques.

Detecting the location of the subsurface archaeological features involves using a proton magnetometer to measure the earth's magnetic field over a grid of 1-m points on the surface of the site. Marked variations or "anomalies" in the earth's field, caused by differences in the concentration, composition, and orientation of iron oxides in the soil are plotted using a variety of graphic displays, primarily SYMAP (computer-generated maps) and line contour maps. Figure 34 presents an example of a SYMAP for one DAP site. On the basis of their geometry and intensity, some of these anomalies can be shown to be caused by archaeological features and their location exactly determined. Where possible, additional comments describing the composition and geometry of the feature are made (Huggins and Weymouth 1979, 1980). Since anomalies in the earth's magnetic field can also be caused by geologic contributions or by recent and historic disturbances, and since adjacent cultural features may produce ambiguous responses to the observer, a degree of uncertainty occurs in the assessment of each anomaly and in some cases no cultural features are located.

In response to these uncertainties, the magnetometer reconnaissance group developed a priority scale, numbered from 1 (high) to 10 (low), for assessing confidence that a given magnetic anomaly in fact indicated the presence of a buried cutural feature. Hence, each mapped anomaly could be assigned a priority rating based on its magnetic characteristics and on the experience of the magnetometer group in recognizing the magnetic "signatures" of cultural features. This priority system lacked systematic empirical verification, however.

This report will assess the present magnetic reconnaissance program of NEBCAR in locating subsurface cultural features on the DAP and will give a quantitative estimate of the success and failure by comparing the results of the

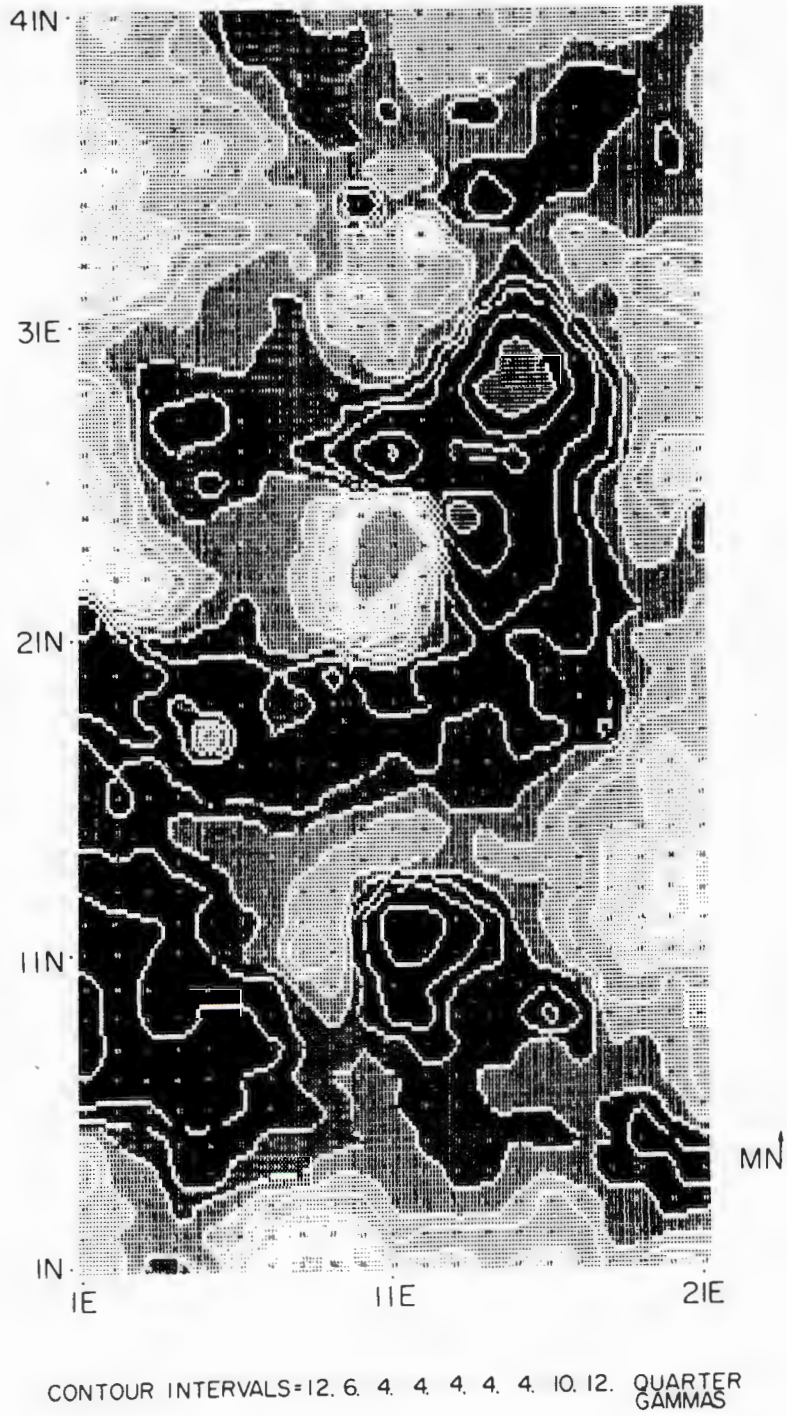


Figure 34. SYMAP depicting the magnetic field at Site 5MT2858.

1978-79 magnetic analysis (Huggins and Weymouth 1979, 1980), with the 1978-79 excavation results provided by DAP. The study will further examine what additional information may be gained from the magnetic data and will establish where refined field and computing techniques can be used to improve the resolution of magnetic methods to reveal additional information to aid in establishing archaeologcal sarnpling strategies.

This report summarizes three major types of evaluation. First, the results of assessment of the existing priority system and of the accuracy of preexcavation characterizations of cultural sources of the priority-ranked anomalies will be reviewed. The data for this section are drawn from the magnetic interpretations of NEBCAR (Huggins and Weymouth 1979, 1980), and the archaeological feature information provided by DAP.

Second, the practicality of using computer-assisted filtering to improve the detection of cultural features will be examined. The data base involves cultural features located during archaeological excavations (information provided by DAP) and image enhancement of the original magnetic data gathered by NEBCAR. Finally, attempts to determine what additional information can be inferred about the interiors of pitstructures from their associated anomalies will be summarized. In this part of the study, profiles of the magnetic anomalies of features drawn from the original magnetic information and assisted by computer-simulated models of how an idealized pitstructure might appear are compared with associated cultural features identified by archaeological operations. The data base is composed of cultural feature information provided by DAP, the original magnetic data provided by NEBCAR, and specifically for the modeling studies, magnetic susceptibility data taken from Pitstructure 2 of Site 5MT2193.

ASSESSMENT OF THE EXISTING MAGNETIC PROGRAM

After the magnetic data had been received, processed, and interpreted by NEBCAR, test squares were selected by NEBCAR to locate the source of these anomalies and were given priority numbers in accordance with a presumed likelihood of encountering cultural sources. The test squares were set out over the anomalies and numbered, with "1" indicating the area with the highest probability of locating an archaeological feature. Although the archaeologists often took magnetometer data into account in decisions of where to excavate, this was not their only criterion.

Through comparision with results of the 1978-79 excavations, the preexcavation interpretations derived from magnetic mapping were assessed for the following:

- accuracy in locating archaeological features
- accuracy in describing the source
- utility or practicality of the priority system

Assesment of the Priority System

With the anomalies numbered according to the expectation of locating a cultural source, it would be expected that correct location of anomalies would decrease as the priority numbers proceed toward 10. This is precisely what occurred (table 11). Priority 1 correctly located 23 cultural sources out of 27 tested anomalies. This was followed by a sharp decrease in correct location of cultural sources for Priority 2, with only 9 of 34 anomalies correctly identifying an archaeological source. Accuracy decreases markedly after Priority 2.

The priority scheme functions well as an indicator of the likelihood of encountering archaeological features and reflects the initial experimental ideology of the magnetic reconnaissance. Anomalies with lower priorities are basically caused by unknown or indistinct sources and are likely to be due to geological contributions to the field. Since areas having geological anomaly sources have now been tested, the likelihood of selecting these anomalies as archaeologically interesting is substantially reduced, leaving room for a generally increased success rate in all priorities.

Description Accuracy

In addition to assigning priority numbers to anomalies of interest, the magnetometer team also recorded descriptions

Table 11. Comparison of magnetic test areas containing cultural sources to those with noncultural sources or areas not tested

	Test square priority										
	1	2	3	4	5	6	7	8	9	10	Total
Total with cultural sources	23	9	1	4	2			1			40
Total with noncultural sources	4	25	27	25	24	7	4	1	2	1	120
Total not tested	8	22	17	16	8	3	5				79
Total	35	56	45	45	34	10	9	2	2	1	239

of the anticipated cultural sources. Such descriptions ranged from simply "burned region" to "pitstructure, burned, with a southern antechamber and a maximum depth of 1.3 meters." The accuracy of these descriptions has been examined according to anticipated source and actual, excavated source.

Of the 20 sources anticipated to be pitstructures, 55 percent (11) were accurately described, 10 percent (2) were described with partial accuracy, 20 percent (4) were inaccurately described, and 15 percent (3) failed to reveal a cultural source. The partially accurate descriptions occurred where the sources were respectively suggested to be (1) a burned area, possibly a pitstructure and (2) a burned region, possibly a hearth or pitstructure. The inaccurate predictions were found to be a sandstone outcropping, a borrow pit containing two hearths, and two surface structures.

Five pitstructures which were identified during excavation were inaccurately described magnetically. Two anomalies suggested to represent burned regions actually represent pitstructures, one of which is unburned. Three other pitstructures were associated with anomalies whose sources had been suggested to be burned regions with soft fill or metal. These last three suggest a magnetic environment typical of subterranean domiciles. The magnetic anomalies at these sites would now be recognized as related to pitstructures.

Forty magnetic test areas were described as the result of burned regions; 32 (80 percent) of these test areas had no cultural sources, but 2 (5 percent) were accurately described, 4 (10 percent) were described with partial accuracy, and 2 (5 percent) were inaccurate descriptions of the anomaly source. The partially accurate and accurate source descriptions involved a variety of sources related to burning. The accurately described burned region sources included an activity area with an ash pit and hearth and a burned subterranean domicile. The partially accurate descriptions included a roomblock and three pitstructures. The roomblock created an anomaly which was described as a burned or compacted area, and while the rooms may not have been burned, their floors are compacted. The pitstructures created sources described as burned regions with soft fill or metal. Inaccurately described burned regions were actually an unburned pitstructure and a portion of a midden. Of the anomaly areas described as burned regions which had cultural features as sources (eight), half were pitstructures and could now be recognized and magnetically described as such.

Of the 28 anomalies suggested to have hearths as their sources, 3 (10.7 percent) did have cultural sources. Only one of the cultural sources was accurately described as a hearth, the other two representing areas within a midden. The areas within the midden could not be defined as specific, localized features. Greater care should be exercised in assigning priority areas to such anomalies, and then the priority number should be low.

Thirteen priority areas were characterized as probable activity areas. Excavation results show none was a totally accurate description, but four descriptions are partially accurate and two are inaccurate. Of the four partially accurate descriptions, three areas that had been described as representing activity areas, either burned or compacted, were found to be surface structures bearing these characteristics. A similar area described as an activity area also was found to be a surface structure. The inaccurately described sources were described as activity areas with burned or compacted soil, but were revealed to be an unspecified pit and a pit with charcoal fill, respectively.

Other sources which were attributed to the anomalies included architectural features (6), burned features (7), structures (4), and a surface structure (1). Of these, the surface structure was the only feature entirely accurately described, while a burnt feature description was partially accurate. "Structures" and "architectural" features accurately described only one excavated anomaly, a structure. Other anomalies (13) and anomalies for which no cultural source was suggested (24) identified only two features.

Summary

Large-scale features such as pitstructures are most easily located. Intensely burned and/or compacted areas may also be detected and lead to the identification of surface structures, roomblocks, and hearth areas. Anomalies described as activity areas are also accurate in locating cultural sources, primarily surface structures.

The more nebulous magnetic anomalies that are described as possibly hearths, architectural features, and areas having no suggested sources seldom locate cultural features (in suggested areas). Many noncultural sources produce small anomalies similar to those expected by hearths or other small, high susceptibility cultural features. More care should be taken in assigning test area status to most of the smaller or nebulous anomalies. Several techniques and graphic display methods are available and may enhance the visibility of these nebulous anomalies, described as follows:

COMPUTER METHODS TO IMPROVE DETECTION

Introduction

After determining the success rates of the magnetic priority scheme, the magnetic data were reexamined to see whether the archaeological features found through excavation, but not clearly visible in the magnetic record, could have been detected by using computer filtering techniques. Concentration was placed on the features which had been found outside of the magnetic priority test areas, but within the magnetically surveyed grid.

The original magnetic data, as presented in the 1978 and 1979 NEBCAR reports, were first reexamined for indications of anomalies missed or ignored by these reports, but which were actually caused by cultural features. Next, methods were sought to improve the detection of cultural features whose responses were weak or confused by other anomalies. Convolution filtering, rather than other pattern enhancement techniques, was chosen because it appears to offer the best resolution of subtle anomalies of a specific size. Most of the features not isolated in the 1978 and 1979 NEBCAR reports were smaller than 1.5 m in diameter, suggesting small subtle responses obscured by background. Convolution filtering can remove most of the larger anomalies, leaving the smaller responses which are suspected to be caused by the smaller features.

Convolution filtering involves the mathematic operation of a function on a matrix of magnetometer data. The numerical value of the magnetometer data at a point is replaced by a weighted average of the surrounding values out to a certain radius from the replaced point. This operation is then repeated for each value of the original data creating a new 'filtered' matrix. Depending on the values of the weighting function, anomalies of a specific size can be removed, leaving those anomalies of interest behind.

With a previous knowledge of the location of excavated features, a search was conducted for indications of anomalies related to the excavated cultural features but not mentioned in the original magnetometer reports.

Of the 144 features revealed through excavation, but not identified by NEBCAR (Huggins and Weymouth 1979, 1980), 49 cultural features were isolated in the magnetic record following the convolution filtering. These include unspecified pits (9), a burned region (1), hearths (19), rooms (11), surface structures (5), a pitstructure (1), trash-filled borrow pits (2), and an unexcavated cultural unit. Of these 49 anomalies visible after filtering, only 25 had been clearly distinguishable above the background magnetic field prior to filtering.

The majority of the features which could not be isolated even after filtering were hearths or fireplaces (42) and small pit features (28). Other cultural features included rooms (5), surface structures (4), burials (2), a large depression (1), pitstructures (3), and unexcavated cultural units (5).

The use of convolution filtering in the DAP magnetic program appears to be a worthwhile endeavor in many cases. Approximately 34 percent of the cultural features revealed solely through excavation created magnetic anomalies which were clearly visible after convolution filtering. Of the remaining 95 magnetically undefined features, over 43.2 percent (41) were masked or distorted by dipoles or situated on steep magnetic gradients.

The comparison of the archaeological information to the magnetic data indicates that the magnetic sampling rate was too great to isolate the smaller cultural features such as hearths or pits. Use of a 50-cm instead of a 1-m sampling interval during the magnetic survey can lead to improved anomaly resolution for the small features. Because of the greater time span required for magnetic surveys at 50-cm intervals, it is suggested that it be employed only at sites of particular interest.

The sensor bottle height may also be dropped, allowing for detection of the more subtle magnetic anomalies which may be masked by irregular magnetic fluctuations, although complications can arise with the lowering of the sensor height. The lowering of the sensor bottle will also necessitate a reduced survey interval, and so require a greater time expenditure. Random variations due to surface irregularities and surface iron will also be relatively greater. However, since the gradient tolerance of the instrument is able to handle most anomalies caused by surface iron variations, it is recommended that the sensor height be lowered in instances where detection of the more subtle magnetic anomalies is required and where the surface irregularities are slight.

INFERENCE OF STRUCTURAL INFORMATION FROM THE MAGNETIC ANOMALIES CREATED BY PITSTRUCTURES

The preceding parts of this study were concerned with improving the ability of magnetometer surveying to locate features. It is also possible to use the data to determine internal structure of some features. This part of the study examined the individual anomalies to determine whether information could be derived about the composition and structure of the causative features. The anomalies from pitstructures, the most common large-scale features of the Dolores Project area, were examined in detail to ascertain whether information could be obtained concerning the boundaries and orientation of the main structure and characteristics of hearths, ventilator shafts/antechambers, intrusive elements, and other general structural features (i.e., cists, activity areas). If such information can be obtained from magnetic reconnaissance, it can provide archaeologists with explicit knowledge of pitstructures before excavation begins or in the absence of an opportunity to excavate.

In order to compare the excavated pitstructures to their corresponding magnetic anomalies, line profiles running south-north and west-east were drawn by computer at 1-m intervals through magnetic anomalies mapped over pitstructures at 12 sites. It was found that the boundaries and dimensions of the pitstructure and its antechamber could be estimated from the magnetic anomaly profiles by locating the inflection points where the curve of the slope

changes direction. The method was demonstrated to be accurate within 20 percent of the excavated dimensions.

The central hearth is often the most readily visible feature of a pitstructure anomaly, frequently dwarfing any other internal contributions. The central hearth is generally the maximum point on the magnetic profile of a typical pitstructure anomaly corrected for the southern shift of the anomaly. The method proved to be a good estimate of the hearth's center.

The ventilator shaft and opening may be difficult to identify at times because of the relatively small magnetic contribution to the pitstructure anomaly. Frequently, it is visible as a slightly increased magnetic measurement on the southern slope of the anomaly profile. An antechamber is easier to detect; on south-north profiles, it may create a change similar to that of a ventilator shaft, but which broadens the entire southern slope of a pitstructure anomaly, or it may create a separate anomaly similar to that of a pitstructure's main chamber. On an east-west profile, the antechamber adopts a standard pitstructure anomaly form, located slightly south of the main pitstructure anomaly.

Intrusive features may be profitably examined through the use of magnetic profiles, the configurations of which can suggest sources for the varied anomalies. Burning within an entire pitstructure is also evident in that the intensity of the burning is indicated by the magnitude of the anomaly created. Localized burning within the pitstructure is more difficult to isolate. The strong anomaly of the central hearth will mask localized burning, unless the magnetic contribution of the latter is greater than that of the central hearth.

It was impossible to identify specific features within the pitstructure other than the central hearth position. Because the hearth is generally the dominant magnetic feature, it will be necessary to subtract or reduce its contribution in order to locate other features. This may be possible either by using convolution filtering to reduce the hearth's contribution or by modeling a hearth using previous susceptibility information and subtracting the idealized hearth anomaly from the real data.

Dot density maps may be useful in establishing the extent of burning within the pitstructure. Areas which have suffered intense burning will appear to be denser than other areas of the structure. This method could possibly identify such things as roof fall patterns.

A great aid to detecting smaller features of a subterranean domicile and refining information already available from pitstructure profiles would be to reduce the magnetic survey interval from the standard 1 m to 50cm. This would allow clearer definition of the features. Until, however, the overriding influence of the central hearth can be reduced or eliminated, many of the interior features of the pitstructure will remain undetectable.

DISCUSSION AND CONCLUSIONS

The assessment of the existing Magnetic Program showed that the priority system of NEBCAR functions well as an indicator of the likelihood of encountering archaeological features. However, its utility might be improved for in-field use if it were keyed to specific features. Large-scale features such as pitstructures are most easily located (80 percent success rate). Intensely burned and/or compacted areas are also detectable and lead to the identification of surface structures, roomblocks, and hearth areas. The smaller, unoxidized, or shallow features such as hearths and small pit features are infrequently identified and more care should be taken in assigning test area status to most of these smaller features.

Image enhancement of the data to isolate contributions from small features was found helpful in many cases. The majority of the features which remained undetected even after filtering were small hearths and pit features, many of which were distorted by nearby dipoles. Some alteration in field techniques, in addition to filtering, would aid in the location of these smaller features where it was deemed necessary. These alterations might include a closer sampling rate along with a reduced sensor height.

Detailed comparison of anomalies with the excavated features revealed that considerable structural information is available from the magnetic data. It is possible to establish the boundaries and orientation of the structure, provide specific location information about central hearths and ventilator shafts, and to identify antechambers and their boundaries. It is feasible to examine complex anomalies to improve individual feature isolation before excavation. The intensity of burning of the structures can also be determined. However, it was impossible to identify specific features within the pitstructures other than the central hearth because of its dominant magnetic contribution.

In conclusion, it appears that the magnetic survey program at the DAP can provide accurate and repeatable information about the location and composition of cultural features, without any site disturbance. This is especially true for those features of larger volume such as pitstructures and surface structures. The data base provided by this report should allow refinement of the selection criteria for choosing smaller anomalies, resulting in a higher success rate in locating and describing hearths, pits, and other features of limited volume.

Section 3

POPULATION INVESTIGATIONS

by Sarah H. Schlanger and
Timothy A. Kohler

ESTIMATING SITE POPULATION FROM SURFACE EVIDENCE: A PROGRESS REPORT

INTRODUCTION

Problem Domain 2 of the Research Design focuses on paleodemography. Among the principal questions raised are "What was the size of the population in the area of interest during each time period?" and "What was the distribution of the population in the area during these periods?" (Kane, Lipe et al. 1981). Several methods of reconstructing population size are reviewed, including those based on number or area of habitiation units, on the rate of accumulation of archaeological materials over time, and on estimation of the area's carrying capacity under particular techno-adaptive strategies. For understanding the distribution of population, it is recognized that survey data will be the primary contributor. Excavation data are expected to be important in calibrating site characteristics with population numbers, but area-wide population estimates will require extension of the results from excavated sites to similar types of sites through use of survey data.

Because so much of the information regarding both human population distribution and population size trends in the Dolores area will depend on surface evidence, DAP demographic work so far has concentrated on identifying surface characteristics that show promise for use in inferring site population size. Because a number of sites now have both extensive excavations and full, controlled surface collections, it is possible to examine the relationships between surface characteristics and subsurface data; the latter generally provide better information on important variables such as habitation area and site duration, while the former are comparable to the kinds of evidence obtainable from survey. The problem is to calibrate the two.

A three-pronged attack is currently being made on this problem: (1) analysis of the relationship of surface attributes, including artifact totals, artifact density, site size, and number of various artifact types (including ceramics, and flaked lithics), to number of pitstructures and/or to habitation floor area (as revealed by excavation); (2) delineation of factors affecting these relationships, as revealed by patterning in site type, function, and duration of occupation; and (3) identification of biases in surface materials that affect their use as indices of human populations.

At least three general benefits will accrue from such inquiries. First, they will contribute to a better understanding of processes of surface assemblage formation, which in turn will allow better prediction of human population size and length of occupation for DAP sites and for surface materials elsewhere. Second, a better understanding of how surface assemblages are formed will increase the ability to make chronological and functional inferences from surface collections. Finally, this knowledge should provide a basis for the design of more efficient surface collection and recording strategies so that the most relevant information can be obtained with the least effort.

In a previous study (Kohler and Schlanger 1980), surface-subsurface relationships were analyzed at a sample of 14 unit hamlets and fieldhouse sites. There was an unexpectedly low correlation between surface attributes and habitation floor area (a possible proxy for human population size). Correlation between the numbers of surface items and total site size, and between the numbers of surface materials and habitation floor area, were stronger in sites having relatively brief occupations and weaker in sites with longer occupations. In that study, it was noted that different classes of artifacts related to site size in different ways. Others (Binford 1979; Schiffer 1975) have also observed that artifacts of different types have different uselives, and that these uselives affect the rate at which different artifacts are added to a site assemblage. These observations suggested that one might profit from modeling the uselives of the artifacts that appear on the surface, and hence mark site area, so that a distinction can be made between artifacts giving the best information about site duration and those carrying the most information about size of site population. Such a model was developed (described in the following subsection) and was given a preliminary test (Schlanger and Kohler 1980) against data from the 9 habitation sites that were among the 14 sites used in the earlier study.

A MODEL OF ARTIFACT USELIVES

In the development of this uselife model, a number of assumptions have been made concerning the structure of the DAP habitation sites under study.

- The surface collections are primarily composed of sheet trash — secondary refuse in Schiffer's terms.

- Trash accumulates continuously during the occupation of a site; living rooms are constructed primarily at the outset of site occupation. Additional rooms may be added if population expands, or in some cases, to replace deteriorated older rooms.

- Initial pithouse size (and hence, in this area at this time, habitation floor area) is dependent on the number of people present at a site when the site is founded.

- Substantial pithouse remodeling is both difficult and rarely undertaken, even when household population size changes. If population stays approximately the same, a new pithouse may eventually be built, however, to replace a deteriorated old one. If population increases, an additional pithouse may be built, but there is also the option of establishing domestic quarters for additional persons in surface rooms.

- Surface habitation rooms can be added and remodeled more easily than pithouses; hence their number and floor area are expected to correlate with momentary occupying population size more closely than would be the case with total floor area of pithouses, at least in sites occupied for a fairly long time.

- Artifacts in the same general class share similar uselives.

A set of six artifact types commonly found in surface collections from the DAP, and which were thought to encompass a range of uselives, were selected: flaked lithic debitage (FLD), flaked lithic tools (FLT), nonflaked lithic tools excluding metates (NFLT), metates (MET), jar sherds (JCER), and bowl sherds (BCER). These artifact types were then ranked by probable uselife (from shortest to longest), based on ethnographic and ethnoarchaeological information:

1. *Flaked lithic debitage.* This class contains flakes with no modification subsequent to removal from a core or tool. This class is seen as a byproduct of tool production and maintenance, and properly has no use life at all.

2. *Flaked lithic tools and nonflaked lithic tools.* The flaked lithic tool class contains use-modified flakes as well as purposefully modified tools; the nonflaked lithic tool category includes all those stone tools primarily shaped by methods other than flaking (with the exception of metates, which are treated later). Most of the nonflaked lithic tools were nodules that were not intentionally shaped and that had been modified primarily by battering. The majority of items in both of these classes were minimally shaped prior to use; co-ranking of these two classes was made with the assumption that the minimal shaping denoted expedient manufacture (cf. Binford 1977a) and, consequently, a relatively short uselife.

3. *Jar sherds.* All ceramic items identified in the laboratory as jar sherds were included in this class, without regard to distinctions between cooking and storage vessels or to other functional distinctions. Jars are assumed to have been used primarily for cooking and storage, but not serving. Foster's (1960) ethnoarchaeological work with pottery breakage patterns in Michoacan suggests that pottery in daily use for cooking, and pottery kept and used at ground level, will have a shorter uselife than will serving vessels, although both types have a uselife of close to a year. Storage vessels kept in a permanent location and shielded from traffic flow pose a problem in that they can be expected to last at least several times longer than cooking or serving vessels. These vessels can not be specifically identified for this analysis, however.

4. *Bowl sherds.* In the Dolores area, bowls are the decorated forms and are assumed to have functioned as serving vessels, with relatively long uselives. Bowls are ranked after jars following Foster's observations regarding cooking and serving vessels, cited above.

5. *Metates.* Metates have been ranked last for a number of reasons, including Bartlett's (1933) ethnographic information from the Hopi where metate uselife was reckoned at a number of years, and a feeling that the greater labor input required to produce a metate would result in greater curatorial effort for these items and, hence, a longer uselife (Binford 1977a).

If the assumptions about site structure are correct, correlations between numbers of artifacts and site size (as measured by the extent of the surface scatter of artifacts) can be expected to be highest for those artifacts with short uselives. Correlations between pithouse area and numbers of artifacts should be just the opposite — highest correlation would be seen with artifacts which have long uselives. Metates and bowls are essentially house "furniture" and, like the house, are only rarely replaced. The exact ordering of correlations between surface structure area and artifacts of various uselives is harder to predict. Most of the sites used here date between A.D. 700 and 850, and not all the surface structures were habitations. These correlations should be intermediate between the site area and pithouse floor area cases because of the possibility of adding surface rooms at any time during site occupation.

Correlations between the length of occupation and numbers of artifacts should be highest in those artifacts with middle length uselives (table 12). A change in the garbage disposal pattern at a site, such as that following the abandonment and replacement of a pithouse, affects artifacts differentially according to uselife. Where previously sheet trash disposal predominated, abandonment of a pithouse frees up that pithouse area and depression for trash dumping, thus diverting some trash from the site surface until the pit is filled up. Rearrangement of disposal areas will have the greatest effect on entry into the surface assemblage of artifacts with rapid accumulation rates. The timing and duration of the rearrangement will determine the relative effects on middle and long uselife artifacts.

Table 12. Expected correlations between length of occupation and artifact type

Uselife of artifact classes		Predicted correlation of site characters with size of surface artifact classes		
Expected uselife	Artifact class	Site area	Site duration	Habitation area
Brief	Flaked lithic debitage	Strong +	Weak + or -	Weak + or -
	Flaked lithic tools			
	Nonflaked lithic tools		Strong +	
	Jar sherds			
	Bowl sherds			
	Metates	Weak + or -	Weak + or -	Strong +
Long				

Results: Artifact Uselives and Surface Assemblages

These expectations were tested with surface assemblage data from a set of nine pithouse habitation sites in the DAP area, five associated with the Sagehill Subphase (A.D. 700-780) and four with the Dos Casas Subphase (A.D. 760-850).

Ranking correlation coefficients between site area and the various artifact types from highest to lowest (table 13) yields an order close to that predicted from the model. Flaked lithic debitage is highest, followed by jars, nonflaked lithic tools, flaked lithic tools, bowls, and metates. Jars fall much higher in the ranking than predicted. Several possibilities might explain this discrepancy. Uselife inferences for this class or for nonflaked lithic tools and flaked lithic tools might be in error, or disposal of jar fragments across the site may not follow that of the other artifact types, as suggested in the earlier paper (Kohler and Schlanger 1980). All correlations are fairly low in absolute value, indicating that site surface area is determined by many factors, with numbers of surface artifacts being a relatively minor component.

When correlations with pithouse floor area are ranked, the order is nearly reversed, as predicted by the model. Bowls are now ranked highest, followed by metates, jars, nonflaked lithic tools, flaked lithic tools, and flaked lithic debitage (table 14). In general, numbers of surface artifacts are relatively good predictors of pithouse floor area.

The situation with surface structure area is mixed, as predicted, but appears to be confused by attributes of the two temporal groups represented in the sample. Interestingly, those artifacts with relatively short uselives — flaked lithic debitage, flaked lithic tools, nonflaked lithic tools, and jars

Table 13. Correlations between numbers of artifacts and site area

Artifact type	r	$p>r$*
Flaked lithic debitage	0.51037	0.1962
Jar sherds	0.23556	0.5744
Nonflaked lithic tools	0.21870	0.6028
Flaked lithic tools	0.21694	0.6058
Bowl sherds	0.19086	0.6507
Metates	-0.00226	0.9958

*Probability of obtaining this or a greater value of r from a population of sites sampled using simple random sampling in which there is no correlation between the artifact number and site area. Low values indicate significant correlation.

Table 14. Correlations between numbers of artifacts and pithouse floor area

Artifact type	r	$p>r$
Bowl sherds	0.68865	0.0589
Metates	0.68336	0.0617
Jar sherds	0.56669	0.1430
Nonflaked lithic tools	0.56479	0.1447
Flaked lithic tools	0.56082	0.1481
Flaked lithic debitage	0.45022	0.2630

— all exhibit slight negative correlations with surface structure habitation area, while metates and bowls, thought to have longer uselives, are slightly positive when correlated with surface structure habitation area (table 15). To determine the exact nature of these correlations, it will be necessary to await the results of analysis of a larger sample of sites for the later Dos Casas Subphase, when surface habitation rooms become common.

Table 15. Correlations between numbers of artifacts and surface structure habitation areas

Artifact type	*r*	*p>r*
Bowl sherds	0.29329	0.5232
Metates	0.16034	0.7313
Nonflaked lithic tools	-0.17521	0.7071
Jar sherds	-0.22964	0.6203
Flaked lithic tools	-0.35673	0.4322
Flaked lithic debitage	-0.45193	0.3087

Site duration was estimated on the basis of the number of pithouses present at a site and the circumstances of their destruction. Excavation evidence from the sample indicated that when multiple pithouses were present they were sequentially occupied. Pithouses which had not burned prior to abandonment were given an estimated lifespan of 20 years, based on stratigraphic and dendrochronological evidence. Pithouses which had burned were given a value of 10 years.[1] As expected, artifacts with middle length uselives had the highest correlation with estimated site duration, while those with shorter uselives were more poorly correlated. From high to low, correlations ranked in the following order: nonflaked lithic tools, jars, flaked lithic tools, bowls, flaked lithic debitage, and metates (table 16). In general, numbers of surface artifacts are better predictors of duration of occupation than they are of surface structure habitation area, pithouse floor area, or site surface area.

[1]Allen E. Kane, Co-Principal Investigator, DAP, Dolores, Colorado, personal communication.

Table 16. Correlations between numbers of artifacts and site duration

Artifact type	*r*	*p>r*
Nonflaked lithic tools	0.70869	0.0326
Jar sherds	0.70311	0.0346
Flaked lithic tools	0.67876	0.0444
Bowl sherds	0.65497	0.0555
Flaked lithic debitage	0.55253	0.1229
Metates	0.40411	0.2807

Results: Artifact Uselives and Total Site Asemblages

As part of a study of the probability sampling program in excavations Kohler and Gross (chapter 5, section 2) compile data on the relationships between the estimated total populations of different artifact classes and indicators of human populations at a small sample of sites (table 17). The size of habitation area was known at these sites, and crew chiefs were asked to estimate the number of person-years their sites had been occupied. Estimates of the numbers of artifacts in each class are projected from the probability sample. Table 18 shows the correlations between person-years, habitation area, and these estimates.

These results are not strictly comparable with those just discussed because "person-years" does not separate out site duration as a separate variable, and because the artifact classes used in table 18 are not in all cases the same ones used in the model (table 12) employed in the current research. Metates are not considered separately from other nonflaked lithic tools, and ceramics are not broken down into bowl and jar sherds. Nevertheless, some rough comparisons can be made. A striking difference between the predictions for suface assemblage (table 12) and the results

Table 17. Human population indicators and artifact population estimates at five sites

Site No.	Habitation (m^2)	Estimated person-years	Estimated total artifact populations			
			FLD	FLT	NFLT	CER
5MT2161	143.0	2000	72 754	2981	1969	220 768
5MT2215	48.6	5	2 107	167	72	24
5MT2854	48.0	390	24 866	3121	143	35 212
5MT4650	245.0	1125	32 099	2214	324	59 854
5MT4789	0.0	2	384	20	2	12

Table 18. Correlations (*r*) between human population indicators and artifact population estimates at five sites

	FLD	FLT	NFLT	CER
Person-years	0.98	0.71	0.91	0.96
Habitation area (m^2)	0.59	0.51	0.40	0.48

from total site assemblages (table 18) is the power of population estimates of flaked lithic debitage from total site assemblages to predict both person-years and size of habitation area. The relationship to person-years is not surprising; the uselife model implied a strong relationship between flaked lithic debitage (and other short uselife items) and site duration, but predicted a weak relationship between the frequency of such items in surface assemblages and duration, due to the effect of various site formation processes on the composition of surface assemblages. Short uselife items were modeled as the most heavily affected by changes in trash disposal patterns, especially from a surface trash scatter pattern to where trash is deposited in depressions formed by abandoned, collapsed pitstructures. The composition of a trash scatter surface is expected to vary over time as activities and the trash generated at a site vary from day to day, and as site formation processes operate on the surface. Any given surface collected during archaeological investigation may therefore not be a good approximation of the long-term output relationship of the various impliments and debris discarded during the site occupation.

Implications

At present, there are not enough independent sources for estimating site occupation duration and artifact uselives, a problem which should be rectified in the future. The relationship of artifact uselives to surface assemblages is encouraging enough to begin to specify what sorts of surface collection data will be most useful for addressing problems of site duration and population size during the Sagehen Phase in the DAP area.

For site duration questions, surface collections should concentrate on those items thought to have middle length uselives. These items — nonflaked lithic tools, sherds, and flaked lithic tools — are fairly easily recognized on DAP sites and collection should be rapid. Possibly collection (or counting) could be limited to nonflaked lithic tools, which have the single highest correlation with site duration. The recognition of these items elsewhere may be more problematic.

For questions of site population size, collection should be directed toward obtaining the surface population — or an estimate thereof — of long uselife items. For this, bowl sherds (from painted wares) are easily recognized in surface scatters, and collection should be fairly rapid. The addition of metates increases the correlation between long-lived artifacts and habitation area — it is suggested that these be collected as well. Metates and metate fragments are fairly easy to recognize, although transport may be rather difficult. As the technique relies on count, however, metates may be counted and left in the field unless they are needed for other research. This holds true for all artifact types discussed in this paper. Where bowl sherds are unavailable or rare, jar sherds should be added to the count or collection.

It should be noted that samples concentrating on painted pottery (bowls) may serve as good samples for population estimation to the extent that numbers of bowl sherds are correlated with habitation floor area, at least in pithouses. Many of the DAP sites, for which population estimates would be desirable, were sampled with grab samples to collect as many temporally diagnostic sherds as possible, to facilitate dating. Where such a strategy resulted in collection of all painted sherds, a sample which is also suitable for population estimation (especially in sites of short duration) has been achieved at no extra cost. The "pothunter effect" from removal of sherds by private collectors must also be considered.

A consideration of artifact uselives in relation to the composition of total site collections indicated that artifact classes were also differentially related to site duration and to population, but that the relationships were not identical to those observed for surface assemblages. In general, a comparison of the two bodies of data indicates that the relationships among artifact uselives, composition of surface collection, and composition of total site collection are somewhat complex. Not surprisingly, estimates of total site content are much better predictors of human population characteristics than are any portion of that content which happens to be on the surface at the time of collection. Unfortunately, the probability excavation necessary to derive these estimates is also much more time consuming than surface collection. The relationships among total site content, artifact uselife, and surface content do appear to be controlled by general, recurrent processes. There is considerable basis for optimism that with further study these processes can be understood and can be used more effectively to infer population characteristics from either surface or subsurface.

Section 4

ENVIRONMENTAL STUDIES

by Robert A. Bye, Jr., Mary E. Floyd, Timothy A. Kohler, William D. Lipe, and Rita A. Shuster

DEVELOPING AN INTEGRATED MODEL FOR CONTEMPORARY AND ARCHAEOLOGICAL AGRICULTURAL SUBSISTENCE SYSTEMS[2]

Part I. A Model of Agriculture Productivity

by Robert A. Bye, Jr., and Rita. A. Shuster

INTRODUCTION

The rise and importance of agriculture in the Greater Southwest over the past 1200 years has created interest among archaeologists. Many attempts have been made to estimate the contribution of agricultural products (e.g., maize and beans) to the diet of people who occupied certain sites during given time periods. These attempts have varied in approach and in results, which tend to be too general and to be applied to a broad time spectrum. The purpose of this portion of this report is to introduce a program which was initiated to add a dynamic component to assessing agricultural productivity in a specific area under specific conditions during certain time periods.

Agriculture is a process of manipulation by humans of the environment and of plant populations so as to harvest an expected yield or productivity. Because agriculure is a process, it is important to know how the components of a specific environment and of certain plant populations respond to known local conditions. During the summers of 1979 and 1980, two gardens were established in the drainage of the Dolores River at two locations approximately 10 km northwest of Dolores, Colorado. These gardens were part of an Environmental Manipulation Study of the Environmental Studies Group of the DAP. Because many of the sites in the impact area range from Basketmaker III to Pueblo III (A.D. 650-1100) in the Anasazi Tradition and because maize and bean remains have been recovered, agriculture appears to be the main subsistence practice of the humans who lived in the area under investigation. Therefore, information is needed on the agricultural potential of the impact area so as to establish the relationship between the inhabitants and their ambient environment at the time of occupation.

Agricultural potential of the area can be estimated by using two types of data resources. The first resources are derived from evidence from the past. These static references include the following:

- Archaeological specimens of cultivated plants
- Associated archaeological remains of biotic and abiotic materials
- Associated archaeological artifacts that may be associated with preparation of fields and other environmental manipulations, and with harvesting, preparation, and storage of agricultural products
- Patterns of settlements and fields which are recognized today through survey and excavation and which vary in space and time with known contemporary environmental factors (e.g., soil, exposure)
- Environmental reconstruction at the time of occupation so as to provide a baseline for "favorable" abiotic growth conditions (e.g., temperature and precipitation).

The second type of data resources focuses on agriculture as a dynamic process that is responsive to local conditions. Many components can be affected so as to alter the amount and types of yield; e.g., humans can munipulate the ambient environment and plant populations to increase yield.

It is not possible to re-create the exact agricultural system because the specific soil, cultivating techniques, and varieties of plants have changed and are not constant. Therefore, patterns of variation under local conditions must be understood and these patterns must be integrated with the evidence of the past for given periods. This integration yields a model for determining agricultural potential.

Evidence From the Past

Most archaeological studies which deal with agriculture tend to focus on the remnants of assumed agricultural activities and products. These remnants include plant remains, food processing artifacts, water control features, field boundary markers, field houses, and the generalized reconstructed environments. The data from these remnants are incomplete in terms of representing all variations in space and time. The initiation, duration, intensity, and representativeness of these remnants are variable and usually are not comparable. Using such fragmentary information it is difficult to obtain specific estimates for the ranges, tendencies, and variations of productivity for a given unit of time. Because this report is meant to discuss a complement to estimating agricultural productivity (and not to criticize previous studies for their approaches and assumptions), previous attempts at interpreting archaeological data will not be discussed.

[2]Because of their continuing field research, the authors were unable to review editorial changes made in this manuscript.

Evidence From the Present

Because agriculture is a process, it must be treated as a dynamic system — an interaction of components which change through time under different conditions. Because we cannot re-create the past, we must use contemporary elements of the components of agricultural systems in order to elucidate general patterns. Once these general patterns are understood, they can be integrated with the limited evidence from the past to produce a better approximation of the contributions of agriculture to the inhabitants of a given area at a given time.

The agricultural productivity potential can be estimated by using contemporary environments at or near sites and contemporary traditional cultivated species and their races/cultivars in order to elucidate general patterns. Continuity between the past and present is seen in the environment and in the plants. Also, certain discontinuities must be recognized. The adjustment of these discontinuities can be derived, in part, from the archaeological evidence.

Certain continuities allow us to correlate the patterns of the present under known conditions with the patterns of the past which may be assumed. Usually the rate, magnitude, and direction of change of certain enviromental factors are minimized. The major drainages, landforms, and certain soil parent material have remained relatively constant over the past 1400 years. The relative relationships of temperature and precipitation to the landscape are fairly predictable although absolute levels may be different. Also, certain biotic factors show consistency in general patterns. Major plants and animals in successional communities are assumed to have been present in the past and their relationship to one another is not thought to have changed. Contemporary traditional cultivated plants are considered to be derivatives of similar ancestry as the plants cultivated by the prehistoric occupants. They retain elements of the general pattern with respect to morphological characters, intrapopulation genetic variability, and basic responses to environmental conditions. Consistency which implies similar responses to environmental conditions is emphasized. These factors are not considered, however, to be the same during different periods of time.

Certain discontinuities exist. They must be recognized and accounted for in the model. Environmental discontinuities include a possible shift in the regional temperature and precipitation patterns. Also, the present-day plant and animal communities have been influenced by postoccupation factors as well as by historical factors (e.g., grazing, farming, logging). Introduced plants and animals are found in ecological niches that were once occupied by native species. The soil may be degraded, shifted, buried, or eroded away so that only a fraction of the soil of periods of occupation exist today. The contemporary cultivated plants which are grown by Anglo farmers are highly selected races of limited genetic diversity and have not been selected for productivity in prehistoric environments or under conditions of aboriginal cultivation.

The Model

Despite the limitations posed by these discontinuities, the strength of the continuities and adjustments for the discontinuities provide a system for evaluating the manipulation of the process which will produce qualitative and quantitative results. The results are based upon known factors such as location, temperature, precipitation, type of cultivated plants, and techniques which are related to the area under investigation. By combining results under various conditions of different growing seasons and varying environments (natural and manipulated) with archaeological evidence for a given place and time, a realistic statement can be made about agricultural potential. The integration of present and past evidence produces the following:

- A comparison of archaeological and contemporary cultivated plant specimens for characters and characteristics which are known to be correlated with responses of known processes.

- A guide for the modification of archaeological sampling design so as to search for more archaeological plant material which may exist but may be overlooked.

- The dynamics of probable agricultural system(s) during the periods of occupation in the area of occupation.

Certain attributes of cultivated plants are expressed in various states (characteristics). Variations of these characteristics result from the interaction of genetic information and the environment (that is, they are phenotypic). The relative stability of the character under different environments is necessary to identify the races of cultivated plants. On the other hand, some characters may have variable characteristics which are correlated with certain environmental conditions (e.g., nutrient level, water availability, density, temperature patterns). Once the relative stability of specific characteristics is known for certain characters under specific conditions, these characters can be analyzed on archaeological material from the sites and conclusions drawn as to the types, diversity, and growth conditions of the cultivated plants.

Often certain assumptions are made in the sampling of archaeological sites. Many sampling designs are instituted to recover expected materials as efficiently as possible. By growing certain plants in the study area and evaluating their responses, it is possible to add certain plants to the "expected" list and modify the sampling and processing of archaeological samples in order to maximize recovery of these species. Knowledge of the potential for growth and deposition of certain parts of "unexpeced" plants can

expand the archaeologists' perceptions of the cultural significance of certain plants. These plants may have been "unexpected" and therefore not searched for because previous excavations and interpretations suggested that they did not occur in that area or at that time period.

The dynamics of the agricultural system suggest that variation exists. Static assumptions may be less than satisfactory in the interpretation of archaeological remains and population changes in the area. A basic assumption in this model is that a correlation exists between the agricultural process and the materials of the process which have the potential for incorporation into the archaeological record. The archaeological material and their analogs from contemporary gardens with known environmental history can provide not only the diversity of cultivated plants, but also the variations in response to cultural and natural environmental conditions and the estimate of productivity for given conditions.

The integration of these components is not the last step of the model. Rather, integration is a continuous process because of the weaknesses of both the archaeological evidence (e.g., poor preservation, limited excavations) and contemporary evidence (e.g., environmental discontinuity). The Environmental Studies Group has defined four overlapping phases of research:

1. Demonstration
2. Experimentation
3. Simulation
4. Synthesis and intepretation.

The demonstration phase is designed to assess the potential of certain cultivated plants to grow in the area. During this phase, observations are made on the growth and reproductive characters of the plant. Comparative and propagative material is collected from the plant.

The experimentation phase is based upon the responses of the plants and the plant populations to known manipulation of the components of the agricultural system. The comparison of the treatments to controls allows for the development of qualitative and quantitative data on the effects of manipulation of the ambient environment on these plants. Differences in water, density, dispersion, competition, geographic source area of diverse races, and other factors may influence certain characters of cultivated plants which could be incorporated into the archaeological record, as well as components of productivity.

The simulation phase is designed to apply human technological input (as interpreted from the archaeological record) to a set of agricultural alternatives from the experimental phase so as to maximize culturally important and reliable productivity. Assumed technology of the given period, analogs of known subsistence agricultural systems in the Greater Southwest, and results from known environmental manipulations in the local area under study are combined so as to provide meaningful estimates of productivity.

The synthesis and interpretation phase integrates the known results from Phases 1, 2, and 3 with the environmental reconstruction and the archaeological evidence. By knowing the patterns of change under known cultural and natural conditions, the meaningful productivity estimates can be combined with estimated changes in response to reconstructed climatic conditions. The cultural factors from the archaeological evidence have been incorporated into Phase 3. The qualitative and quantitative data can be extrapolated to larger units in the study area. Such variables as available land, human input, population size, demands on other resources, importation of exotic resources (for consumption or cultivation), and other factors can be manipulated so as to provide alternative interpretations which can be compared with the archaeological record. Essentially, the agricultural potential is extrapolated from known productivity which is affected by local factors related to the study area.

At the present time, the DAP gardens are in Phases 1 and 2. R. Shuster has served as the manager by designing and maintaining the gardens with occasional help from other members of the Environmental Studies Group.

Two gardens were established and reflect the land available for study which most closely fit the objectives of the Environmental Maniplulation Study. The lower garden site is located along the lower terrace of the flood plain along the Dolores River. It is situated in the riparian woodland and riparian grassland-shrubland vegetation zones (Bye 1981a). The elevation is approximately 2000 m above sea level. The soil is a fluvent (an Entisol) which is shallow, poorly developed alluvium and overlying gravel (Leonhardy and Clay 1981). The upper garden site is located on an east-facing slope above a small drainage. It is located in a sagebrush sere of the pinyon-juniper woodland (Bye 1981a). The elevation is approximately 2160 m above sea level. The soil is Witt Loam (an Aridisol) which is deep, well drained, mixed mesic, and of fine silty consistency (Leonhardy and Clay 1981). The soils had not been cultivated for at least 30 years.

The present-day general climate in the DAP area can be classified as semiarid. Cortez, which is located approximately 23 km to the south of the garden sites, is the nearest long-term recording weather station in the Dolores area. The following data are based upon temperature and precipitation records from Cortez from 1951 through 1973 (National Oceanic and Atmospheric Administration 1975).

The highest daily maximum temperature (31.8 °C) occurs in July while the lowest daily maximum temperature (5.2 °C) occurs in January. The highest daily minimum temperature (17.7 °C) occurs in July while the lowest daily minimum temperature (-9.9 °C) occurs in January. The mean monthly temperature for the anual period is 18.1 °C.

Agriculture as a System

Agriculture as defined above is a system of environment and human interaction. Humans invest input into the system to gain a greater output. Human input tends to alter the ecosystem such that it takes on certain characteristics of an immature ecosystem stage of Odum's Development Model (Odum 1969). At this early stage, greater net productivity is available in the system than at later mature stages. Also, the quality of net productivity may be different in the early stages as compared to mature stages. It is inappropriate to assume that high productivity in more mature stages is a good predictor of productivity in earlier stages. Humans tend to modify the ecosystem so as to increase their yield; thus, humans become the main predator in the system. Certain characteristics are similar in immature ecosystem development stage and agriculture:

- Ratio of gross production to standing crop biomass is high
- Net community productivity (yield) is high
- Species density is low
- Niche specialization is broad
- Size of organisms is small
- Life cycles are short and simple
- Mineral cycles are open
- Nutrient exchange rate (between organisms and environment) is rapid
- Production emphasizes quantity
- Nutrient conservation is poor
- Stability (e.g., resistance to external perturbations) is poor
- Entropy is high.

With some modification, and with some exceptions, agricultural systems resemble immature, early successional stages in an ecosystem. Human activities can alter some of the specific factors, but many of the general patterns exist.

In agriculture, humans exploit the manipulated environment so as to increase productivity. Crops (cultivated plants which are usually domesticated) are considered to be the major primary productivity component. Humans harvest the primary productivity and transform it into secondary productivity as a consumer or predator. The maize crop, for example, yields productivity in the form of food in the fruits or kernels. Also, the productivity can be measured in accordance with human value of perceived resources such as fiber and sugar sources (from earless stalks and immature ears and leaves), as food preparation material (from husks), and as fuel (from shelled cobs). The human value of the crops varies with culture and with time. Other elements of the crop component include beans, cucurbits, and other cultivated plants.

Another component which affects primary productivity is competition. Intraspecific competition (i.e., within a population of a given species) may affect the maintenance, survival, and productivity of a given crop. The density and dispersion of crops can be manipulated by humans and is related to the efficiency of human input/output ratio. Interspecific competition (i.e., between populations of different species) can be between different crop plants as well as between crop plants and noncultivated plants. Noncultivated plants grow in agricultural fields and are associated with anthropogenic communities. These plants are considered weeds—plants which grow in areas of human disturbance—and are not wild plants. The survival of weeds is dependent upon the human alteration of the natural environment. Although some agro-industrial societies consider weeds harmful, these plants may grow within limits so as not to harm the productivity of cultivated crops. The theoretical basis for this nonharmful interaction is found in multiple cropping theory in which different plant populations draw on different resources in the environment at different rates, in different areas, and at different times (Papendick et al. 1976). Also, these plants can be harvested and prepared as food and are converted as secondary productivity (Bye 1981a). Examples of elements of the interspecific weed competition component include pigweed, goosefoot, and purslane.

Predators and parasites are part of the secondary productivity of the agriculture system. This component lives off of the crops and weeds of the field and may decrease the overall net primary productivity harvested by humans. On the other hand, the predators and parasites, within limits, may not necessarily be deleterious to subsistence agriculture. They may serve as human food surviving off of the primary productivity which is concentrated by human manipulation of the ambient environment. Consequently, these "pests" are concentrated in a limited area and can be gathered as food with little foraging. Elements of this component include rodents, birds, and maize smut. "Garden hunting" can be considered to be one aspect of this component (Linares 1976).

The human value of these components varies with culture and with time (over human generations as well as within agricultural cycles). The components of competition, predators, and parasites may be more valuable than harmful under certain environmental, cultural, and technological situations.

Various biotic factors such as those listed above are important factors in assessing productivity of systems with given crops. Cultural input can alter these biological components by manipulating their relative importance. Also, humans can alter the genetic components by introducing "exotic" elements which could alter the environment as well as respond in such a way that it diverges from the established elements. Subsequent incorporation, introgression, and substitution by this "exotic" element could be related to cultural changes.

Various abiotic factors are known to affect primary productivity of the biological components of agricultural systems. Temperature, water, soil, light, nutrients, and landform affect productivity in predictable manners for given environments, elements, and relationships (Eastin et al. 1969; Milthorpe and Moorby 1974). Some modern agronomic studies control certain factors and vary others. Unfortunately, these studies have little application to subsistence agriculture because of its limited cultural input, wide genetic diversity within and between crops, different concepts of productivity and of human values of different biological components, and different environmental conditions. The wide divergence between research stations yields and average farmer yields of genetically uniform agro-industrial crops in highly modified environments (Schneider 1976) is greater than the diversity of subsistence agricultural yields of genetically diverse crops in various lightly manipulated environments. Agro-industrial data are of little value in assessing subsistence agricultural potential.

Any one of these components (e.g., temperature, water, landform) may be the limiting factor to certain levels of agricultural productivity. The limiting factor may vary from location to location and may vary from one agricultural season or segment of agricultural cycle to the next in the same area.

Conclusions

Assessing agricultural potential in an archaeological context is not easy. It is therfore difficult to evaluate the reliability of any statement about agricultural productivity. The model in development attempts to combine archaeological evidence with contemporary evidence. The integration of these in a site-wise manner from demonstration phase through the synthesis/interpretation phase allows one to cross-check the data. In this way, a dynamic agricultural system is constructed as a process which changes over time in response to given factors. The combination of archaeological remains with known responses allows meaningful interpretation of archaeological data. Extrapolation from contemporary patterns of productivity to past conditions suggests a more realistic assessment of the importance of agriculture to human populations at a particular point in time and space. The interaction of the components of the environment and of culture is always changing.

The maintenance of this program as well as the establishment of similar comparable programs in the Greater Southwest will provide a realistic basis for the study of the growth of agriculture in this region. Brand (1936:7) suggested such a program:

> the substitution of experimental laboratory method for that of those who would rather sprinkle hypothetical irrigation systems over the Southwest, or laboriously and mathematically transfer — on paper — to the Pueblo area . . . the fluctuations in precipitation indicated by tree rings of California Sequoias, rather than actually test the soil and climate by experimental plantings [emphasis added]. An increase in the number of experimental farms, planted not only to all available varieties of maize but also beans and cucurbits, and equipped with meteorological instruments, should eventually aid the dry-farmers of the Southwest as well as anthropologists.

Part II. Preliminary Results from the Dolores Archaeological Program Gardens

by Rita A. Shuster and Robert A. Bye, Jr.

INTRODUCTION

Two gardens were established near Dolores, Colorado, and maintained in 1979 and 1980 to fulfill Phase 1, Demonstration, and Phase 2, Experimentation, of the DAP Environmental Studies Program for modeling prehistoric agriculture (Bye and Shuster 1981). Seeds for planting in the gardens were obtained from specialists on the different taxa, private and public seed storage facilities, and commercial sources. An attempt was made to find varieties which resemble those available to prehistoric Anasazi farmers in the area, based on the archaeological literature and on personal examination of vegetal artifacts in the University of Colorado Museum, the Denver Museum of Natural History, and the Mesa Verde National Park Museum. Actual seeds from prehistoric sites have lost their viability and cannot be germinated (Nabhan 1977), so it was necessary to find modern replacements. Hopi blue flour maize was used for some of the maize experimental work because it was possible to obtain a large seed supply and it had been used in previous garden studies (e.g., Toll et al. 1981).

Planting and cultivating was done with hand tools, in accordance with our knowledge of traditional Southwest farming techniques and following standard horticultural practice. Observations and measurements of all crops were made throughout the growing season (Shuster 1979, 1981a, 1981b). The following crops were planted in demonstration plots to assess their growth responses, to estimate potential

productivity, and to provide comparative specimens for use in identifying archaeological materials (numbers of varieties in parentheses):

- Maize: *Zea mays* (8), *Zea mexicana* (1)
- Bean: *Phaseolus acutifolius* (2), *P. coccineus* (3), *P. lunatus* (3), *P. vulgaris* (17)
- Squash: *Cucurbita ficifolia* (1), *C. maxima* (2), *C. mixta* (5), *C. moschata* (5), *C. pepo* (6)
- Other crops: cotton (*Gossypium hirsutum* var. *punctatum*), chili peppers (*Capsicum annuum*), tobacco (*Nicotiana rustica*), devil's claw (*Proboscidea parviflora*), and bottle gourd (*Lagenaria siceraria*)

Weather records from the garden sites show that both the 1979 and 1980 growing seasons were particularly short and dry. Average frost-free seasons for the gardens were only 87 days in 1979 and 83 days in 1980. Total precipitation from June to September was approximately 4 cm in 1979 and 6 cm in 1980. Despite these limitations, several varieties of maize, bean, and squash reached maturity in the gardens. The contributions of this research program will be presented under three headings: (1) the assessment of potential productivity; (2) the role of abiotic factors in affecting productivity; and (3) the role of biotic factors in affecting productivity. Examples from each category will be given in this report, and more detailed treatments of individual topics will be presented in future reports.

THE ASSESSMENT OF POTENTIAL PRODUCTIVITY

Comparison of the potential productivity of different ecosystems can be made by studying the existing plant communities. The higher humidity and soil moisture at the lower garden in Dolores is reflected in the greater density and lush appearance of the riparian vegetation there compared to the more open sagebrush-pinyon-juniper vegetation at the drier upper garden. Samples of the vegetation within and adjacent to each garden were collected in August 1980 and analyzed to determine potential productivity of both ecosystems. In both early and later stages of succession, aboveground biomass production was higher at the lower than the upper garden. The first-year successional community of annual weeds such as sow-thistle (*Sonchus oleracea*) and sunflower (*Helianthus annuus*) produced 94 ± 11 g/m^2 of dry matter at the lower garden and 72 ± 11 g/m^2 at the upper garden. Immature maize plant produced 54 ± 4 g/m^2 at the lower garden and 45 ± 6 g/m^2 at the upper garden. These data suggest that agricultural productivity would be higher at the lower garden site. However, crop yields at the lower garden were reduced due to predation and early frost later in the 1980 growing season.

Total aboveground biomass production is commonly measured in plant ecology studies, but only yield of crop products is commonly reported in agronomic studies. Both are of interest because the familiar crop product, usually the mature fruits or seeds, is just one component of productivity in a subsistence agricultural system. Many crop plants have multiple uses (Cushing 1920). Allocation of biomass to different plant parts was measured. In Hopi blue flour maize, for example, only 23 percent of the total biomass was stored in mature ears. The remaining 77 percent was allocated to leaves (22 percent), husks and immature ears (23 percent), tillers (5 percent), stalk (22 percent), and roots (5 percent). Collection and use of these other plant parts is documented by archaeological specimens from others sites in the region (e.g., Cutler and Meyer 1965).

When considering productivity, the degree of maturation of fruits and seeds is important. For crops to be propagated year to year, seeds must reach a level of "productive maturity." In maize and squash, viable seeds can be produced before the fruits are fully developed. Later in the season, further development brings the fruits to "full maturity" with increased size and weight, and changes in color, texture, and nutritive value. From 13 to 72 percent of the ears harvested from seven races of maize plants in the upper garden in 1980 could be classified as fully mature, but all ears harvested had kernels which were viable. Viable seeds were also collected from squash fruits which had been harvested when the rind and flesh were still tender. Unless bean fruits (pods) have dried fully on the vine, however, the bean seeds are not viable.

Yield of mature crop products varied with different varieties or species. In beans, for example, tepary bean (*P. acutifolius*) and common bean (*P. vulgaris*) produced fully mature fruits, but seiva bean (*P. lunatus*) and runner bean (*P. coccineus*) did not. In maize, the Southwest races Hopi blue flour and Papago produced mature ears, but Chapalote did not. The five Tarahumara races which were planted in Dolores showed a divergence in rate of development and maturation and production of mature ears (Shuster and Bye 1981). Azul, Apachito, Blanco, and Cristalino matured earlier and produced more ears than the standard for comparison, Hopi blue flour maize. Blanco, which performs similarly to the other Tarahumara races in their native Chihuahua, was slow to mature and produced very few mature ears in Dolores. These differences have important implications for the potential productivity of agricultural systems. Availability and selection of crop varieties which perform well under the growing conditions specific to a given region have a great effect on the potential for acceptance and utilization of any crop. Identification of the factors which influence crop productivity in subsistence agriculture will contribute to an understanding of the processes of crop diffusion and introduction of exotics into new regions over time.

Others have recognized the difficulties of farming in the Southwest:

> In a biological sense, farming is ill-adapted to the conditions of environment on the Colorado Plateau, and insuring the consistent yield of cultigens necessary to support sedentarism requires the individual to expend far more energy than he would have to devote to gathering wild foods (Schoenwetter and Dittert 1968:60).

Because of losses to predators and frost and yield reduction from drought stress, average yield of dry beans was only 30 ± 5 g/m^2 and of maize kernels was 35 ± 8 g/m^2 in 1980. By contrast, the seed output of the weedy sunflower (*Helianthus annuus*) which grew in disturbed soil in and adjacent to both gardens, was 118 ± 8 g/m^2. This sunflower is not a "wild" plant, but a weed, because it grows primarily in areas of human disturbance; it certainly requires less direct input than cultivated crops of maize or bean.

THE ROLE OF ABIOTIC FACTORS

The effects of light, temperature, water supply, and soil properties on growth of crop plants have been described by other workers (Aldrich and Leng 1965; Eastin et al. 1969; Salisbury and Ross 1969). Reports are available for agricultural research using contemporary crops and techniques, but some of these findings are inapplicable to subsistence agricultural systems because most modern agricultural research is carried out under careful environmental control and with genetically uniform seeds. Some agricultural research is done with plants grown in containers under artificial climatic conditions. In Dolores, however, the challenge was to conduct research in the field under marginal environmental conditions and with genetically diverse traditional crop varieties. A series of basic agronomic assumptions were made about the growing conditions in Dolores in attempt to achieve good experimental control in the field situation. Experience soon showed the difficulty of meeting these assumptions and led to several revisions. For example, it was assumed that moisture content and soil properties would be uniform across the test plots used in the demonstration and experimental gardens, but it was found that variation in these factors occurred on a very local scale and was important to plants at the sensitive seedling stage. The role of abiotic factors in affecting plant growth is one of dynamic interaction. Over the course of the growing season, for example, the moisture content of the soil near the surface becomes of less significance to plant growth because roots have penetrated to deeper levels.

Unfortunately, the subsistence agriculturist is not able to control all abiotic factors and bring them to optimal levels. The concept of limiting factors is one approach to identifying conditions which are of critical importance in limiting productivity. Even though supplies of other factors may be optimal, or at least adequate, it is the factor which is in short supply that limits crop production. The role of drought as a limiting factor in Southwest agriculture has traditionally been emphasized, but this work documents the role of short growing seasons as well. The effects of temperature, water supply, and soil properties will be briefly discussed as examples of the abiotic factors.

Temperature. Rates of seed germination and seedling emergence depend on soil temperature at the time of planting. Seeds of maize germinated in 12 to 13 days at mean soil temperatures of 14 °C and in 7 to 8 days at temperatures of 16 °C. Although seeds planted early into cool soil may take longer to germinate, they may benefit from higher soil moisture content. The soil surface dries out quickly as temperatures increase in the late spring. Seeds of annual weeds did not germinate in the gardens in 1979 or 1980 because the soil surface was quite dry by the time soil temperatures reached 15 °C. Average daily minimum-maximum temperatures for 1979-80 in Dolores were 4 to 28 °C in June, 9 to 32 °C in July, 8 to 30 °C in August, and 6 to 25 °C in September. Cool night temperatures limited maize growth and yield in Dolores by increasing the number of days between planting and maturity. The growth of maize plants is directly related to temperature, measured in accumulated heat units in day-degree Celsius and calculated by the formula: Heat Units = Daily Mean Temperature - 10 °C. Average heat units per week in 1980 increased from 10 in early June to 90 in early August and then decreased to less than 25 by late September. An average of at least 80 heat units per week is considered the minimum for successful production of maize (Aldrich and Leng 1965). Even though this level was maintained for less than 3 weeks of the 1980 growing season in Dolores, six of eight races of maize produced fully mature ears. Growth of maize plants, measured as the number of leaves per plant, showed a very high correlation ($r = 0.99$) with accumulated heat units. The duration of vegetative growth prior to tasseling and silking in maize is much more closely related to temperature than to calendar days.

The very short frost-free season in Dolores limited growth and maturation of crops more than any other factor. Drainage of cold air into the river valley caused an early frost which killed plants of maize, beans, and squash at the lower garden on 21 August 1980, more than a month earlier than frost damage occurred at the upper garden. Frost-free season at the lower garden in 1980 was only 67 days; and at the upper garden, 98 days. The combination of cool nights during the growing season, which slows plant growth, and early frosts in the fall, which terminates plant growth, is doubly limiting to agricultural efforts.

Water supply. Irrigation at the time of planting promoted good seed germination and seedling establishment. The combination of planting in deep holes and adding 5 L of

water per hill resulted in 75 percent germination for maize planted at the upper garden in 1980, compared with less than 5 percent germination for maize planted near the surface and not irrigated in 1979. Deep planting is preferable to shallow planting because it places the seed lower in the soil, where moisture levels are higher. All seeds were soaked in water for at least 24 hours before planting to initiate germination responses. Applying even 5 L of water per hill requires considerable expenditure of labor; however, this is the only point in the growing season when so little water can contribute so much to productivity.

Once established, plants continued to grow despite apparent drought stress. In 1979, an experiment was conducted with Hopi blue maize to test the effects of irrigation during the third to eighth week after planting. No precipitation was recorded during the treatment period, and the equivalent of 5 cm of rainfall was supplied to experimental plots. No significant increase in height due to irrigation could be detected. Perhaps the amount supplied was insufficient to adequately wet the volume of soil penetrated by the root system. Plants of drought-tolerant races of maize such as Hopi blue flour have deep root systems that reach 3 to 4 m into the soil. Drought stress during tasseling and silking is reported to cause significant yield reductions in contemporary hybrid maize (Denmead and Shaw 1960), but did not have an apparent effect on the races grown in Dolores. Poor kernel-set and reduced filling of the kernels at the tips of the ears, symptoms of drought stress in maize, were occasionally present, but not common, in the maize harvested in 1979 or 1980.

Plants of squash (*Cucurbita pepo*) have a more shallow root system and are more affected by moisture levels near the soil surface than are maize plants. Squash plants grew larger and had larger leaves at the lower garden, where soil moisture levels were 2 to 3 percent higher throughout the growing season. In each of five varieties of *C. pepo*, vine length and leaf diameter were significantly greater at the lower than the upper garden. Neither squash nor bean plants showed reduction in the number or size of fruits that could be attributed to drought stress.

Soil properties. The physical and chemical properties of the soils in both gardens were assumed to be uniform across all test plots. No nutrient deficiencies were noted per se in the crop plants, but uptake of nutrients was limited by drought conditions. Soil texture varies between plots and is of great importance to the hand cultivator. Light sandy soils are preferred over heavier clayey soils because they are easier to till. In an arid climate, availability of soil nutrients is closely linked to soil moisture content. Even though the clayey soils may gave a higher moisture content, they may be less desirable field locations because of their physical properties.

Even in a carefully prepared field, the environment is very heterogeneous at the size scale of a seed or seedling. Variation in microtopography caused by the presence of clods of soil or uneven soil texture can be important. Soil density and water content vary over short distances and affect water uptake by seeds, root penetration, and seedling emergence. Seeds planted into rough ground may not be covered to the same depth and will emerge at different times. Once plants have started to grow, differences in soil moisture and composition determine the resource supply to each plant and differences in the competitive ability of individuals are established. The differences in size and growth rate between individuals increase over time under continued stress, and large plants with more extensive root systems can better use the available resources for continued growth. Much of the variation observed in mature plants of all crops can be attributed to this early response to varied conditions. The phenotypic heterogeneity shown by members of crop plant populations is especially notable for traditional races because it expresses an underlying genetic heterogeneity as well.

The factors of temperature, water supply, and soil properties are not easily controlled by the primitive cultivator. Selection of field sites is based on perception of these abiotic factors and identification of locations where they will favor crop growth. An initial assumption was that the lower garden would be more productive than the upper, based on estimates of potential ecosystem productivity. However, overall crop performance was better both years at the upper garden. Although soil moisture levels were lower, the growing season was several weeks longer there and nighttime temperatures averaged 1 to 1.5 °C higher. Biotic factors must also be considered in site location, and will be considered next.

Biotic Factors Affecting Productivity

Important biotic factors affecting productivity include competition between crop plants, competition between crops and weeds, predation, and properties of different varieties and species of crops. The effects of these factors can be regulated by the activities of the cultivator. Spacing and density of crop plants, removal of weeds and predators, and selection of suitable crop varieties represent human manipulation of the agricultural system. Experimental studies can provide information for a model of prehistoric agriculture by identifying the conditions which are likely to ensure a reliable yield. By contrast to modern monoculture-based agricultural systems that emphasize maximum harvest of a single crop product, subsistence agricultural systems may be based on the exploitation rather than total removal of crop competitors such as weeds and predators. Recognition of these components of the system as additional resources brings a different perspective to the study of productivity, and suggests that low levels of competition and predation may be acceptable even though some crop yield loss is involved.

One goal in studying competition was to measure the effects on maize growth and yield of competition with annual weeds such as pigweed (*Amaranthus retroflexus*), goosefoot (*Chenopodium album*), and sunflower (*Helianthus annuus*) for durations of 0, 6, and 12 weeks into the growing season. Instead of these annual weeds, however, perennial weeds such as dogbane (*Apocynum cannabinum*) and wild licorice (*Glycyrrhiza lepidota*), and the introduced weeds bindweed (*Convolvulus arvensis*) and thistle (*Cirsium arvense*) were present as competitors, particularly in the lower garden. These perennials produced new shoots from perennial rootstocks after each weeding and were more persistent as competitors than annual weeds which are killed by uprooting. Growth, dry weight, and yield of ears of Hopi blue flour maize were all reduced by weed competition, especially at the lower garden where weed populations were higher. The effects of this competition with perennial weeds were more severe than would be expected from annual weeds because competition started earlier in the season and lasted over a longer time interval. The best course of action for a subsistence agriculturist faced with competition from perennial weeds would be to relocate the field to a site without these weeds.

The amount of crop loss due to predation depended on susceptibility of the crop variety, time of attack, type of pest, and garden location. Crops differed in their attractiveness to insect and vertebrate predators. For example, fewer grasshoppers attacked the prickly foliage of *Cucurbita pepo* than the soft, tender foliage of *C. moschata*. Ears of Apachito and Blanco maize had short husks which left kernels exposed to bird predators, but the ears of Hopi blue maize were well protected by long husks. Attack by predators early in the growing season can be devastating since a larger proportion of the plant biomass is destroyed by removal of each bite. Both generalist predators, such as rabbits, and specialists, such as corn earworms, were present in Dolores, but both types were more common at the lower garden than the upper garden. The increased plant cover provided better protection there and the increased humidity and moisture supply were utilized also. The most severe crop losses were to grasshoppers at the lower garden in 1980. They consumed most of the developing ears of maize and defoliated the bean plants repeatedly. This predation might have been reduced if turkeys had been introduced into the gardens to control the grasshopper population.

THE EFFECTS OF CROP PLANT DENSITY AND DISPERSION

In trial plots of Hopi blue flour maize, a range of densities from 0.8 to 2.5 plants/m^2 was achieved by varying the number of plants per hill (from 1 to 6) in plots of 25 hills spaced 1 by 1 m. In these plots, differences in plant growth due to density were not apparent during the growing season, but at maturity, plant height, number of tillers, and number of ears per plant were inversely proportional to density. Weight of mature ears per unit area, however, did not differ significantly between treatments. Within this range, the crop plant population as a whole compensated for density differences and produced a consistent yield, although individual plants were affected in their size and productivity. This suggests that precise regulation of crop plant populations is not necessary to achieve a certain yield at harvest.

For comparison, another plot of Hopi blue flour maize was planted at an intermediate overall density of 1.5 plants/m^2, but in hills of 12 to 15 plants spaced 3 by 3 m rather than in smaller, closely spaced hills. In these widely spaced hills, individual plants grew significantly taller, showed better drought resistance, and matured earlier than plants in the closely spaced hills. Number and weight of mature ears produced per unit area was significantly greater in the widely spaced hills. The superior performance of maize grown in widely spaced hills brings scientific support to a traditional Southwest practice (Beaglehole 1937). Improved growth and yield of these plants compared to closely spaced plants recommends the system. Another advantage, important to the hand cultivator, is that only one-sixth as many planting holes need to be dug and prepared in the wide spacing system.

VARIATION AMONG VARIETIES AND SPECIES OF CROPS

Races of maize and varieties and species of other crops showed variation in rate of growth, sensitivity to drought and predation, time of maturation, vegetative morphology, yield, and storage qualities. These differences need further study because they have important implications for potential productivity of the different crops. Within the maize crop, yields ranged from no mature ears in the race Chapalote to over 200 g/m^2 of mature ears in the Papago flour corn. For beans, *Phaseolus coccineus, P. acutifolius* and *P. vulgaris* produced up to 50 g/m^2 of dry beans. For squashes, *C. pepo* and *C. mixta* produced mature fruit in 1979 but only immature fruit in 1980. Other species of crops which produced mature fruits in Dolores are in accord with the archaeological record of crops cultivated in the area. Two crops, which are known from archaeological sites within 50 km of Dolores, did not grow to maturity in the gardens and were apparently most limited by cool temperatures and frosts. These are the bottle gourd (*Lagenaria siceraria*), and Hopi cotton (*Gossypium hirsutum*). In both cases, the plants flowered and initiated fruits just before frost but were unable to develop fully. More sheltered and warmer microsites within the Dolores region might be utilized for the cultivation of these crops, or they might be cultivated at lower elevations to the south or west of Dolores. A crop which is relatively unknown from prehistoric sites in the Southwest is the Indian tobacco (*Nicotiana*

rustica). This crop grew vigorously, produced abundant foliage, flowered in August, and matured viable seed. Its positive response to the growing conditions was so marked that its acceptance as a cultivar would seem to depend only on availability of seeds and not on any of the more complex biological adaptations (such as overcoming a photoperiodic response or developing cold-hardiness) that delayed the introduction of other crops.

The variability within a given crop species or variety is important not only during the growing season, in terms of plastic responses to environmental and biological factors, but also in terms of the morphology of harvested parts. For example, seeds of maize for planting in the demonstration plots were selected from single ears of each race. The plants which developed from these seeds ranged greatly in height and yield of mature ears, as might be expected in response to local variation in growing conditions and rate of maturation. Morphology of the ears was expected to be more conservative; however, mature ears from the race Cristalino varied in length from 6 to 25 cm, in row number from 10 to 14, and in kernel color from pale yellow to dark amber. Immature ears from the same race (which might be mixed with mature ears in a collection of archaeological remains) also varied in length, diameter, and degree of cob development and kernel maturation. This range of intraracial variation must be acknowledged when making interracial comparisons.

SUMMARY

1. Although potential productivity of ecosystems can be compared by sampling existing vegetation, the yield of crop products may not be proportional to total aboveground biomass production. Predation and early frost can cause crop losses. Immature fruits and other plant parts may be harvested and consumed, and in some cases, viable seed may be produced, even though fruits do not reach full maturity.

2. It is difficult to isolate and control the individual factors of temperature, water supply, and soil properties. Not only do these factors interact, but the effect of different conditions on plant growth changes over the course of the growing season. In Dolores, insufficient soil moisture was most critical at the stage of seed germination. Soil properties are most important to plants at the seedling stage. Cool night temperatures slowed plant growth prior to flowering and a short frost-free season terminated growth prior to maturity in many cases. Perception of the optimum levels of these abiotic factors is a consideration in choosing field locations.

3. Competition with weeds and predation both reduce crop yields, but these other components of the agricultural ecosystem can be used as alternate food resources. Density and dispersion of crop plants affect growth and yield. In maize, dispersal of hills had a significant effect, even when overall density was held constant. Plants from large hills spaced at 3 by 3 m grew taller, resisted drought better, matured earlier, and produced more mature ears per unit area than those in small hills spaced 1 by 1 m. Varieties and species of crops vary in their potential to grow and yield under specific environmental conditions, and within each crop much morphological variation is often observed.

MODELING WOOD RESOURCE DEPLETION IN THE GRASS MESA LOCALITY

by Timothy A. Kohler, William D. Lipe, Mary E. Floyd, and Robert A. Bye, Jr.

INTRODUCTION

Within the last 8 years, dramatically higher fossil fuel prices around the world have reawakened interest in the use of wood for fuel and sharpened our awareness of the ease with which wood resources can be depleted (Eckholm 1975). In this report the proposition that availability of wood for fuel and construction may have been an important influence on Anasazi development in the Dolores area in particular, and in the northern Southwest in general, is examined. The test case is the Grass Mesa Site (Site 5MT23), a large Pueblo I village near Dolores, Colorado. The study begins to address portions of DAP Research Design Problem Domain 1, Economy and Adaptation. In this problem domain, it is most relevant to Question 3, which asks, "How were . . . these resources used . . . within each temporal unit?" In discussions of how this question might be approached, the Research Design suggests the development of "models of expected usage patterns and their predicted archaeological residues for various resources" and that these models be tested to "define adaptive techniques and strategies for . . . used resources for each temporal unit" (Kane, Lipe et al. 1981). While this is a preliminary report, the authors anticipate fuller treatment of the use of wood resources for fuel and building materials, along the lines of inquiry suggested by the DAP Research Design.

The possibility of wood resource depletion in archaeological contexts has been proposed before — for example, in the Indus Valley civilization and even in the heavily wooded American Bottoms region of the midwestern U.S. For Plains Village groups, David Griffin has made the important observation that:

> timber resources may not need to be entirely decimated before rendering an area uninhabitable by . . . sedentary village populations . . . .The exhaustion of timber does not refer to a complete denudation, but rather to the [difficulty of] utilization of

particular kinds of trees and, perhaps more importantly, a limited size range of trees (Griffin 1977:183).

One of the best cases so far for a shift in wood species use due to probable exhaustion of resources comes from Dean's (1969) work at Betatakin and Kiet Siel, Tsegi Phase (late A.D. 1200's) sites in northeastern Arizona. In his analysis of the wood from Kiet Siel, Dean noted that the aspens and boxelders of the canyon bottoms appear to have been the first to have been used up, perhaps as a byproduct of the early clearing of bottomlands for fields. He concludes that the inhabitants of Kiet Siel nearly denuded the immediate vicinity of trees, despite the fact that Kiet Siel was probably never occupied by more than 150 people, and the major occupation spanned only 14 years.

Palynology and packrat midden studies in the Southwest have also suggested fairly extensive local depletion of forest resources in the vicinity of population centers. Don Wyckoff (1977) was able to demonstrate a postabandonment succession of plants on Chapin Mesa, Mesa Verde National Park, by using palynological data from a series of statigraphic events in the fill of Mummy Lake, a possible Anasazi reservoir. In this sequence, sage and composites dominated the earliest postabandonment levels, with a later increase in both pines and juniper at the expense of sage. Wyckoff attributes this sequence not to change in climate but to "secondary forest succession onto previously disturbed, cleared, and cultivated lands" (1977:1). More recently still, Betancourt and Van Devender (1980) have attempted to document a local reduction of the pinyon-juniper woodland in Chaco Canyon sometime between A.D. 720 and 1490, bracketing the major occupation of the canyon. Thus, both archaeological and paleoenvironmental data suggest that wood resource depletion may have been greater in some areas than has usually been acknowledged.

CULTURAL RESPONSES TO FOREST EXHAUSTION

Five general categories of responses to such depletion seem to be logical possibilities:

1. A change in species utilized for fuel and construction, as species accessible at the beginning of the occupation are exhausted and the quest for firewood and construction materials is carried farther afield. This might also include a switch to use of brush, or even corn cobs, for fuel.

2. Organizational responses such as scheduled group forays, or group stockpiling of material.

3. A shift from use of deadwood for fuel to cutting live trees and drying wood especially for fuel. This might involve girdling trees 1 or 2 years in advance to increase the standing crop of deadwood.

4. Conservation attempts, which might include building structures which require less and/or different kinds of wood, or building structures which are thermally more efficient to conserve fuel.

5. Finally, and probably most dramatically, a change in residence to a location with still plentiful forest resources.

Most of these implications have the desirable feature of being potentially visible in the archaeological record. However, most share the undesirable quality of also being test implications for hypotheses which are unrelated to wood resource depletion. For example, site relocation might just as easily be due to soil exhaustion, unfavorable climatic regimes, or a large series of other alternatives. Clearly, the careful study of wood resource depletion makes large demands on a data base, and requires information which might not normally be collected in the field by archaeologists.

THE GRASS MESA SITE

The Grass Mesa site and its locality were not as heavily occupied as the Indus Valley or the American Bottoms, nor are they as arid as Chaco Canyon or Tsegi Canyon, in which Kiet Siel is found. Grass Mesa provides a conservative test case for the hypothesis of wood resource depletion. Because this is a pilot study (and a preliminary report), the authors have chosen to concentrate on just one site for now. If the present study suggests that wood resource depletion may have been serious around this site, then consideration will be given to widening the study to include a greater area.

The average elevation of DAP sites is around 2070 m (6800 ft), and the average annual precipitation, about 460 mm, is more than most of the Anasazi Culture Area receives. The Grass Mesa site sits atop a prominent wedge of sandstone intruding into the flood plain of the Dolores River at its confluence with Beaver Creek and Dry Canyon. In the 13-km^2 area of the surrounding Grass Mesa Locality, pinyon-juniper is by far the most common association today, dominating the west- and south-facing slopes of the canyon wall and much of the high dip slope south and west of the canyon. The Douglas-fir association, next in abundance, is primarily limited to the cooler and moister north-facing slopes of the canyon wall. Gambel oak is today an important species in both these associations, but may not have been so at the time of occupation.

The riparian association, approximately equal in modern extent to the Douglas-fir association in the locality, is dominated by cottonwood and boxelder, both rapidly growing trees. The last major association, the ponderosa pine association, is most common beyond the canyon rim to the northeast, but individual ponderosas are occasionally found in most of the other associations as well. Today ponderosa is dominant in only about 5 percent of a 1-km

radius circle drawn around the Grass Mesa site, but may have been more important at the time of occupation.

Paleoenvironments

The paleoenvironmental detail sufficient to translate data on modern vegetation into probable vegetation at the time of occupation is not yet adequately available, nor are the structural studies from all the modern vegetation associations yet complete. Pollen studies from the La Plata Mountains to the east of the study area indicate that from about A.D. 800 to 1050, the region was probably slightly cooler, but with about the same amount and seasonal distribution of annual precipitation, as today (Petersen 1981a). If studies now in progress on packrat middens and tree rings support this, then distributions of modern vegetation, after subtracting the effects of modern disturbance, can be used as a fairly good analog for the vegetation at the time of occupation. One probably significant recent disturbance factor, the effects of which are poorly understood and need further local study, is grazing.

The Magnitude of the Present Resources

For this study, the potential resources within a 1-km radius around the site are considered. According to a DAP draft potential natural vegetation map, this zone contained about 170 ha of pinyon-juniper, 56 ha of Douglas-fir, 65 ha of riparian vegetation, 15 ha of ponderosa pine, and smaller amounts of bare sandstone and active stream channel. Based on preliminary structural studies of the associations and on a review of the literature, numbers of trees with probable size distributions (assuming mixed-age mature stands) can be assigned to each of these associations (table 19). The structural studies make it possible to estimate the proportion of each of these stands that would be suitably straight for various construction uses.

Table 19. Tree stands surrounding Grass Mesa (Site 5MT23)

Species	Density per hectare			
	< 6 cm	6-10 cm	> 10 cm	Total
Pinyon-	482	73	433	988
Juniper	119	40	119	278
Ponderosa	138	89	114	341
Douglas-fir	200	130	166	496
Cottonwood	511	333	1067	1911

Estimates of dead fuel loadings (that is, the forest floor combustibles available at the beginning of occupation) in Southwestern ponderosa pine stands can be obtained from Sackett (1979), who computed a mean value of all dead fuel larger than 2.5 cm (1 in) in diameter at 9.2 (short) tons/acre in a sample of 62 mature stands. Since some of that would be too large or too rotten to utilize conveniently, a standard figure of 5 tons/acre or 11 tons (metric)/hectare for ponderosa has been used. The same figure has been applied to the Douglas-fir and riparian stands, for which no comparable studies can be found. For pinyon-juniper the somewhat smaller figure of 9 tons usable fuel loadings per hectare was used, which may be too liberal. Dead fuel loadings for a 1-km radius around Grass Mesa are presented in table 20.

Rates of production of deadwood in mature stands of various types do not seem to have been studied intensively. The best figures available in the literature have been used (table 21), but more local work on this problem is needed.

Table 20. Dead fuel loadings within a 1-km radius of Grass Mesa (Site 5MT23)

	Pinyon-Juniper	Ponderosa	Douglas-fir	Riparian
Hectares	170	15	56	65
Tons (metric)	1530	165	616	715
Total fuel available at beginning of occupation = 3032 tons				

Table 21. Rates of deadwood production

Stand type	Total annual production tons/hectare	Usable annual production tons/hectare
Pinyon-Juniper	0.2	0.1
Ponderosa	0.3	0.1
Douglas-fir	0.3	0.1
Riparian	6.0	1.0

Patterns of Wood Use

Given this environmental information, the next question of interest is which of these resources were being used, and for what purposes? Figure 35 shows the relative frequencies of archaeological remains for species used for construction on the mesa. Most of this sample is from pitstructures, although some surface structures are also included. Ponderosa and juniper were the woods most commonly used for uprights and primary roof beams, with Salicaceae (probably mostly cottonwood) most popular for secondaries and roof closing material. For fuel use the sample so far available is dismally small, since not all the botanical data for the 1979 and 1980 seasons are yet available; so far juniper and pinyon seem to be the materials of choice. Incidentally, Dean (1969) reported that pinyon and juniper were the species most frequently represented in the firepits at Kiet Siel.

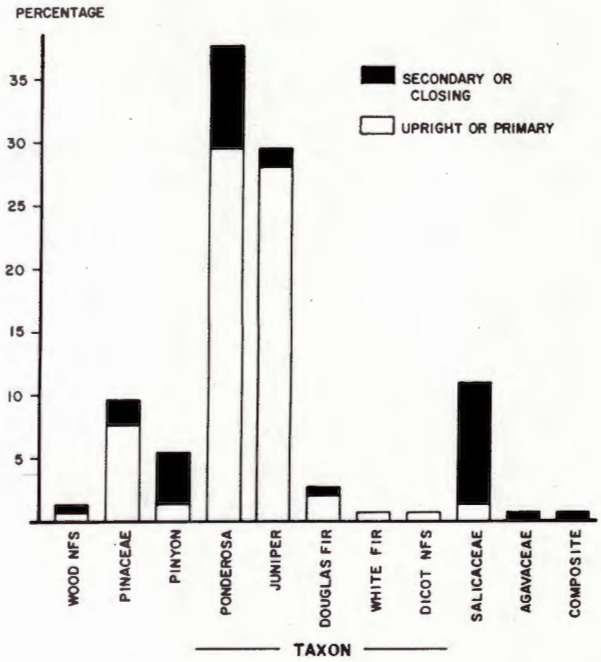


Figure 35. Relative frequencies of construction materials (Site 5MT23).

It is somewhat more difficult to arrive at rates of wood use. The authors' approach has been to estimate average sizes of construction elements based on observations made by field workers plus measurements taken on a sample of 16 post-A.D. 750 pitstructures in the project area. This is followed by an estimate for the number of pitstructures at Grass Mesa. The same method was used for the surface structures. Estimates of average lengths of construction elements are probably more accurate than estimates of diameters (table 22).

Rates of firewood consumption must be derived through very indirect means. The present study uses a figure obtained by taking the mean per capita firewood consumption for three nonindustrialized countries studied by the Food and Agriculture Organization of the United Nations Educational, Scientific, and Cultural Organization — Tanzania, Gambia, and Thailand. The figure arrived at in this

Table 22. Wood requirements for structures at Grass Mesa (Site 5MT23)

Structure type	Part	Average number	Average length (m)	Average diameter (cm)
Pitstructure	Main supports	4	2.5	18
	Main roof primaries	4	3.5	15
	Roof subprimaries	2	3.5	13
	Roof secondaries	53	1.7	7
	Stringers/leaners	60	1.3	7
Surface room/small	Main posts	4	2.3	12
	Long primaries	2	2.0	10
	Short primaries	2	1.2	8
	Secondaries	15	1.2	6
Surface room/large	Main posts	4	2.3	15
	Long primaries	2	4.4	15
	Long subprimaries	1	4.4	13
	Short primaries	2	2.0	10
	Secondaries	30	2.9	7

NOTE: Figures for surface structures assume no posts in walls. In fact, jacal walls were sometimes used in surface construction, especially prior to the late 800's.

manner is 1.4 tons/person a year (Openshaw 1974). Rates of wood use in modern Navajo families cited by Lamphere (1977:138-143) seem to be roughly comparable to these figures.

Another bit of evidence needed is a probable population and construction curve for the site. Based partly on the results of the probability sample to date and partly on informed guesses, a total figure of about 145 pitstructures and 725 surface structures built during the occupation of the site has been derived (table 23). Many of these surface structures appear smaller, however, than the rooms in the standard late Pueblo I surface "apartment" units on which the estimates in table 22 were based.

Table 23. Estimates for numbers of structures, Grass Mesa (Site 5MT23)

Area	Pitstructures		Surface structures	
	$\hat{X}$*	95% CI**	$\hat{X}$*	95% CI**
1	0	0	6	73
2	10	81	0	0
3	8	26	109	346
4	17	55	14	44
5	81	74	419	341
6	—	—	—	—
7	5	70	64	922
8	—	—	—	—
Total, areas sampled	121	111	612	860
Multiplier for portion not yet sampled	1.2		1.2	
Total estimates	145		725	

*estimated population total.
**95 percent confidence interval for the estimate.

Finally, all available information was used to estimate the numbers of structures and people on the site by 25-year intervals from A.D. 775 to 925 (table 24). Intervals of 25 years were used since they are believed to also represent the approximate lifespan of the structures. The resultant curve describes a small colonizing population around A.D. 775, rising to a maximum of 300 inhabitants between A.D. 875 and 900 and then falling off rapidly.

Estimating Severity of Depletion

Using these approximations, it appears that about 60 people could have lived on the mesa without using more firewood than was ordinarily produced within 1 km of the site. However, if the riparian vegetation — a major potential producer of firewood — had been largely cleared for fields, this equilibrium figure drops to only about 25 people. Assuming no river-bottom clearing for fields and no significant alteration of the mature stand structure by cutting for either firewood or construction — the most conservative scenario — the readily available fuel within 1 km of the site, including initial deadfuel loadings, would have been exhausted between A.D. 850 and 875. After this time, attempts to expand collecting in any direction but into the uplands to the east of the site could have met with opposition from the inhabitants of the targeted areas, who presumably had similar wood needs. If the riparian vegetation had been cleared for fields, the use of upland resources would have been forced earlier and travel times would have been longer. If girdling of trees between 5 and 10 cm in diameter was practiced intensively, initial average travel times for fuel would have decreased, but travel times for structural materials would have increased.

Would construction materials also have become scarce by this time? Tentatively, it appears that there would have been some depletion of construction materials. However, since these materials are needed occasionally, rather than daily, the impact of such scarcities might not have been as great as the impact of the increasing collection time for firewood.

Evidence for Change in Wood Use through Time on Grass Mesa

In the samples so far available for study, there are two major trends of change in wood species used. In the earliest occupation (although the sample is terribly small) juniper is the only wood species represented (fig. 36). From A.D. 800 to 850, other woods appear as construction materials, including ponderosa and Douglas-fir (fig. 37). During the peak of occupation, in the last half of the ninth century, cottonwood and pinyon first appear as building materials.

Table 24. Population estimates for Grass Mesa (Site 5MT23) in 25-year intervals

	775-800	800-825	825-850	850-875	875-900	900-925
Pitstructures	2	2	10	50	60	21
Surface structures	10	10	50	250	300	105
People	10	10	50	250	300	105

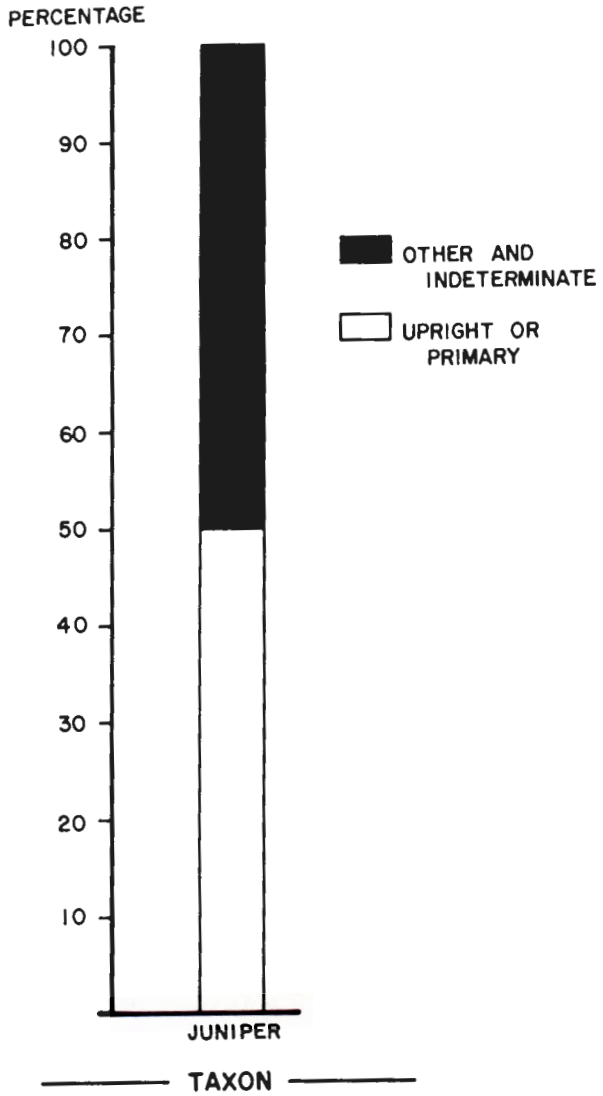


Figure 36. Percentages of wood species before A.D. 800 (Site 5MT23).

The use of juniper continues to decrease during this period (fig. 38). Finally, during the last years of occupation at the site, cottonwood remains an important species and Douglas-fir increases in relative importance. Juniper remains at about the same level as in the third period (fig. 39). The most apparent trends are the increase in the use of cottonwood, Douglas-fir, ponderosa, and pinyon, and a decrease in the use of juniper during the occupation of the site.

There are also definite changes in building practices through time at the site, including the increasing use of surface structures for habitation. The possibility that these changes may be partly interpretable as adaptations to scarcity of wood cannot be discounted.

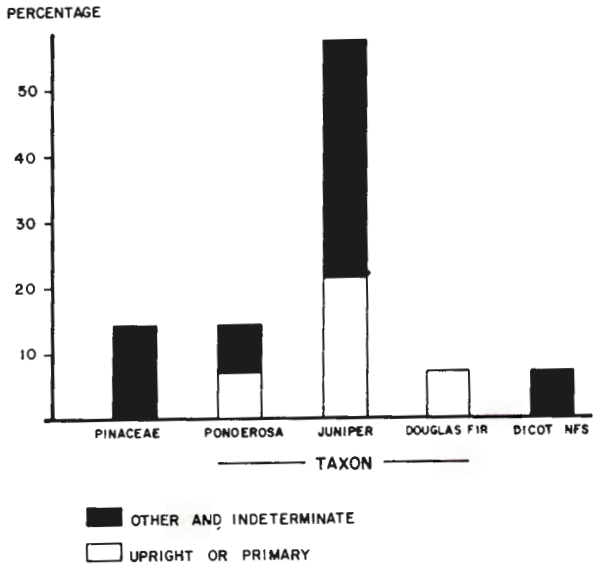


Figure 37. Percentages of wood species, A.D. 800-849 (Site 5MT23).

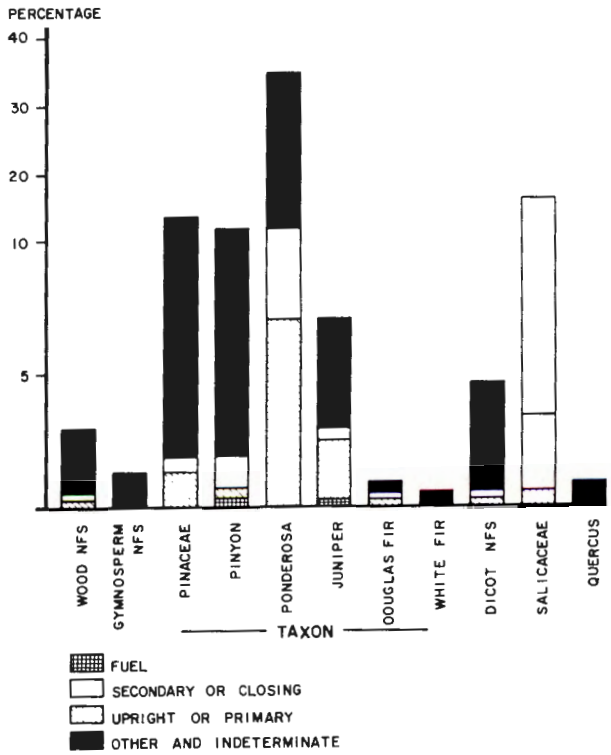


Figure 38. Percentages of wood species, A.D. 850-899 (Site 5MT23).

SUMMARY AND CONCLUSIONS

Some of the elements which were predicted as potential consequences of wood resource depletion do appear in the

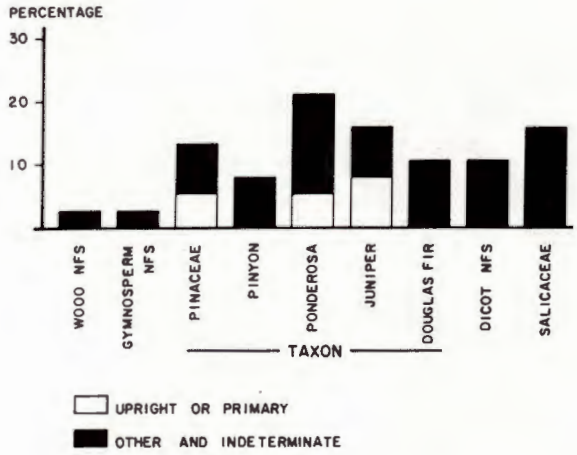


Figure 39. Percentages of wood species after A.D. 900 (Site 5MT23).

archaeological record on Grass Mesa, including changes in species used, changes in building practices, and ultimately site abandonment. To be able to seriously propose that these changes are due to wood resource depletion and not to other equally plausible factors, it would be necessary to show that forest depletion is possible or even likely, and then to demonstrate that the alternative hypotheses which can be put forward to explain these same changes can be discounted. To make further progress with the first part of that program, outside funding is being sought to develop a simulation complex enough to deal with many interacting factors ignored in this trial attempt — factors such as the relationship of deadwood production to changes in stand structure due to harvesting for construction and fuel. The problem of reuse of timbers has also been ignored here, as has the possible use of brush for fuel. To make progress on the second aspect of the project, a wide range of data from the continuing excavations of the DAP is needed.

Unless some of the values used here are quite erroneous, it does appear that some depletion of wood resources in the vicinity of Grass Mesa is likely. Given the nature of the environment, this depletion is not so drastic as, say, the present-day exhaustion of the Hopi mesas. Would a walk of 2 or 3 km for firewood and structural timbers be enough to provoke a change in habits? The energy embodied in such materials versus the energy cost of various alternatives needs to be examined.

This study suggests that the impact on the local environment surrounding Grass Mesa may not have been total alteration of the plant associations, but rather the removal of all deadwood and of much of the timber smaller than 10 cm in diameter in a fairly large area around the site. This would presumably have different effects on the understory in different associations: in the ponderosa, a kind of park-like environment might result, while in riparian, pinyon-juniper, and Douglas-fir stands, a brushy understory would probably grow up unless other factors, such as fire, worked to prevent this. The effect of the removal of these smaller trees from each association probably would not have been immediately apparent, but as senescent trees were not replaced, stand maintenance would have been seriously impaired. The length of time that harvesting could be sustained in particular size classes without reducing stand maintenance potential is one of the many topics for future investigation. If trees of larger size classes were indiscriminately girdled, of course, the impact on stand reproductive potential would have been more immediate.

Section 5

CERAMIC STUDIES

by Scott E. Travis and Eric Blinman

MODELING LEVELS OF SOCIOECONOMIC INTERACTION WITHIN THE DOLORES RIVER VALLEY: A TENTATIVE ASSESSMENT

by Scott E. Travis

BASIC ORIENTATION, METHODS, AND ASSUMPTIONS

The questions of intra- and interregional interaction and/or exchange has both intrigued and perplexed archaeologists for quite some time. Historically, this aspect of Anasazi organizational systems has invariably been dealt with on an impressionistic level by identifying supposed stylistic variability in everything from ceramics to architectural forms. These observations have relied upon diffusion, trade, migratory movement, and social interaction to create simplistic and incautious interpretations. More recently, however, socioeconomic interaction has been examined in an analytical fashion, emphasizing detailed chemical-physical material source analysis (Bishop 1980; Deutchman 1980; Earle and Ericson 1977; Hammond et al. 1977; Weigand et al. 1977; Wilson 1978), use of analog models employing ethnographic and ethnohistoric information (Arnold 1971; Bates and Lees 1977; Dalton 1977), and the integration of systems theory with geographic modeling (Hodder and Orton 1976; Irwin-Williams 1977; Johnson 1975; Kelly 1976; Renfrew 1977; Smith 1976). Efforts such as these have resulted in an expanding body of archaeological literature which explores a spectrum of socioeconomic behavior from band to state level social organization and from local to regional geographic levels. The following discussion examines the potential of DAP ceramic assemblages in relation to more recent techniques of exchange system analysis and outlines some aspects of a tentative distributional patterning. The ultimate utility of the investigation may then be viewed in terms of an increasing sensitivity towards data variability, and a clarification

of the unique role that the Dolores River occupation played in prehistoric Anasazi exchange systems.

Encouraging as the more recent analytical procedures are, many conceptual problems do exist. In addition to the inherently problematic issues of postdepositional preservation and retrieval are those difficulties in distinguishing the constituent elements of any exchange network — the material attributes, distribution, magnitude, and directionality of exchange. Consequently, the examination of exchange should proceed with the discrimination of local/nonlocal material origin, technoenvironmental relationships, and hierarchical levels of socioeconomic interaction. Within each of these realms of inquiry, basic characteristics, analytical assumptions, and modeling constructs need to be explicitly formulated. These orientations provide the focus and motivation of the DAP exchange system analysis.

Differentiation of local and nonlocal ceramics is based on microscopic discrimination of temper types, field survey of local clay, temper and paint sources, minimal amounts of petrographic analysis (Kamilli),[7] and oxidation attributes of ceramic pastes. The analytical assumptions within this framework include:

1. Variability in temper and clay types is related to ceramic assemblage material variability (Lucius 1981c).

2. In accordance with the "Provenience Postulate," this variability may be recognized by compositional differences among spatially distinct clay and temper resources (Weigand et al. 1977).

3. Refiring of ceramic paste standardizes the oxidation states of iron compounds and therfore provides a scale (color spectrum) with which to distinguish clay sources (Shepard 1956).

Broad areal generalization concerning the correlation of regional traditions with temper, paint, and slip types has provided a rough guide in assessing geographical origin and technological tradition (Breternitz et al. 1974; Colton 1955, 1956, 1958). Unfortunately, with the exception of contributions from the Chaco Center (Toll et al. 1980; Toll 1981), the Salmon Ruin Project (Franklin 1979; Wilson 1981), and Shepard's studies in the La Plata area (1939), little has been done in this regard for clays within the Four Corners region. A summary of the distribution and relevant characteristics of clay, temper, and paint resources within the project boundaries can be found below in the discussion of local ceramic material resource availability.

Turning now to technoenvironmental relationships, one moves into the realm of identifying procurement-production zones on the local level. This concept is defined as the spatial relationships among resource availability, procurement activities (energy expenditure) involved in the extraction of a resource, and the technological processes which convert a resource from the natural to the cultural system.

> In an investigation that places heavy emphasis on ceramic paste composition as a guide to trade, it is operationally expedient to assume a one-to-one relationship between procurement zones for raw materials and production zones for pottery manufacture. In accordance with the principle of least cost, we suspect that these zones are usually equivalent in an approximate way (Rands and Bishop 1980:19).

While these observations may be accurate, certain doubts arise when manufacturing loci lie in equal proximity to compositionally distinct, and technologically usable, clays. This situation distorts the least-cost models by introducing the possibility of variable clay selection by a single manufacturing locus due to idiosyncratic, functional, or social factors (Rands and Bishop 1980). Arnold (1975, 1980) has addressed these problems in ceramic ecology within modern pottery manufacturing communitites of both the Ayacucho Basin, Peru; and Ticul, Yucatan. His results depict the elegant relationship of source, space, and manufacturing site — in each instance geographical proximity to clay resources and highly specified, patterned exploitation of those resources being characteristic. Energy expended in the extraction of resources is also of concern in any portrayal of ceramic ecology. Foley (1977) has succinctly described the significant features which may be assessed, although he deals with the extractive value of biomass resources rather than those of a geological origin.

A further characteristic of interest is whether or not craft specialization may be observed in the system. Again, Arnold (1975) has presented organizational conditions which would indicate ceramic craft specialization among horticultural societies — in all cases being reflective of either restricted access to, or total lack of, agricultural lands. This query of craft specialization becomes important since rudimentary modeling efforts by the DAP tend to imply population increase and consequent agricultural stress. Present evidence tentatively indicates increasing areal specialization, and therefore decreasing heterogeneity in locally used paste compostional groups, after A.D. 900. Prior to this time, however, substantial confusion continues to exist over whether or not all habitations within a procurement-production zone were manufacturing pottery, a situation which has been similarly seen in the Southwest by Plog (1980).

Translating the above perceptions into an archaeological context can be very disconcerting. Ideally, the one-to-one correspondence between resources and identifiable ceramic

[7] Diana C. Kamilli, University of Colorado, Boulder, personal communication.

manufacturing loci should be visible in the archaeological record. Disapppointingly, this is often next to impossible given the aforementioned postdepositional status. Therefore, the critical analytical assumption is that:

> pottery of a specific paste compositional group should normally have been manufactured in the locality in which it is best represented. . . . [and thus] frequencies [emphasis added] of a compositional group according to archaeological provenience serve as a guide to the general location of clay procurement zones (Rands and Bishop 1980:20).

Modeling of procurement-production zones is simplified by the analytical assumptions outlined above. In its most reified form, a model of local, utilitarian ware manufacture includes spatially restricted procurement zones; either singular or multiple manufacturing loci; and relative homogeneity in clay-temper combinations, and technological and stylistic attributes. Implicit within this structure are rather slow rates of change. The production of local, nonutilitarian wares (e.g., white ware bowls or jars) would be expected to have a more restricted procurement-production zone resulting from exploitation of a specific clay resource as well as being subject to increasing rates of modification in response to stylistic variability.

> By determining the chemical and mineralogical composition of the pottery, and by relating the compositional data to the distribution of clay types and other natural resources used in ceramic production, one may infer the location of distinct centers of pottery manufacture. . . . In combination with traditional archaeological ceramic attributes, these analytical data will provide an empirical base for reconstructing the related aspects of socioeconomic and political organization (Bishop 1980:47).

Exchange differs from the procurement-production zone concept in that there is distribution of manufactured items through either informal or formal mechanisms and on levels ranging from the local to the interregional. Exchange, then, represents a sociocultural process; whereas a procurement-production zone depicts a spatially bound geographical area characterized by consistency in procurement and ceramic manufacture, i.e., a manufacturing community. The operational pragmatics of modeling exchange systems present innumerable pitfalls; for the levels of sociocultural/socioeconomic organization, postdepositional processes, and temporal modification must always be accounted for. Preliminary distributional analyses of the DAP ceramic assemblages indicate that socioeconomic analog models, employing ethnographic and geographical systematics, will need to be constructed for multiple, overlapping exchange networks. A partial listing of these networks encompasses modeling the following: exchange of local, utilitarian gray wares and nonutilitarian white wares within dispersed and agglomerative (village) horticultural societies; intraregional exchange of utilitarian and nonutilitarian wares between multiple manufacturing loci and differential ecological-settlement systems; and interregional exchange of variable ware, vessel, and stylistic types within socioeconomic systems.

With the recognition that the exchange systems identified within the DAP are inherently complex, systematic procedures of characterization and modeling are required. Plog (1977) has defined nine exchange system attributes which should be examined in modeling exercises.

1. What is the artifactual content of the exchange network — the overall range of materials that are being exchanged?

2. What is the magnitude or frequency of those materials being exchanged?

3. What is the diversity or variability of materials being exchanged in terms of form, style, or material attributes?

4. What is the spatial extent of the exchange system — the territory over which exchange operates?

5. What was the temporal duration and rate of modification in the exchange network?

6. What is the directionality of the network — where do materials begin and where do they end?

7. What are the symmetrical qualities of the system — variability in magnitude of directionality and in overall shape of network?

8. Evidence of network centralization — a pattern wherein substantially greater amounts of material exist in specified segments of the network?

9. What is the overall network complexity — variability in the degree of integration seen in the various levels of the exchange network?

The assumptions of exchange system modeling therefore acknowledge the relationship between manufacturing behavior and the distributional patterning of ceramic artifacts. Any variability within patterns may in turn reflect different network formats and/or levels. That systems of exchange may be quite rudimentary or highly complex should be apparent. Equally important, however, are the many permutations which may occur at the juncture of local, intra-, and interregional levels of exchange. Attributes such as these dictate the formalization of analytical categories in any modeling procedure — categories which are implicitly ideal, frequently static, and segregated only for purposes of investigation. The following categories of

exchange explore relationships thought to exist within the northern San Juan Anasazi, although their generality would make them amenable to any embedded exchange networks of similar sociocultural complexity. While exchange is in no way limited to ceramics, the focus of these models are, and thus should be interpreted accordingly.

Localized Exchange Network

This level of exchange refers to the distribution of materials from a procurement-production zone throughout a consistently interacting community of individuals, whether related or not.

1. Content of network limited by manufacturing homogeneity and the primarily reciprocal nature of relationships — refers to the entire range of materials exchanged within the localized network.

2. Magnitude and role of exchange relatively high due to internal interaction.

3. Diversity of ceramic assemblage generally low, since exchange usually involves utilitarian and gift items.

4. Spatial extent of system bounded — limited territorial coverage.

5. Modification of system slow due to constancy of manufacturing traditions and social organization.

6. Directionality of network roughly equal due to reciprocal relationship.

7. Symmetry or shape of system may be correlated to shape of settlement system constituting community.

8. Centralization low to nonexistent except in instances of socioeconomically complex chiefdoms.

9. Complexity low.

10. Exchange can be seen as a function of social organization involving the balancing of resources within a community, maintenance of kin alliances, etc.

Intraregional Exchange Network

The primary characteristics of this level are the redistribution of resources from ecologically diverse areas, maintenance of sociopolitical alliances, and potential reinforcement of kin-based alliances. Intraregional exchange implies geographical proximity in all instances.

1. Content of network extensive due to ecological redistribution and manufacturing heterogeneity — interaction of manufacturing tracts (Lucius, appendix C, this report).

2. Magnitude of exchange moderate given distance-limiting factors.

3. Material and technological diversity apt to be high since multiple manufacturing loci are characteristic.

4. Spatial extent of system variable given ecological characteristics — frequently loosely bound.

5. Change proceeds at a moderate pace.

6. Directionality can be quite diverse given multiple centers of material distribution.

7. Symmetry of the system tends to be variable and more or less unpredictable.

8. Centralization may be moderate for systems employing redistribution on a more formalized scale.

9. Complexity is variable.

10. Exchange is primarily a function of nonkin-based socioeconomic organization, although social alliances cannot be ruled out.

Interregional Exchange Network

This indicates a level of exchange generally regulated in some fashion by political, economic, or religious functionaries. Implicit within this level of exchange are forms of structured trade.

1. Content of network can be quite extensive due to manufacturing diversity, economic redistribution from multiple loci, and socioeconomic intensification of exchange systems.

2. Magnitude of exchange variable given socioeconomic and sociopolitical factors.

3. Within any one regional interface, diversity of ceramic material will tend to be low due to stylistic and functional valuation; increasing amounts of diversity will occur with the addition of other interregional networks.

4. Spatial extent of system extensive — for all intents and purposes system is bounded only by its own capacity to expand.

5. Change can be rapid and unpredictable.

6. Directionality must be seen as unimodal since one can only determine the end point of most exchanged materials.

7. Symmetry highly variable, but does generally follow predictable paths, e.g., linear, branching, etc.

8. Centralization potential high due to controlled nature of systems.

9. Complexity generally high due to multiple interface with localized and intraregional systems.

10. Exchange mechanisms within this type of network invariably a function of economic interaction.

In using these network models, a few qualifications need to be made. First, each of the models represents polythetic rather than monothetic constructs. That is, a network of exchange may be characterized as local and yet not incorporate all of the attributes listed. Clearly, as an ideal manifestation, these exchange typologies are genus-like groupings which give the broadest possible range of characteristics. Any given local exchange network would then be seen as a subset of the genus and therefore analogous to a species (Dalton 1981). Second, it is important to realize that within a specific society (e.g., Pueblo I Anasazi) networks may all be operating simultaneously along either independent (an unlikely event) or interacting formats. Obviously, the differences between network potential and variability in small political-jural communities versus that in cephalous chiefdoms should be kept firmly in mind.

In summary, then, the orientation of investigation recognizes the logical necessity of beginning with the environmental-procurement interface, subsequently moving to technological/stylistic variability, and finally to examining how and why materials are distributed through space (Harris 1979). The general DAP Research Design provides a further structure of inquiry by detailing various problem domains within which procurement, production, and exchange may be appraised. Problem Domain 1, Economy and Adaptations, is directly juxtaposed to the goals of designating procurement-production zones — the assessment of environmental-technological interaction. The analysis of exchange systems, on the other hand, can be advantageous in addressing Problem Domains 3, 4, and 5. By characterizing local exchange, advances can be made in elucidating community social organization. The potential for this level of analysis to depict natural rather than arbitrarily defined systems of interaction is self-evident. In fact an argument can be made in support of the priority of localized exchange system analysis in comparison to nonlocal investigations (Arnold 1980; DeGarmo 1977; Bishop 1980).

Extraregional Relationships, Problem Domain 4, encompasses both nonlocal exchange and actual population interaction via migration, expeditionary activities, etc. The importance of the DAP ceramic assemblages appears considerable in regard to extraregional interaction. Characteristically, nonlocal ceramics are a consistent feature in most site assemblages, implying that exchange occurred on a constant basis. This characterization goes one step further, however, by indicating that the exchange occurring in the geographically peripheral Dolores River valley, from approximately A.D. 600 to 900, represents a developmental form of intra- and interregional exchange prior to the emergence of the Chacoan system. Given these contributions to the interpretation of extraregional interactions, one may easily comprehend the potential of studying sociocultural change (Problem Domain 5) using these approaches.

Local Ceramic Material Resource Availability

Field sampling of local ceramic resources — clay, temper, and paint — has produced 50 clay, 13 temper, and 2 mineral paint samples. These materials were for the most part collected by systematically surveying geological strata suspected of containing clay deposits, along with a selection of temper materials throughout the project area. Earlier collections were obtained in periodic trips to the field and therefore represent an unsystematic sample. In accordance with procedures established for the Material Source Sampling Program, geographical location, surrounding geological setting, stratigraphic positioning, and sample characteristics were documented.

All of the clay samples were treated in a similar fashion to ensure analytical comparability. Clays were screened, ground, mixed with water, and compressed into uniform tiles for firing purposes. Quantitative attributes recorded both before and after firing were Munsell color, weight, and shrinkage, while qualitative attributes included plasticity, preparation necessities, texture, bloating, and nonplastic inclusions. Selection of these attributes was based upon both analytical and cognitive criteria. Temper samples were reduced to an appropriate grain size by grinding and incorporated into tiles for firing. Similarly, the paint samples were ground to a powder consistency, mixed with liquid binders, and applied to tile surfaces for oxidation experiments. Each of the procedures was designed to measure the effects of a constant firing temperature/atmosphere and to clarify attributes identified in preliminary analysis. The ultimate purpose of these investigations was to establish a comparative data base within which to assess local versus nonlocal ceramic origin.

The geographical extent of clay resources within the Dolores River valley (fig. 40) is somewhat distorted in that point-located samples frequently minimize the spatial dimensions of a resource. Also, modern disruption of natural hillsides, drainages, and outcrops reveals a pattern of distribution no doubt quite dissimilar to that encountered prehistorically. In general, however, there are relatively high frequencies of clay in association with the Morrison and Mancos Formations, with lesser amounts seen in a very thin band of carbonaceous shales in the Dakota Sandstone.

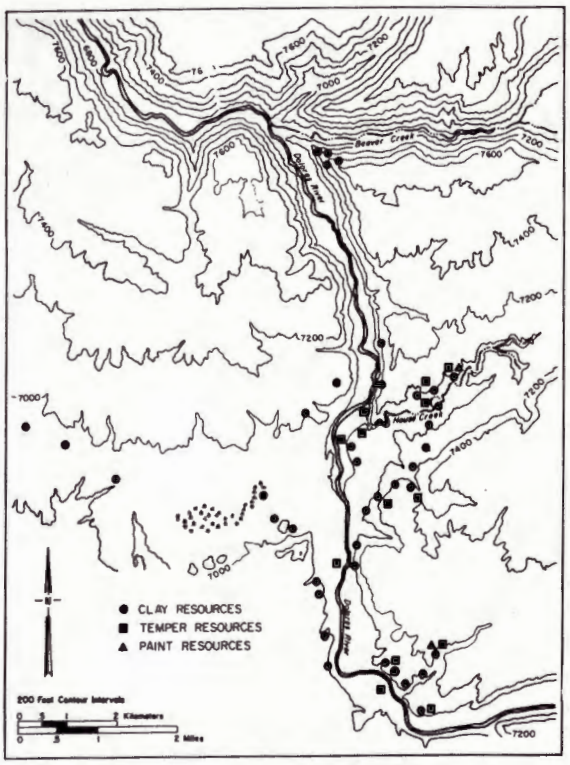


Figure 40. Distribution of ceramic resource sampling sites. (A single symbol may indicate more than one site.)

Even though most of the Morrison clays sampled have been exposed by fairly recent roadcuts, the Mancos Formation, as evidenced in various hillocks and residual outcroppings, has probably changed only minimally in the last 1500 years. Further clay sources of variable quality are located in the Burro Canyon Formation and in small sedimentary deposits in association with hillside drainages. A schematic plan of clay distribution may be obtained by examining the Preliminary Geologic Map of the DAP (Leonhardy and Clay 1981).

Having established the frequency of clay occurrence, it is also necessary to consider clay variability. Variability is not only a definable characteristic of the clay resources, but is also a major factor in accounting for patterns of selection and utilization. Certain clays are superior to others in the manufacture of pottery, leading one to speculate that only a minimum number of clay sources were ever utilized in the river valley. Oxidation evidence, however, refutes this position, establishing instead a situation wherein multiple clay sources, with spatially diverse locations, were being used.

Tempering materials are equally well distributed within the project area. These materials include dioritic rock of igneous origin in the form of river cobbles, sandstones, conglomerates, and various types of riverine sand. In comparison, the distribution of paint resources is so limited that one can only conclude that paint materials were obtained from areas external to the project boundaries. Any attempt at revealing a correlation between these ceramic resources and the prehistoric settlement systems is premature at this time.

In summarizing the qualitative/quantitative attributes of the individual clay samples, one conclusion becomes immediately apparent — variability is characteristic for the entire sample as well as for single depositional formations. Postoxidation Munsell color, reflecting the proportional amounts of iron oxides within the clay specimens, expresses a continuum of red (2.5YR-10R, value 8 and lower), yellow-red (5YR, value 8 and lower to 7.5YR, value 7 and lower), pink (10R-5YR, value 9 and above; 7.5YR, value 8 and above), yellow-red-buff (10YR, value 9 and above), buff (2.5Y-5Y, value 9 and above), and gray-brown (10R-5Y, chroma equals 2; 10YR, value 7 and lower). These categories provide for a simplified data structure for comparing raw clay from source areas, prepared clays within sites, and locally manufactured ceramics. By engaging in comparisons of this sort, rough approximations of source-site utilization profiles and eventually procurement-production zones, may be accomplished.

The attributes of weight and shrinkage also reveal considerable variability. Weight loss after firing may be due to absorption capacity or amounts of carbonaceous materials, and in general does little to clarify the desirability of a given clay. Shrinkage, however, is considered a critical attribute in the selection of clays for pottery manufacture — excessive shrinkage indicating a fairly plastic, but rather difficult to control clay. The range of weight loss is from 8 percent to slightly over 39 percent. Prefiring shrinkage varies from a low of 2 percent to a high of 16 percent; whereas postfiring values range from 1 to 6 percent.

As expected, substantial variability exists in plasticity and texture, while lesser amounts are noted for both preparation necessities and bloating. The variability in nonplastic inclusions presents such a confusing picture, especially without the aid of petrographic analysis, that its usefulness is questionable. Table 25 summarizes the variability in clay attributes for each of the larger geological orders of Morrison, Mancos, Dakota, Burro Canyon, and sedimentary deposits. This summary suggests that the clays of the Dakota and Mancos Formations are more desirable from a utilization standpoint. Redeposited clays such as those formed in marshy areas, while having excellent plasticity and texture, tend to be more difficult to control under primitive firing conditions. In contrast, the Morrison and Burro Canyon Formation clays are less desirable given their marginal plasticity, coarse texture, and tendency towards vitrification.

Observable variability in the temper and paint resources is limited to macroscopic levels. Each of the individual

Table 25. Summary of clay variability within geological formations*

Geological formations	Munsell paste color categories	% mean weight loss, postfiring	% shrinkage pre-firing	% shrinkage post-firing	Plasticity	Preparation	Texture	Bloating
Morrison Formation N = 12	Categories: Red-6 Yellow-Red-3 Pink-2 Yellow-Red-Buff-1	8.3	5.8	0.9	Marginally plastic	Moderate grinding and sieving necessary	Silty to fine	Slight vitrification
Dakota Formation N = 9	Categories: Red-3 Yellow-Red-1 Pink-3 Yellow-Red-Buff-1	18.1	8.0	0.9	Plastic	Moderate grinding and sieving necessary	Silty	None
Mancos Formation N = 11	Categories: Red-3 Yellow-Red-2 Pink-4 Yellow-Red-Buff-2	17.7	6.7	1.4	Plastic	Sieving	Silty to fine	None
Morrison/Burro Canyon Formation N = 11	Categories: Red-6 Yellow-Red-4 Gray-1	18.1	6.4	0.4	Marginally plastic	Moderate grinding and sieving necessary	Silty	Slight vitrification
Redeposited clays N = 17	Categories: Red-3 Yellow-Red-2 Yellow-Red-Buff-2	11.0	5.6	1.7	Plastic	Sieving	Fine	Slight vitrification

*With the exception of paste color categories, all attributes are either mode or means values.

temper types exhibits differential requirements in reduction processes. The river cobbles demand the most energy expenditure because they need to be exposed to extremes of temperature and rigorous grinding. Progressively smaller amounts of reduction, however, are needed for the more friable sandstones, conglomerate, and multilithic sand. Incorporation of the reduced tempers into clay tiles produced predictable results — identifiable variation in paste compactness and workability. Paint resources consisted of two hematite/limonite nodular concretions and numerous, small angular fragments coated with a purplish-black manganese dioxide. Other than color characteristics upon firing — all samples remained within their original color spectrum — nothing can be said of the paint samples.

In attempting to correlate specific resources with manufacturing sites, two problems were encountered. As can be seen in table 25, the paste color variability within any one depositional stratum is considerable. Since fired paste color is the only compositional attribute available, serious problems occurred in data comparability. Obviously, any given clay could correlate, in terms of oxidized color category, with multiple geological formations. This problem is alleviated slightly by using Munsell values rather than color categories, and then observing the spatial distance between manufacturing site and possible resources. Those resources found to have poor qualitative/quantitative attributes, e.g., excessive shrinkage, marginal plasticity, etc., may be tentatively disregarded. Emphasis should be placed on the fact that direct source-site relationships, while very encouraging for the interpretation of ceramic ecology, are not necessary to the development of procurement-production zones, which are based upon ceramic compositional frequencies.

A second problem is the extremely limited extent of raw clays within secure proveniences. At present, raw clays occur in Sites 5MT23, 5MT2151, 5MT2193, 5MT2194, 5MT2854, 5MT2858, 5MT4479, 5MT4671, and 5MT4684. Although other DAP sites contain raw clays, they are either located in nonsecure proveniences, or have yet to undergo

oxidation analysis. The results of the raw clay firing analysis are summarized in table 26. Insofar as there is little paste color variability within the 43 firing samples, the only conclusion to be made is that uniformity in clay utilization is characteristic. Just how and why this conclusion differs from the refiring analysis discussed in the localized exchange network section is a source of confusion. Perhaps the simplest explanation lies in the realm of sample size and quality. Also, it is not certain that the raw clays were used in pottery manufacture, although most of the samples did contain the locally ubiquitous andesite/diorite temper.

Table 26. Summary of raw clay paste color category frequencies after oxidation at 950 °C

Site No.	Categories*					
	1	2	3	4	5	6
5MT23	—	—	8	—	—	—
5MT2151	—	—	1	—	—	—
5MT2193	—	—	1	—	—	—
5MT2194	—	1	—	—	—	—
5MT2854	—	—	1	—	—	—
5MT2858	—	—	2	—	—	—
5MT4479	—	2	22	2	2	2
5MT4671	—	1	—	1	—	—
5MT4684	—	—	1	—	—	—

*1 = red (2.5YR-10R, value 8 and lower).
2 = yellow-red (5YR, value 8 and lower to 7.5YR, value 7 and lower).
3 = pink (10R-5YR, value 9 and above; 7.5YR, value 8 and above).
4 = yellow-red-buff (10YR, value 9 and above).
5 = buff (2.5Y-5Y, value 9 and above).
6 = gray-brown (10R-5Y, chroma equals 2; 10YR, value 7 and lower).

In examining the above information, four conclusions may be drawn:

1. Clay and temper variability is a consistent and important feature of ceramic material resource availability within the project area.

2. Due to the ubiquitous distribution of clay/temper resources and the inconclusive evidence of the provenienced raw clay firing analysis, the identification of procurement-production zones must rely on ceramic material attribute frequencies.

3. Paste color variability within the geological formations of the project area complicates the comparability of in situ raw clays with site-specific raw clays, thus minimizing the capability of source-site linkage.

4. Overall correlation of the DAP settlement system with ceramic resource availability is unobtainable at this time.

That the utilization of paste color as a distinguishing attribute is both necessary and rudimentary should be apparent. However, further analysis employing more sophisticated chemical-physical techniques is needed. Bishop's (1980) discussion of the basic correspondence between petrographic and neutron activation analysis provides a sensitive set of guidelines in the formulation of compositional modeling. By implementing these analyses, a much more secure and valid approximation of the resources used in each procurement-production zone can be achieved.

ARTIFACT DISTRIBUTIONS WITHIN DAP EXCAVATED SITES: SUBSTANTIVE RESULTS

In an attempt to establish a meaningful dialog concerning exchange systems within the project area, four sets of intersecting data were examined. The first set represents paste compositional data from oxidation experiments on 352 locally manufactured utilitarian ware sherds. While this data set has only recently been formulated, with substantial amounts of refiring yet to be accomplished, some intriguing patterns have emerged. Of more direct consequence to the questions of exchange are the distributional profiles of the numerous temper types. Keeping in mind the concept of Manufacturing Tracts (appendix C, this report), individual temper type frequency distributions may signify exchange network form, magnitude, directionality, and interconnections. A brief glimpse at figures 41 through 76 should convince the reader of, at the very least, distributional variability. Caution, however, is encouraged since the distributional profiles depicted in the figures do not address the attributes of site type, temporal variability, or different levels of recovery during excavation.

Figures 41 through 76 were constructed by calculating the percentages of specific temper-ware combinations within all of the excavated sites. Thus, a given circle does not represent the percentage of the combination at that site in comparison to site assemblage, but rather reflects the percentage in relation to all project area sites. Some of the problems encountered with this approach are the overrepresentation of these sites intensively excavated, e.g., Site 5MT4475, in comparison to those only tested, and the unavoidable overlapping of circles. In many instances this overlap may be interpreted as constituting a meaningful clustering of the temper-ware combinations in question. In others, though, the incorporation of smaller circles (percentage) within a larger circle may in fact have no relationship whatsoever, being, instead, an "artifact" of small sample sizes.

A third set of data revolves around the distributions of various ware types. Obviously, this is linked to the temper distributions discussed above, but can, in its own right, be assessed for spatial-temporal patterning. Finally, the fourth data set involves the use of the Shannon-Wiener information measure (Wilson and Bossert 1971) — essentially an

index which measures the diversity of temper types within individual sites (populations) by indicating the level of uncertainty in any random selection (fig. 77). Each information set expresses a given potential in examining the various levels of exchange, but should not be looked upon as a final statement. All of this information reflects only a horizon in the development of the ceramic data base. Therefore, the patterns discussed below are preliminary and of such elementary quality as to dictate against any explanatory efforts.

In order to rectify the problem of impressionistic data analysis, three statistical techniques are envisioned for future investigation — measure of dissimilarity and multidimensional scaling using multiple material and technological attributes (Fry 1979, 1980); factor and discriminant analysis using appropriate variables (Rands and Bishop 1980); and linear regression modeling (Renfrew 1977; Sidrys 1977). The combination of these techniques will explore the true potential of the data. Further utilization of spatial-locational modeling must await complete temporal segregation of the settlement systems involved.

The Localized Exchange Network

The localized exchange system is simply defined as that area encompassed by the project boundaries. For all intents and purposes, this means the Dolores River valley itself and those sites either excavated or bladed by the DAP. Further analysis depicting presence or absence of various temper types in surface collections (survey sites) is being finalized and will hopefully expand this rather myopic view. Within the context of localized exchange, innumerable actions may occur. Sahlins (1972) has carefully grouped these behavioral sets into the categories of gift giving, balanced and unbalanced reciprocity, trading partnerships, and redistribution. Regardless of the form of exchange, an inherent relationship exists between the distributional materials themselves and their context of sociability. At the level of localized exchange this observation is of critical importance (Sahlins 1972). Clearly, the intertwining of exchange and social form implies group maintenance, leveling mechanisms, and communication (Plog 1980). In regard to an archaeological context, the problem becomes one of modeling each of the exchange possibilities and formulating multiple hypotheses to test against the patterned reality.

The utilization of refired local utilitarian wares (andesite/diorite temper) along with distributional profiles of the Dolores Tract tempers — andesite/diorite-sherd and dark andesite/diorite — established the criteria for identifying procurement-production zones and local exchange. Table 27 details the frequency of paste color categories among the refired samples. Sample size variability is due to the restriction of using only ceramics from secure proveniences. That

Table 27. Refired paste color categories in local utilitarian wares

		Paste color categories*					
N	Site	1	2	3	4	5	6
		Percentage					
15	5MT2854	7.0	47.0	33.0	6.5	6.5	—
22	5MT2151	—	—	55.0	18.0	18.0	9.0
18	5MT23	—	16.5	56.0	16.5	5.5	5.5
6	5MT2181	—	33.0	50.0	—	17.0	—
6	5MT4650	—	—	50.0	33.3	16.7	—
1	5MT2320	—	—	100.0	—	—	—
14	5MT2161	—	—	43.0	43.0	14.0	—
17	5MT2192	—	6.0	23.5	65.0	6.0	—
3	5MT2193	—	—	33.3	66.6	—	—
11	5MT2194	—	—	18.0	46.0	27.0	9.0
66	5MT4475	—	4.0	32.0	46.0	11.5	6.4
104	5MT4479	2.9	1.9	29.8	52.9	7.7	4.8
13	5MT4644	—	—	30.8	46.2	23.0	—
16	5MT2858	—	13.0	31.0	6.0	50.0	—
6	5MT4614	—	—	—	—	100.0	—
7	5MT4545	—	—	—	14.3	85.7	—
1	5MT2235	—	—	—	—	100.0	—
13	5MT4477	—	—	38.5	38.5	15.4	7.7
13	5MT4512	—	—	30.8	38.5	30.8	—

*1 = red (2.5YR-10R, value 8 and lower).
2 = yellow-red (5YR, value 8 and lower to 7.5YR, value 7 and lower).
3 = pink (10R-5YR, value 9 and above; 7.5YR, value 8 and above).
4 = yellow-red-buff (10YR, value 9 and above).
5 = buff (2.5Y-5Y, value 9 and above).
6 = gray-brown (10R-5Y, chorma equals 2; 10YR, value 7 and lower).

this creates a severe problem of comparability is recognized and can only be solved by refiring large collections of utilitarian wares from randomly selected proveniences. Following the assumptions of intrasite artifact frequency indicating procurement, the data seem to cluster in paste color categories 2 through 5. The strongest groupings occur in color category 3 (pink) — with sites 5MT2151, 5MT23, 5MT2181, 5MT4650, and 5MT2320 all revealing predominant frequencies of 50 percent or higher — and color category 4 (yellow-red-buff) including Sites 5MT2192, 5MT2193, 5MT2194, 5MT4475, 5MT4479, and 5MT4644 with frequencies of nearly 50 percent and higher. Smaller groupings occur in color categories 2 (Site 5MT2854) and 5 (Sites 5MT2858, 5MT4614, 5MT4545, and 5MT2235). This patterning lends itself quite nicely to the identification of distinct procurement-production zones based upon a rough geographic proximity. Keeping in mind the problem of temporal control, these zones are as follows:

Procurement-production zone A - Grass Mesa group
Procurement-production zone B - McPhee Village and Sagehen group
Procurement-production zone C - North Sagehen group

Procurement-production zone D - Southwest Sagehen group

If the lesser intrasite frequencies are any guide to localized exchange, zones A and B can be viewed as participating in some form of reciprocal action. Both of these zones have a lesser degree of exchange with zone D, while interaction with zone C occurs only minimally. A unimodal direction may be represented by category 3 ceramics in zone C, implying either a consumer or negative reciprocity relationship with zone A. Similarly, zones A and B appear to be consumers of ceramics produced in zone D, although the sample size problem is critical at this time. Frequency profiles which differ from the others in general characteristics occur in Sites 5MT2161, 5MT4477, and 5MT4512, presenting the possibility of redistribution. Important as these patterns may seem, their primary utility is heuristic — leading the analysis into areas of hypothesis testing. It cannot be emphasized strongly enough that these patterns are only preliminary, and no doubt will be modified with continued analysis of larger samples and other excavated sites.

In the remainder of the Dolores Tract tempers, further patterns emerge. Dark andesite/diorite is found in both gray and white wares. Gray ware distributions (fig. 41) are of a moderate magnitude, limited to jar forms, and dispersed throughout the project area. There is a distinct clustering of around 50 percent in the Grass Mesa Locality, specifically at Sites 5MT2151 and 5MT2161; whereas proportions of <1 to 5 percent exist in numerous sites to the south and southwest. Accordingly, this pattern may reflect a single manufacturing locus engaged in marginal exchange, or, more likely, an interface connecting a Dolores Tract manufacturing site from further north along the river to this portion of the river valley. Subsequent dispersion of materials seems consistent with reciprocal relationships as envisioned by the refired ceramic evidence. The white wares (fig. 42) differ markedly in their patterning — low magnitude, minimum spatial extent, and decentralization — and may actually depict a form of gift exchange.

Andesite/diorite-sherd temper introduces a late (post-A.D. 900) modification of the prevailing Dolores River ceramic technology. Figures 43 through 45 exhibit the distributional profiles for gray, white, and red wares. Both the gray and white wares have highly centralized distributions, with only minimal dispersal (<5 percent) to adjacent field houses. The white ware occurrence of 50 to 75 percent at Site 5MT2235 represents a much later occupation unrelated to the rest of the system. Nonutilitarian red ware distribution follows the patterns indicated above, with the notable exception of 5 percent at Site 5MT4671 — a situation which occurs repeatedly, but in much higher percentage, in all of the distributional profiles. That nonlocal red wares (Blanding Tract) should pattern in a similar fashion to local material establishes a singular argument for nonformalized intraregional exchange. This implies a condition wherein nonlocal ceramics encounter the local system and simply follow the prevailing exchange contours.

The localized exchange system may therefore be characterized as follows:

1. In general, substantial amounts of utilitarian and lesser amounts of nonutilitarian ceramic exchange occurs.

2. The diversity of exchanged ceramic materials is linked to ware type and temporal variability.

3. The spatial extent of the exchange system is variable according to local procurement-production zone manufacture, temper, and ware type.

4. Two temporally distinct exchange horizons appear to exist in the local exchange system. The earliest, prior to A.D. 800, is apparently based upon informal and decentralized reciprocal relationships. Sometime after A.D. 800-850, centralization becomes characteristic, with local ceramic production probably occurring in the Grass Mesa and McPhee locales. Evidence for the exchange of andesite/diorite-sherd tempered red wares from the Blanding Tract in southeastern Utah completes the picture.

5. When directionality is apparent, it seems to be a function of either intratract exchange (e.g., dark andesite/diorite) or an aggregate settlement system — materials flowing from village manufacturing loci to seasonal use facilities. Further evidence for directionality may be seen in the complex relationships of the procurement-production zones.

6. The symmetrical forms of the system are (a) unimodal for dark andesite/diorite gray wares; (b) bimodal for andesite/diorite-sherd gray, white, and red wares along with procurement-production zones A and B; (c) uniform for dark andesite/diorite white ware distributions.

7. Network centralization is characteristic for late Sagehen and McPhee Phases, reflecting the aggregation of the population into large, complex habitations.

Intraregional exchange

The traditional designation of the Mesa Verde region provides the spatial focus for intraregional exchange. Five ceramic manufacturing tracts, defined by means of temper and paste utilization, have been identified as lying within the region as a whole (appendix C, this volume). Evidence for exchange between these tracts is therefore contingent

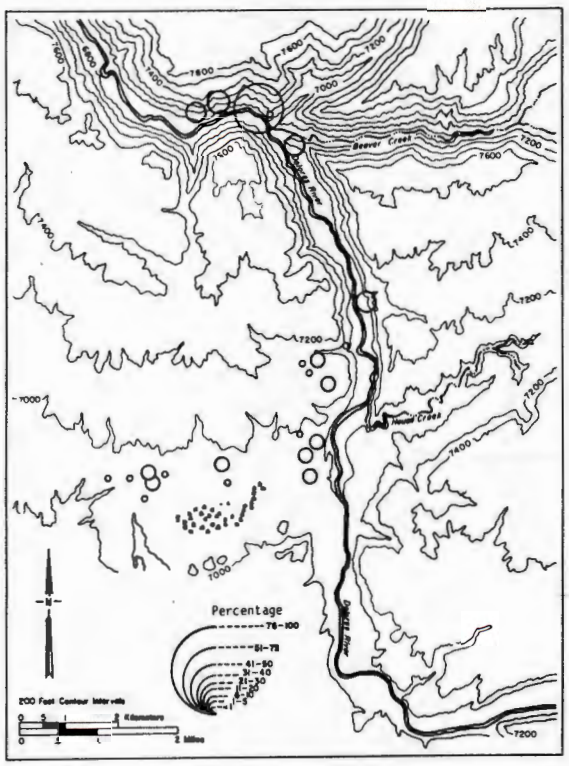


Figure 41. Distribution of dark andesite/diorite temper throughout DAP excavated sites. (Gray wares, N = 440.)

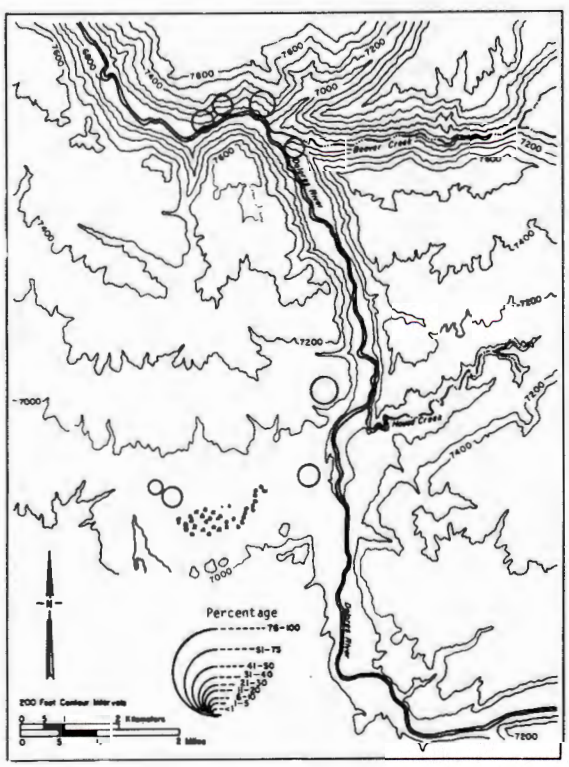


Figure 42. Distribution of dark andesite/diorite temper throughout DAP excavated sites. (White wares, N = 33.)

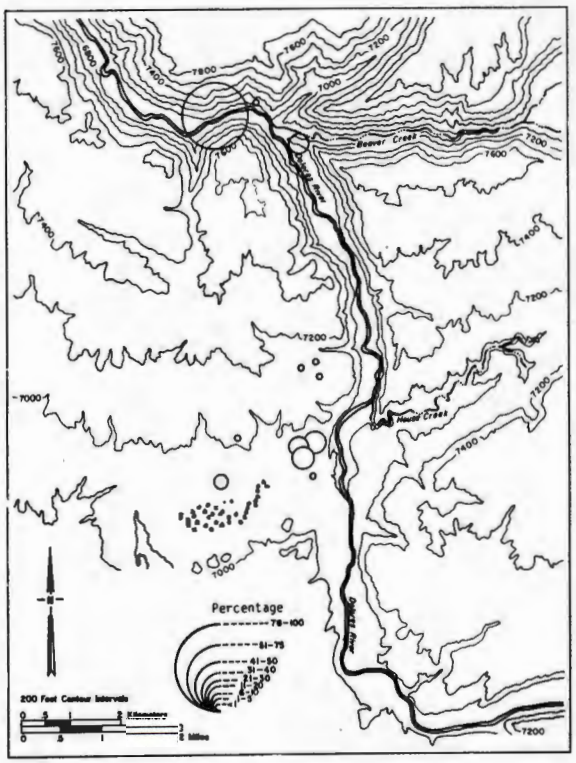


Figure 43. Distribution of andesite/diorite-sherd temper throughout DAP excavated sites. (Gray wares, N = 217.)

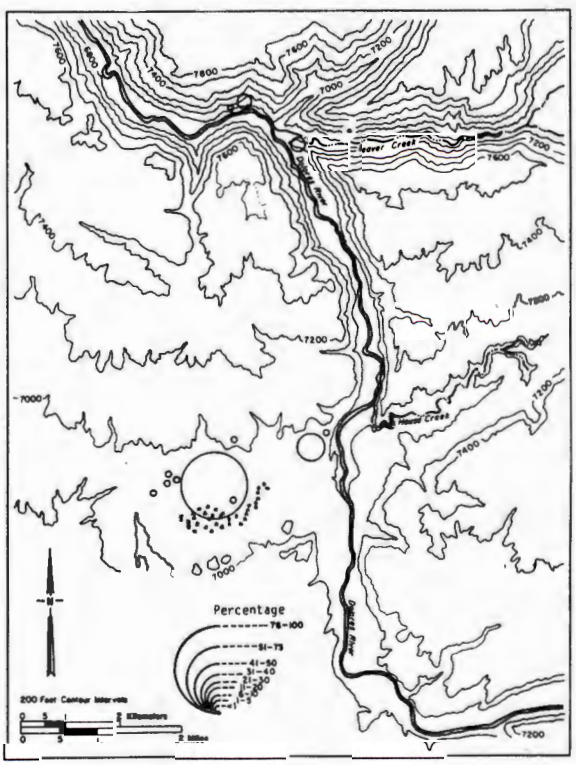


Figure 44. Distriubtion of andesite/diorite-sherd temper throughout DAP excavated sites. (White wares, N = 513.)

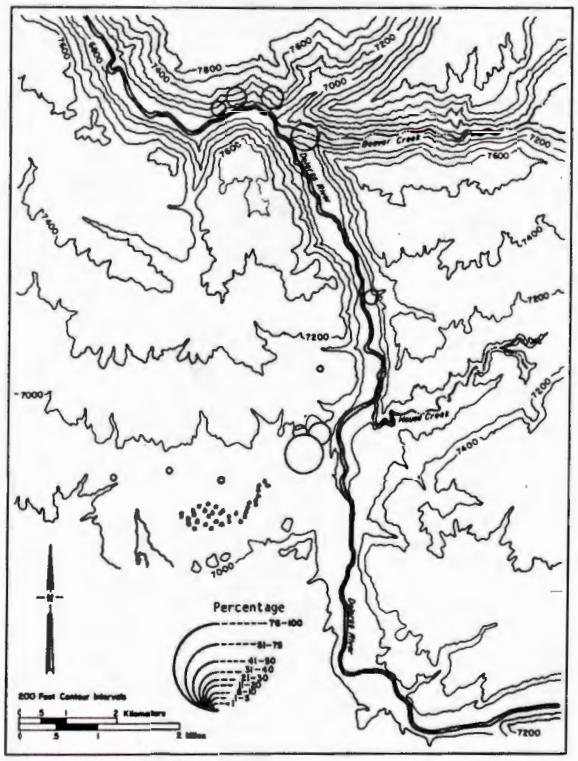


Figure 45. Distribution of andesite/diorite-sherd temper throughout DAP excavated sites. (Red wares, N = 129.)

upon recognizing the various tempering agents within DAP proveniences. Again, each of the temper types — San Juan crushed, sherd/San Juan crushed, multilithic sand, conglomerate, combined, sherd/sandstone, Dakota sandstone, and grey matrix sandstone — has been examined by ware category and plotted according to frequency distributions.

Cahone Tract ceramics are classified by the presence of multilithic sand or conglomerate temper. Multilithic sand consists of roughly sorted quartz, jasper, and quartzite sand grains that appear as red, yellow, white, clear, and gray sand. The grains are subangular and large in relation to the body wall, generally not fracturing with the body wall. Conversely, conglomerate temper consists of sandstone fragments with matrix, individual sand grains, and angular fragments of quartzite and/or light chalcedonic fragments. While the temper size is generally large, it does not break with the sherd. Within river valley proveniences, gray utilitarian jar forms predominate with substantially smaller amounts of white and red wares. Temporally, both the multilithic sand and comglomerate ceramics appear to enter the Dolores Tract exchange system around A.D. 700-750.

Spatially, the multilithic sand gray and white wares tend to cluster in the western portion of the Sagehen Flats Locality and in the Grass Mesa area (figs. 46 and 47). This may represent either a fortuitous clustering or possible distributional nodes, since the remaining distribution mimics a fall-off model to some extent. Red ware distribution (fig. 48) is fairly generalized with roughly equal proportions throughout the river valley. In this sense the red wares pattern in a similar way to the dark andesite/diorite white wares. Interestingly enough, however, the presence of the red wares at Site 5MT4671 continues a distributional pattern first noted with the andesite/diorite-sherd profiles.

The distributional profiles for conglomerate gray wares (fig. 49) differ in that higher proportions now appear at McPhee and Grass Mesa Villages. White ware evidence is so minute as to be inconclusive, while red wares again reveal distributions at Site 5MT4671 (figs. 50 and 51). Given the observation that red ware distribution is generally more restricted in spatial extent, this consistent appearance at one site, with the apparent addition of Site 5MT4644, encourages interpretation. Does this represent a direct connection with red ware manufacturing centers, or perhaps a migratory interconnection?

The basic impression recovered from these distibutional profiles is of a continuing level of exchange revolving around utilitarian vessels. One possible interpretation of this would then be in terms of ecological redistribution and continuous reciprocity. White and red ware distributions are clearly more limited both in magnitude and spatial extent. Without the luxury of hypothetical models which explore the archaeological patterning of ceramics involved in various activities, these interpretations are little more than educated guesses at this time.

Interaction with the Blanding Tract is complicated by evidence indicating multiple procurement-production zones based on both temper and paste. Basically, all ceramic materials from this tract are red wares with temper types andesite/diorite, andesite/diorite-sherd, San Juan crushed, San Juan crushed/sherd, and combined. Composed of translucent to transparent crystals of crushed rock, San Juan crushed is angular with hornblende crystals generally detached from the groundmass. Combined temper is a combination of crushed angular, gray to white to translucent quartzite in conjunction with rounded grains or multicolored, possibly multilithic sand. General characteristics of Blanding Tract red ware exchange are restricted magnitude and spatial extent, slightly greater variability in vessel forms, a very complex directionality due to the intervening Cahone Tract, and an apparent centralization of at least some degree at Site 5MT4671 (figs. 45, 48, 61, and 69). Clearly, the red wares are being distributed for their own value, but as to the exact exchange mechanisms, symmetrical forms, and/or social constructs in evidence, only confusion exists. It can be stated with some certainty, however, that this exchange system begins at approximately A.D.

750 and declines quickly around A.D. 900 (Lucius and Wilson 1980). Post-A.D. 900 San Juan crushed/sherd red ware distribution reflects only minimal amounts of material being located at Grass Mesa and McPhee Village locales.

The San Juan crushed distributional profiles exhibit the single greatest magnitude of exchange beyond the local level (figs. 67-69). Both gray and white wares are seen to group at McPhee Village with secondary dispersal, probably based upon seasonal use, to outlying field house facilities in west and north Sagehen. Since the introduction and distribution of San Juan crushed ceramics roughly correspond to agglomerative village development, the simplest conclusion is that centralization of this system is becoming characteristic. Supportive evidence may be seen in the distribution of these materials in slightly higher proportions to the other village sites within the project area. The later reduced proportions of San Juan crushed/sherd depict the deterioration in exchange relationships, leading inevitably to conclusions favoring settlement system retraction and attendant sociocultural transformation (figs. 70-72).

Of the remaining intraregional temper types, only Dakota Sandstone — comprising angular fragments of sandstone with sand grains enclosed within a white to pale yellow matrix — presents distinct distributional profiles. Significantly, there is a clear correspondence between the gray and

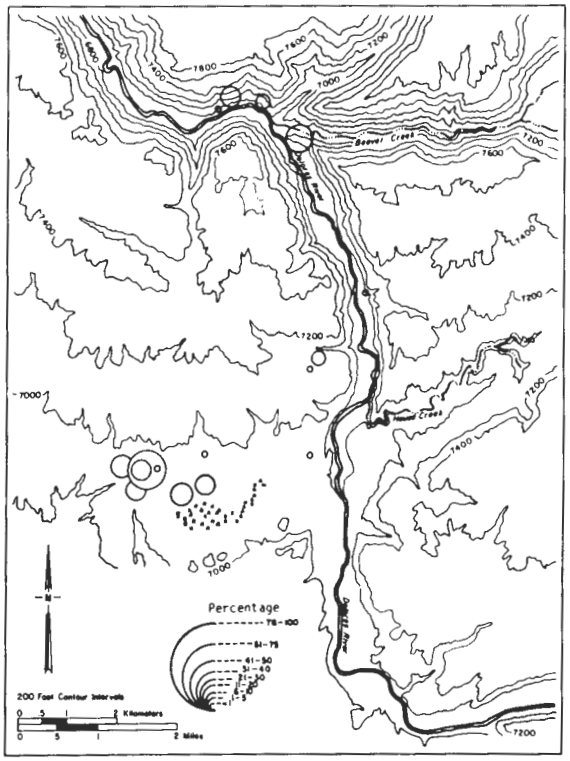


Figure 47. Distribution of multilithic sand temper throughout DAP excavated sites. (White wares, N = 189.)

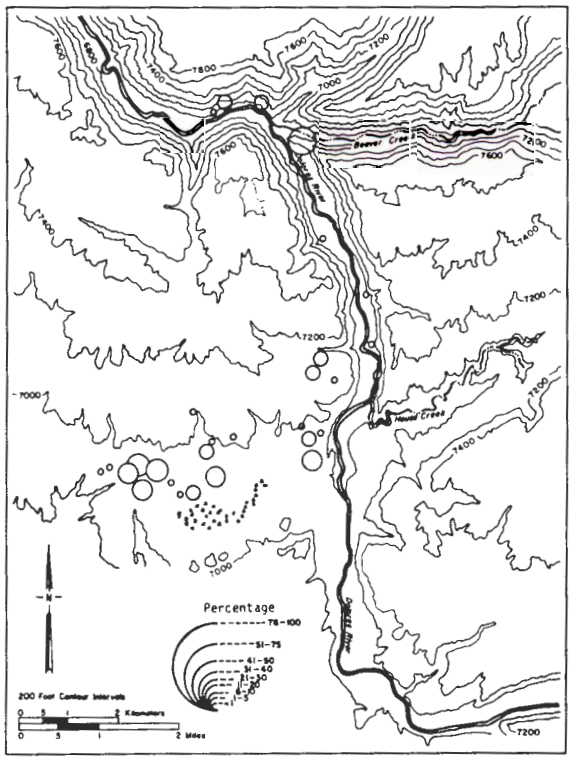


Figure 46. Distribution of multilithic sand temper throughout DAP excavated sites. (Gray wares, N = 1601.)

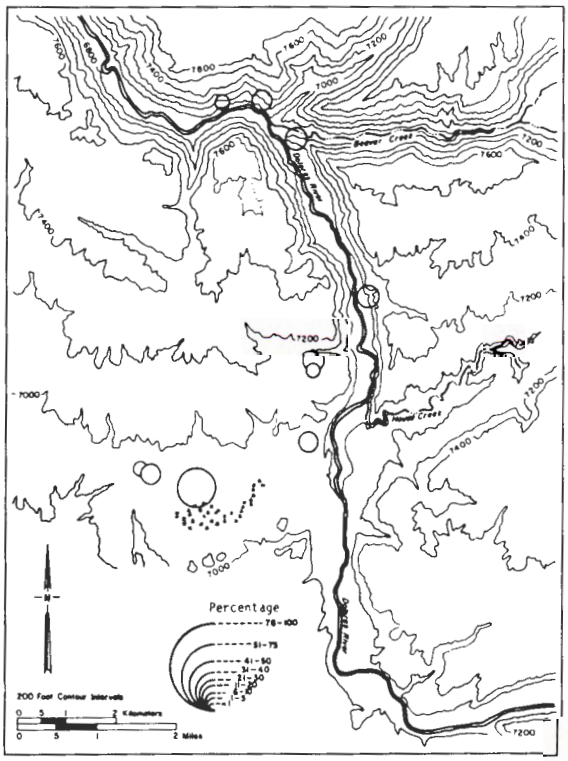


Figure 48. Distribution of multilithic sand temper throughout DAP excavated sites. (Red wares, N = 95.)

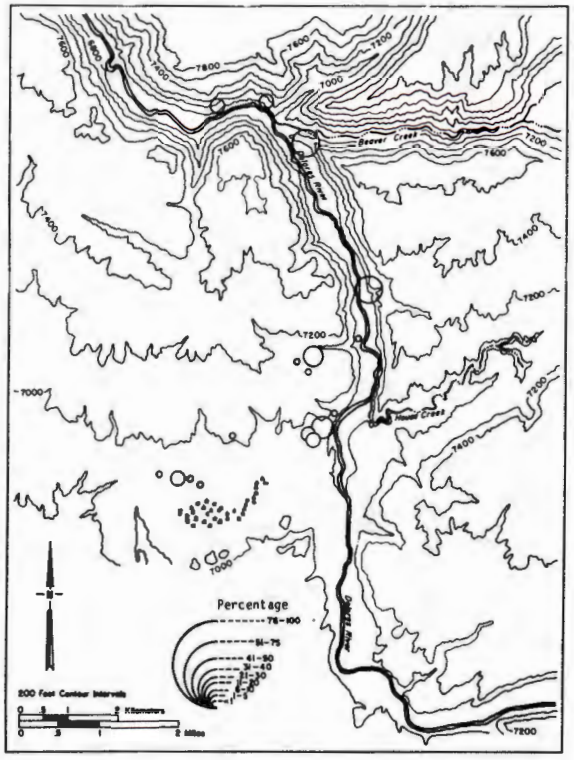


Figure 49. Distribution of conglomerate temper throughout DAP excavated sites. (Gray wares, N = 543.)

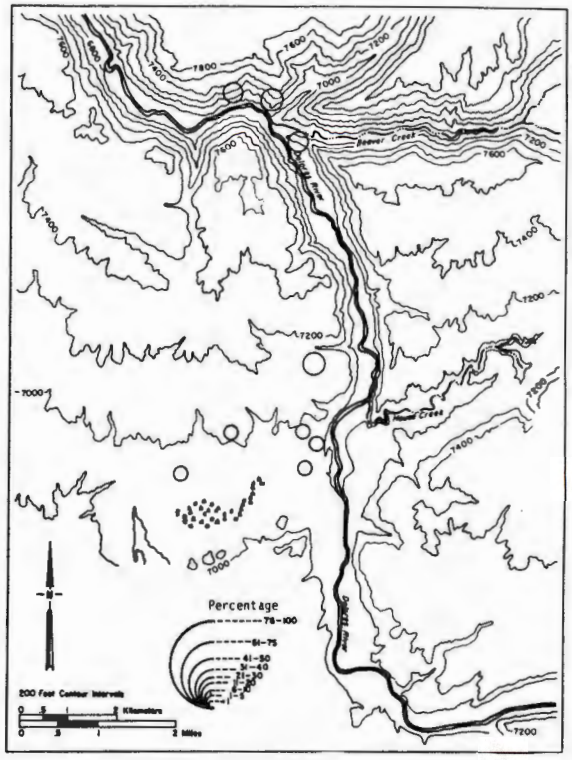


Figure 50. Distribution of conglomerate temper throughout DAP excavated sites. (White wares, N = 11.)

white ware distributional profiles of Dakota Sandstone (figs. 52 and 53) and those portrayed for multilithic sand. Whether or not this means similar exchange mechanisms is open to debate, but certainly that implication is there. Again, it is tempting to interpret these patterns as being reflective of exchange systems balancing out regional ecological diversity and/or maintaining kinship alliances. The red ware distribution is ephemeral, exhibiting little in the way of patterning (fig. 54).

It is hoped that this brief description of the major features of intraregional exchange clarifies the differences from the localized system, while at the same time projecting the inherently rudimentary levels of analysis completed. In characterizing the intraregional system, Plog's (1977) guidelines again become useful:

1. The magnitude or frequency of exchange is quite variable. Attributes having significant covariance are temper type, ware type, and temporal introduction into the localized system.

2. Material diversity is generally limited to jar and bowl vessel forms with slightly greater diversity observed in the San Juan white wares.

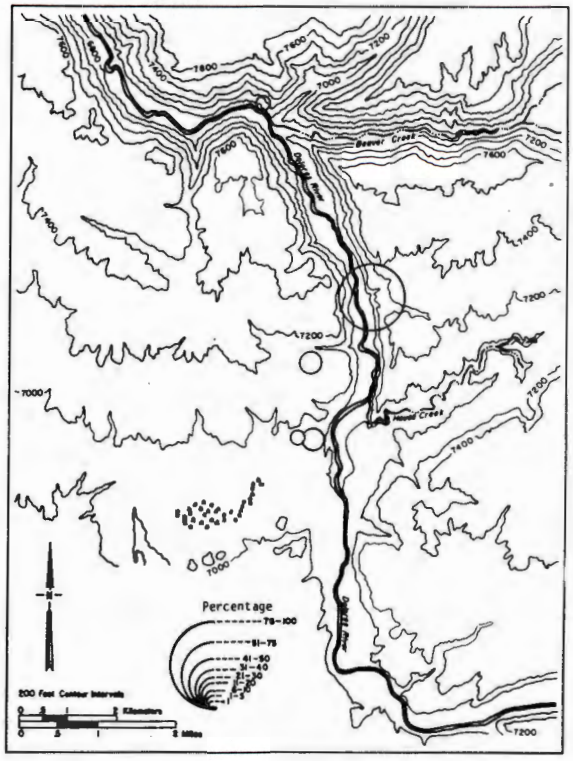


Figure 51. Distribution of conglomerate temper throughout DAP excavated sites. (Red wares, N = 27.)

3. Spatial extent varies from a maximum level for all gray wares to increasingly smaller distributional ranges for the white and red wares.

4. Temporal variability in the system is pronounced. The earlier forms of intraregional exchange (prior to A.D. 800) focus upon gray, white, and red ware distribution from the west. After approximately A.D. 800-850, the exchange system apparently shifts in major activity towards the San Juan Tract, although there does not appear to be a complete termination of the Blanding-Cahone Tract interconnections. Consistent with other DAP data bases, the distributional evidence implies a substantial modification of intraregional exchange mechanisms after A.D. 900.

5. The directionality of the intraregional system is both to the west and south. Evidence not fully explored in this report adds a link to the east with the Animas Tract.

6. Symmetrical forms of varying shape and intensity, evidenced by the locale of exchanged ceramics, are clearly characteristic for this level of exchange and no doubt reflect the temporal variability discussed above.

7. Network centralization is also variable given the time frame involved and various subsystemic distributional profiles; e.g., red ware centralization at Site 5MT4671.

Interregional Exchange

As a traditional area of archaeological interest, interregional exchange explores a complex spectrum of human interaction. Unfortunately, the evidence displayed in this report is so fragmentary and tentative that even identifying patterns is difficult. Three regional interfaces are presently recognized. The Kayenta region of northeast Arizona and southeast Utah encompasses a vast and poorly understood area. At present, the distribution of 12 quartz sand white ware sherds represents the total extent of Dolores River valley-Kayenta interaction. Chuska wares, as identified by a trachy basalt temper — dark green to black platey rock fragments with a micaceous appearance — have their origin in the Chuska mountains along the Arizona-New Mexico border (Windes 1977). Again, the sample size of Chuskan ceramics is relatively low. A third area of interaction is with that vast region of northwest New Mexico designated Cibolan. Diagnostic ceramic attributes are a quartz sand temper in both gray and white wares and the combination of a thin white slip in conjunction with a mineral paint in the white wares. As above, extremely limited amounts of this material exist in the Dolores River valley ceramic assemblages. Further ceramic evidence from these areas has been identified in preliminary analysis, but has yet to be incorporated into the distributional profiles.

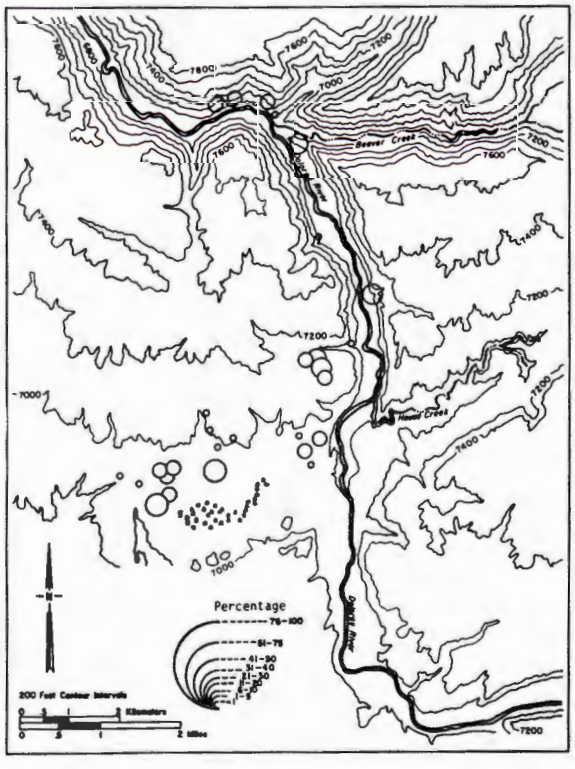


Figure 52. Distribution of Dakota Sandstone temper throughout DAP excavated sites. (Gray wares, N = 678.)

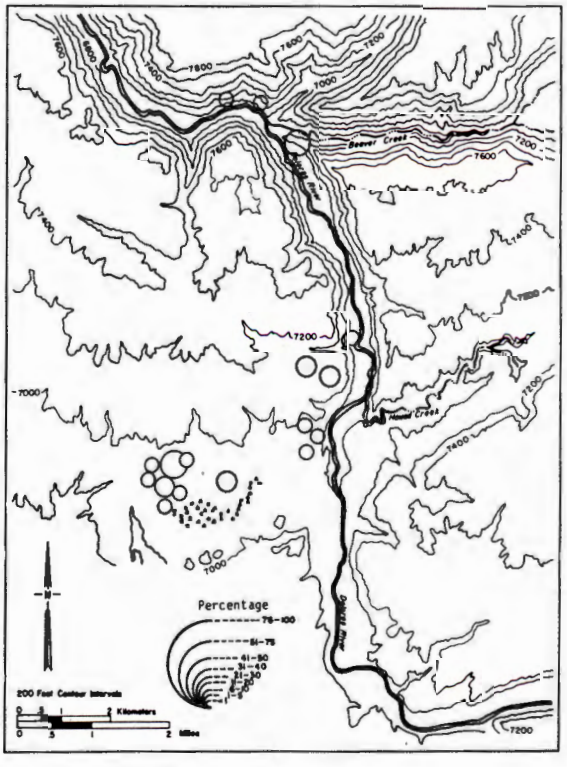


Figure 53. Distribution of Dakota Sandstone temper throughout DAP excavated sites. (White wares, N = 77.)

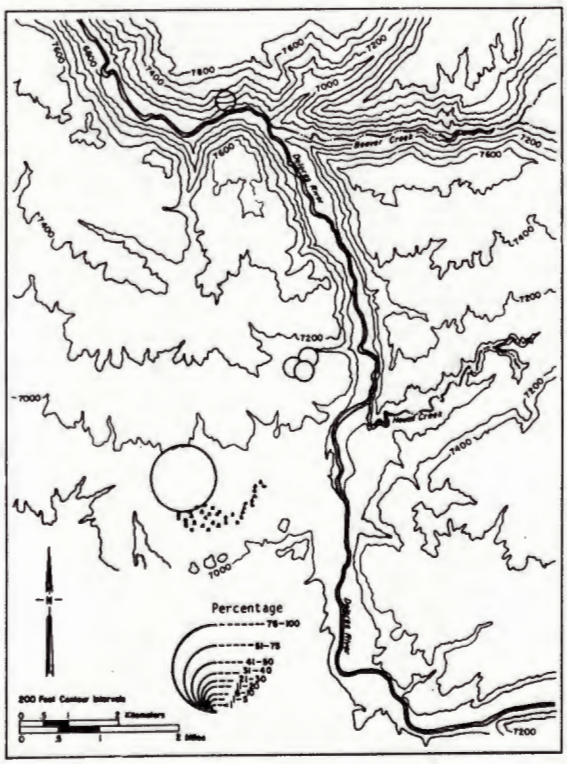


Figure 54. Distribution of Dakota Sandstone temper throughout DAP excavated sites. (Red wares, N = 11.)

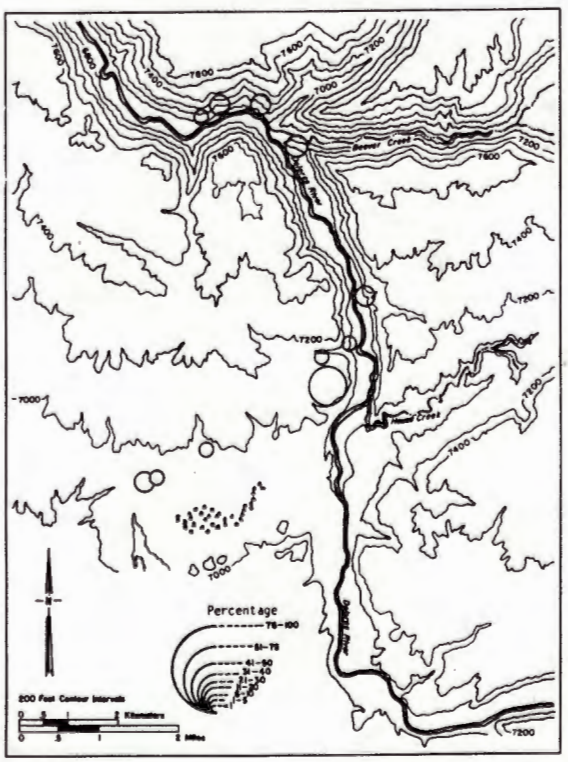


Figure 55. Distribution of dark matrix sandstone temper throughout DAP excavated sites. (Gray wares, N = 175.)

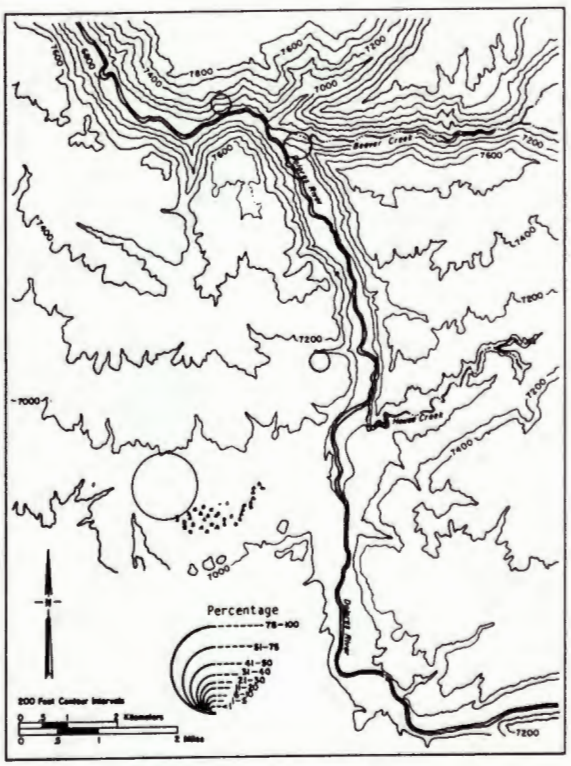


Figure 56. Distribution of dark matrix sandstone temper throughout DAP excavated sites. (White wares, N = 10.)

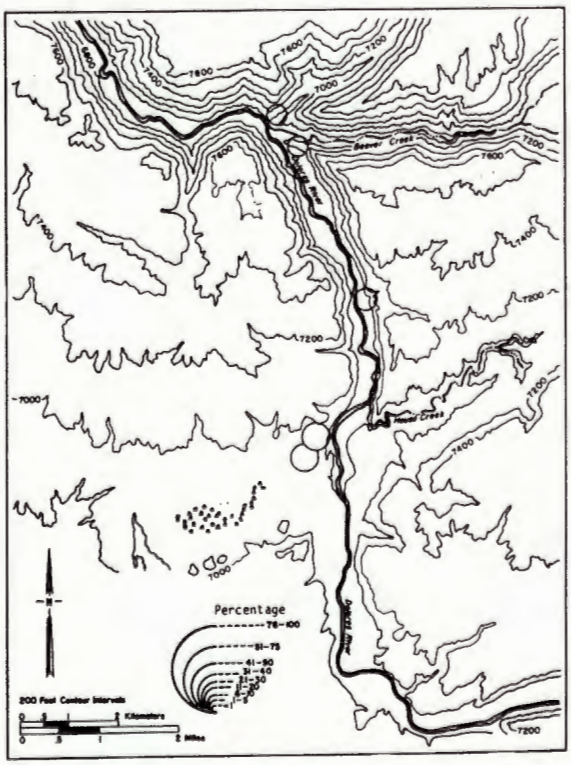


Figure 57. Distribution of sandstone temper (indeterminate) throughout DAP excavated sites. (Gray wares, N = 19.)

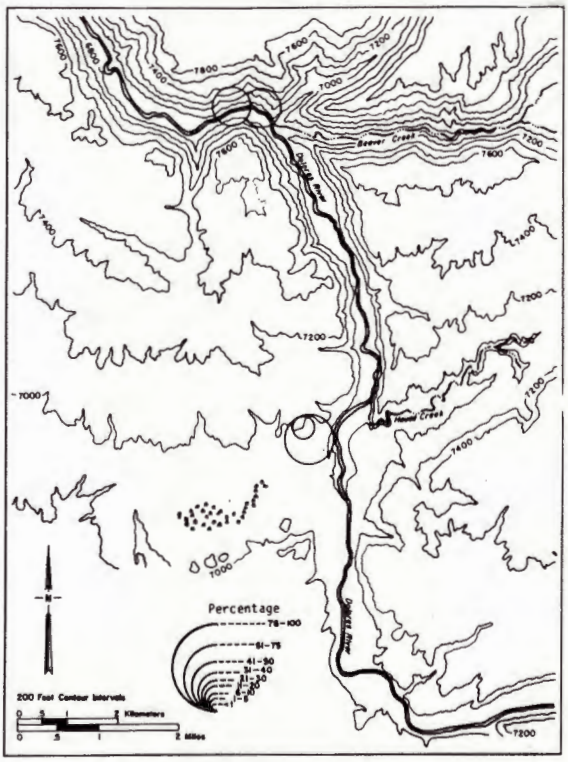


Figure 58. Distribution of sandstone temper (indeterminate) throughout DAP excavated sites. (White wares, N = 9.)

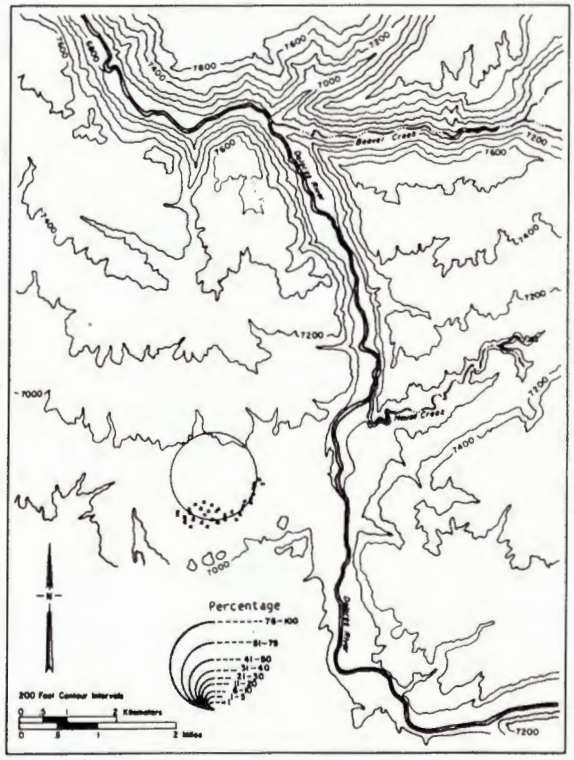


Figure 60. Distribution of sherd temper throughout DAP excavated sites. (White wares, N = 151.)

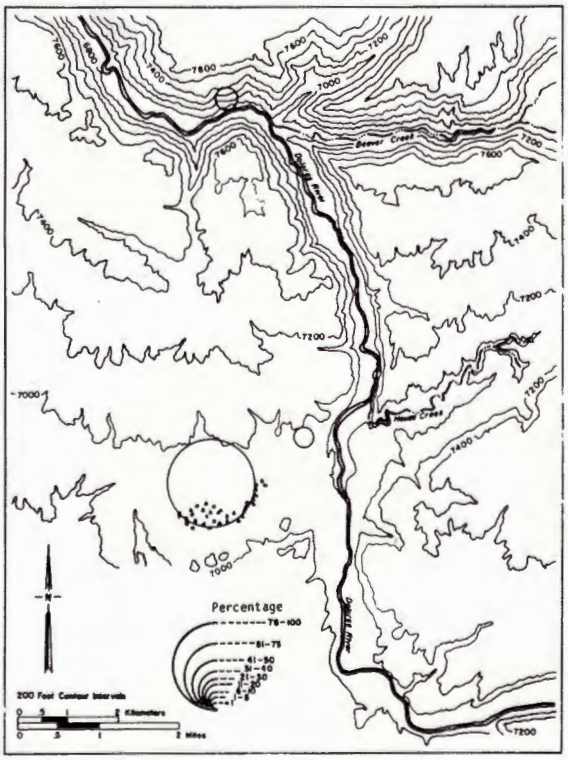


Figure 59. Distribution of sherd/sandstone temper throughout DAP excavated sites. (White wares, N = 15.)

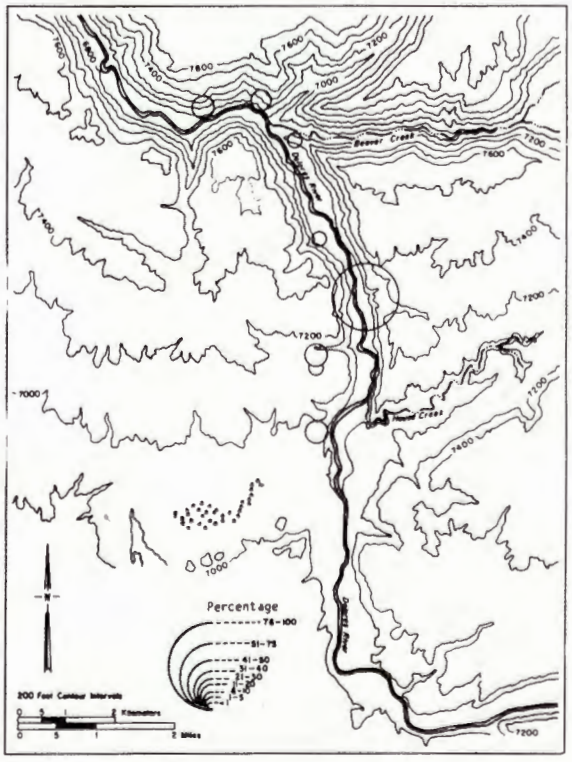


Figure 61. Distribution of combined temper throughout DAP excavated sites. (Red wares, N =69.)

In viewing the evidence of Kayenta, Chuska, and Cibolan exchange spheres, numerous conclusions may be drawn. Kayenta ceramics are overwhelmingly centered upon Site 5MT23 (Grass Mesa Village), with miniscule amounts at only three other sites in the river valley (fig. 73), although this, again, may be the result of varying retrieval. Predictably, the Chuskan gray and white wares cluster at the large, agglomerative villages of Site 5MT23 and McPhee. This may be a function of the Chuskan materials being "redistributed" by an adjacent Cibolan system, or simply their temporal correspondence with an emerging aggregate settlement system (figs. 65 and 66). The final regional interface revolves around the Cibolan Tradition, wherein almost all of the ceramic evidence is clustered at Site 5MT4475 (McPhee Pueblo). Indisputedly, this is extremely limited evidence for any substantial interaction between the river valley and the Cibolan Tradition (fig. 74). It has been suggested, in a very informal way, that this evidence represents only a segment of a system incorporating the San Juan Tract white wares and the full extent of the Chacoan system. At this point in time the evidence is generally unsupportive of these notions; however, the reader should be aware that large amounts of 1980 excavation data, primarily from village sites, was unavoidably omitted from this discussion because preliminary analysis had not been completed.

Further distributional profiles of sandstone (figs. 57 and 58), sherd, sherd and quartz sand (figs. 62 and 63), and quartz sand indeterminate (figs. 75 and 76) do more to confuse than enlighten. Individually, a few of these profiles reveal understandable patterns. For example, sherd-tempered white wares being located in abundance at Site 5MT2235 probably indicates a correspondence with the Escalante Ruin (Site 5MT2149) and the Chacoan system (figs. 60 and 63), but in general the evidence is disparate and essentially detached from any systematic format. This discussion invariably leads to the conclusion that any characterization or interpretation of interregional exhange must await more advanced analyses.

Discussion

Throughout the preceding discussion an attempt has been made to explore the potential of exchange system analysis by formulating generalized models and by examining date patterning. Briefly, the outlined data for procurement-production zones roughly corresponds to the projected modeling of utilitarian wares, although the levels of information are so insecure as to make any statement purely tentative in nature. Further correspondence is seen in the evidence of exchange system modeling. In reference to the localized exchange model, the greatest divergence exists in directionality, symmetry, and temporal modifications. A cursory examination of the refiring and distributional data dictates greater levels of systemic diversity — numerous exchange mechanisms operating coevally — and change

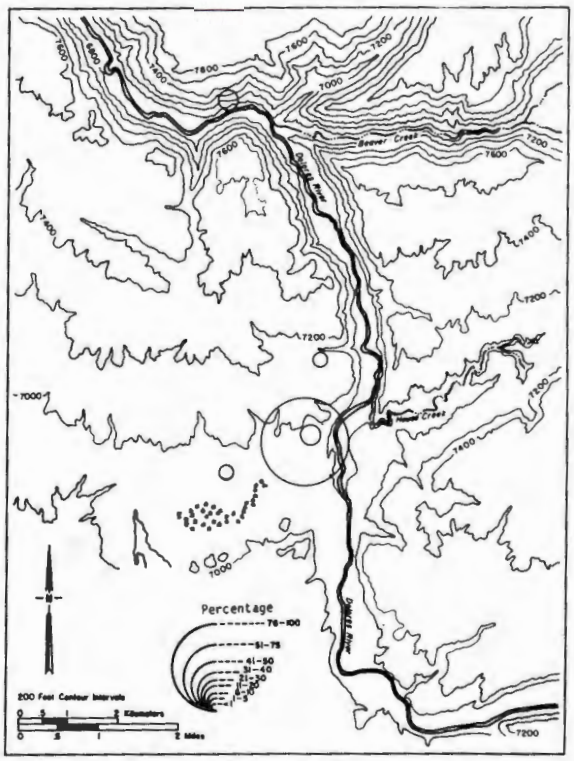


Figure 62. Distribution of sherd/quartz sand temper throughout DAP excavated sites. (White wares, N = 43.)

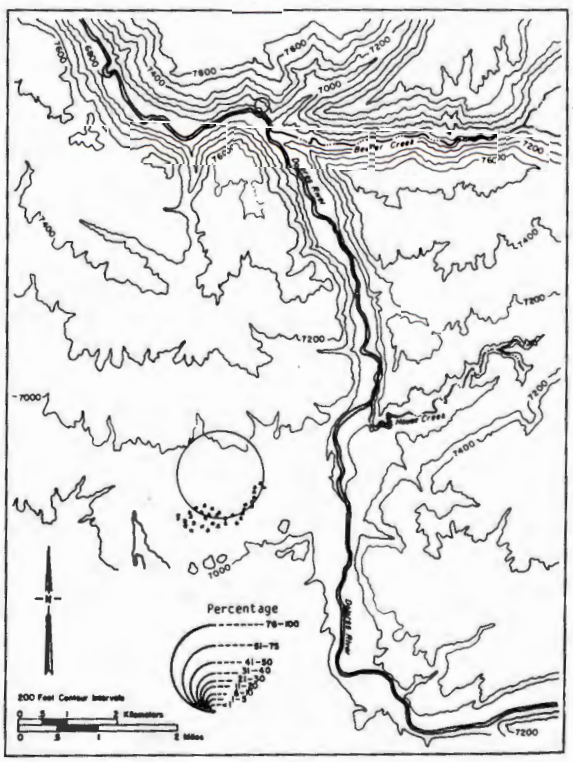


Figure 63. Distribution of sherd/quartz sand temper throughout DAP excavated sites. (Red wares, N = 21.)

due to the intra- and interregional interfaces. Furthermore, a comparison of the evidence and the intraregional exchange model reveals a much more impressive magnitude than originally imagined. Also, the interconnections between the various tracts confounds directionality and symmetrical form. Finally, the similarity between interregional models and the appropriate distributional models is generally strong; however, the construction of inferential statements can not be accomplished at this time. By way of conclusion, then, a series of generalized models, revolving around differential levels of exchange, have been constructed and cursorily examined in relation to the artifact distributional patterning. That this represents only a first approximation should be obvious. Future work must focus upon more specific models, hypotheses, and test implications, along with the necessary analytical assumptions and methods to explore the complete range of socioeconomic behavior at each level of exchange.

A brief chronological summary of the exchange systems evidenced in the Dolores River valley begins by recognizing an early Sagehen Phase segregation of ceramic procurement-production zones on the local level. Each of these zones reflects specific clay use and therefore can be linked to observable spatial dimensions. Exchange of both gray utilitarian and white nonutilitarian vessels probably occurred

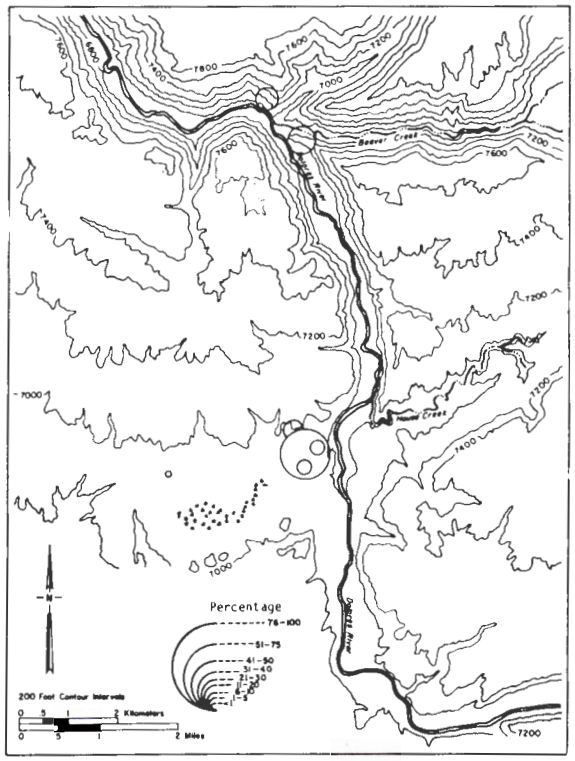


Figure 65. Distribution of trachy basalt temper throughout DAP excavated sites. (Gray wares, N = 52.)

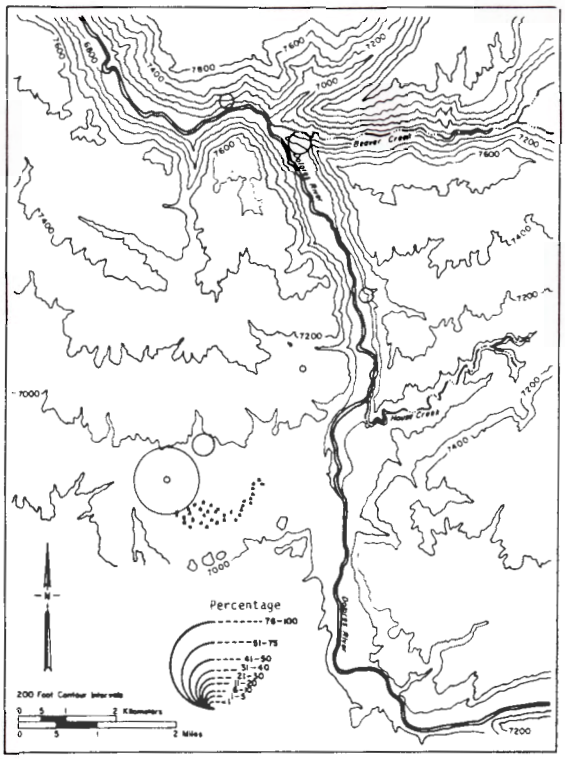


Figure 64. Distribution of salmon matrix temper throughout DAP excavated sites. (Gray wares, N = 129.)

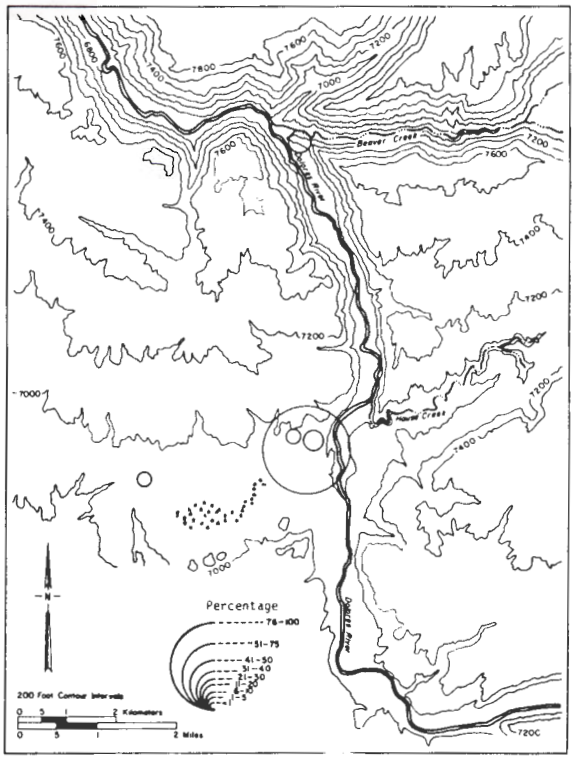


Figure 66. Distribution of trachy basalt temper throughout DAP excavated sites. (White wares, N = 51.)

along reciprocal avenues, with lesser amounts of consumer-producer interaction. At or around the same time, consistent interaction of a substantial magnitude occurred with the Cahone Tract to the west. Since most of this exchange involved gray wares, a tentative conclusion would include ecological redistribution of both domestic and nondomestic commodities. Complicated as this picture is, it can be stated with some justification that the local and intraregional exchange systems blend into one another and are centered upon the various small hamlets of the west Sagehen locale.

At approximately the end of the Sagehill Subphase of the Sagehen Phase, a complex interaction between the Dolores River and the Blanding Tract of Utah is documented. Contrary to the rather generalized commodity exchange occurring with the Cahone Tract, this establishes the distribution of intrinsically valuable red ware vessels, perhaps along numerous conduits, across an appreciable distance. Since there is no evidence whatsoever for systemic replacement, a complex interrelationship of local and various forms of intraregional exchange exists contemporaneously. Clearly, there are segments of the Dolores River settlement system which appear to be more involved with these exchange mechanisms. This is substantively illustrated by the presence of exchange nodes, or points of concentrated activity, e.g., Site 5MT4671. Interestingly, the red ware exchange continues until the end of the Periman Subphase of the

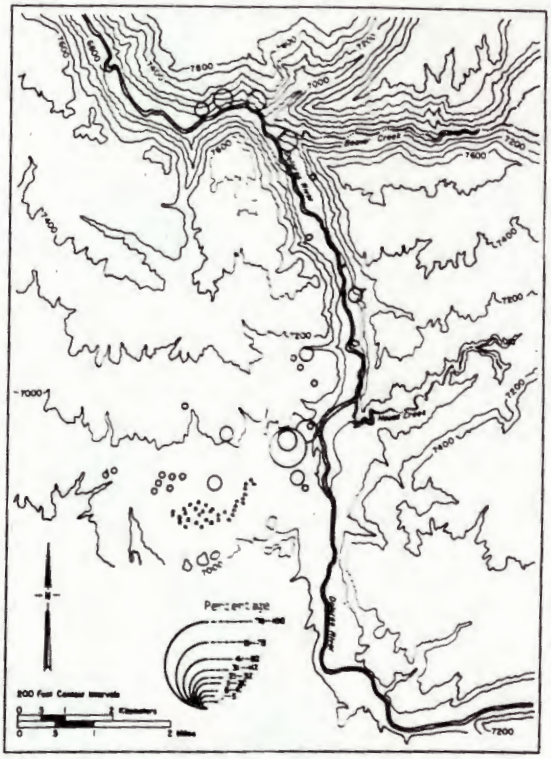


Figure 68. Distribution of San Juan crushed temper throughout DAP excavated sites. (White wares, N = 1821.)

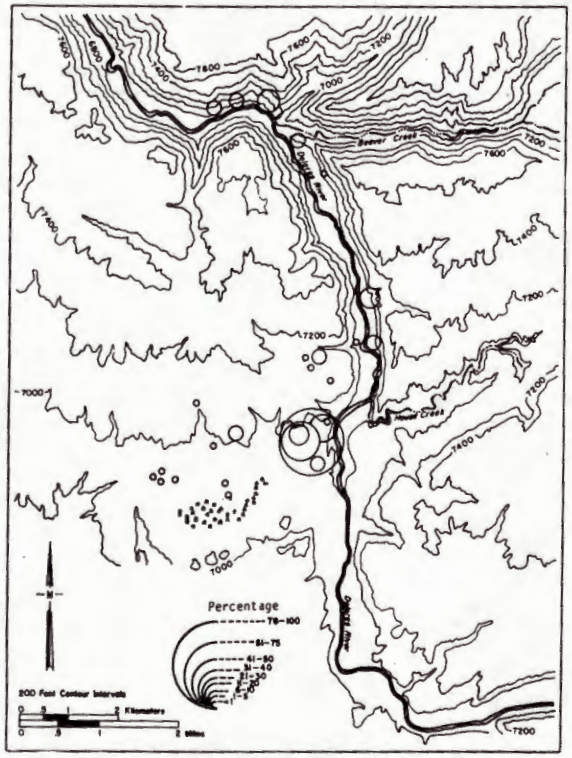


Figure 67. Distribution of San Juan crushed temper throughout DAP excavated sites. (Gray wares, N = 1492.)

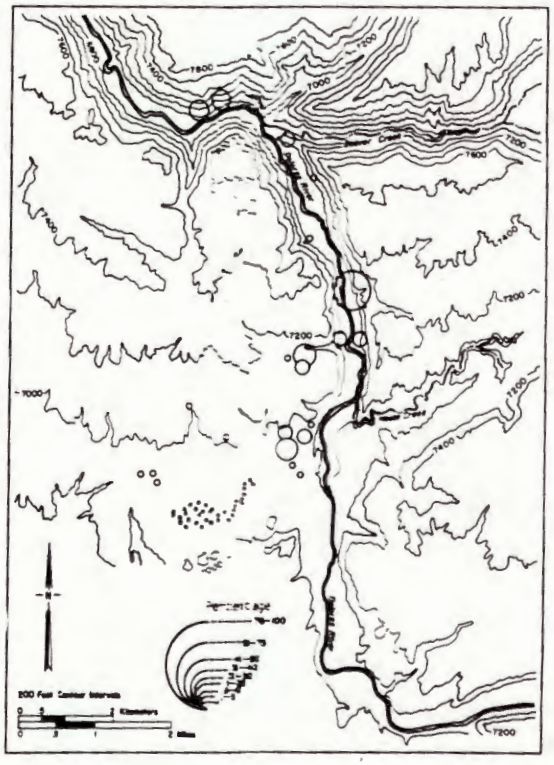


Figure 69. Distribution of San Juan crushed temper throughout DAP excavated sites. (Red wares, N = 1897.)

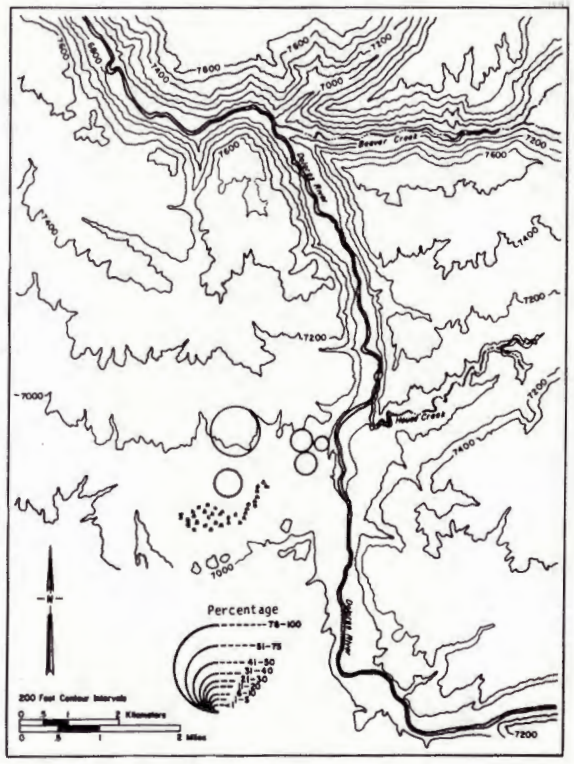


Figure 70. Distribution of sherd/San Juan crushed temper throughout DAP excavated sites. (Gray wares, N = 29.)

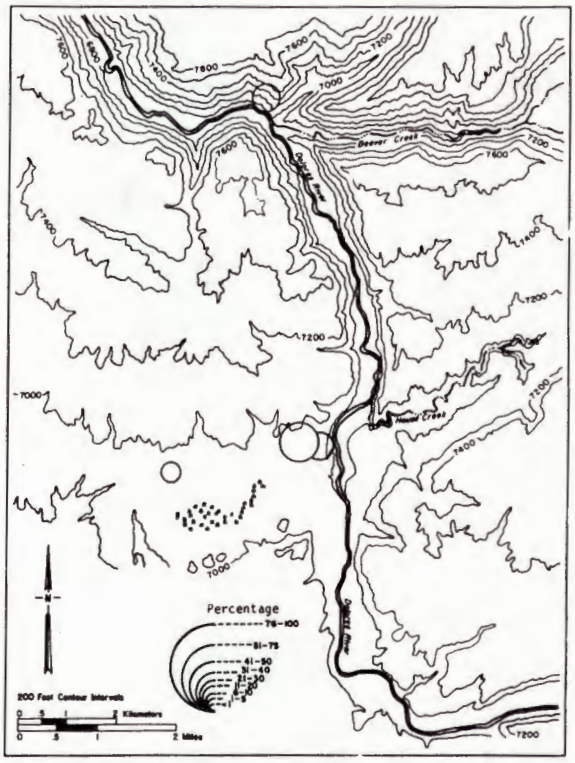


Figure 72. Distribution of sherd/San Juan crushed temper throughout DAP excavated sites. (Red wares, N = 18.)

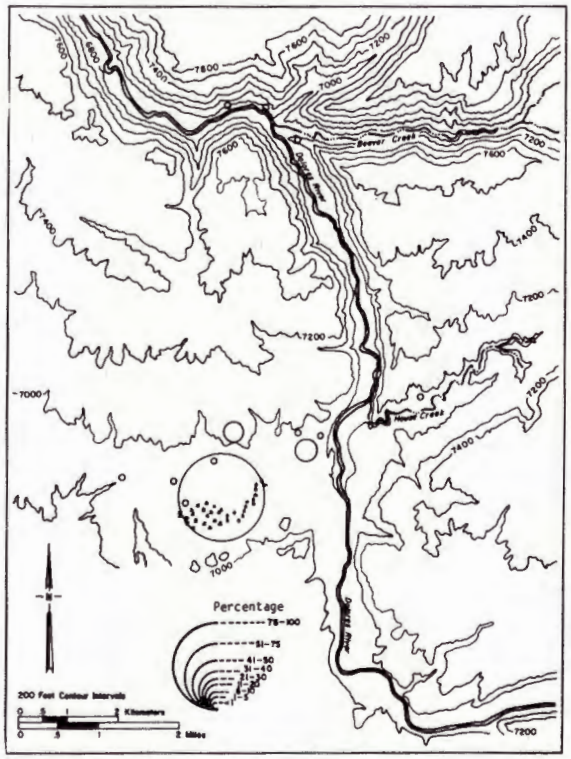


Figure 71. Distribution of sherd/San Juan crushed temper throughout DAP excavated sites. (White wares, N = 997.)

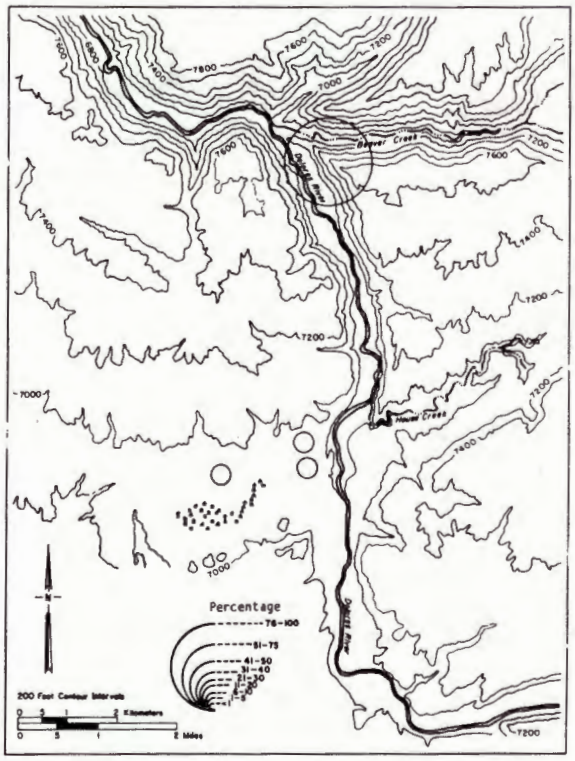


Figure 73. Distribution of quartz sand (Kayenta) temper throughout DAP excavated sites. (White wares, N = 12.)

McPhee Phase, thus documenting a very consistent and stable sphere of interaction. Just what this type of interaction represents is still open to debate. Perhaps an entrepreneurial group, based on familial cooperation, established and maintained this connection. But the possibility of initial migration and continued contact, or any number of other interpretations, may be just as likely.

Throughout most of the Sagehen Phase, interregional exchange was very limited and somewhat generalized. Interaction between Kayenta centers to the west and Site 5MT23 (Grass Mesa Village) seems possible, although other distributional interpretations are also possible. However, there is fragmentary evidence suggesting introduction of migratory groups from south of Chaco Canyon, which would substantially modify inferences based solely on exchange (salmon matrix distributional profile, fig. 64).

Contemporaneous with settlement aggregation during the McPhee Phase is the appearance of an intraregional directional shift from the Cahone to the San Juan Tract. Massive amounts of gray utilitarian vessels, distributed primarily at McPhee Village, may indicate a continuation of ecological redistribution and thus risk minimization. Correspondingly, however, there are equal amounts of white nonutilitarian vessels which generally indicate exchange based upon intrinsic value. Of substantial interest at this juncture is the possibility of nonutilitarian white wares

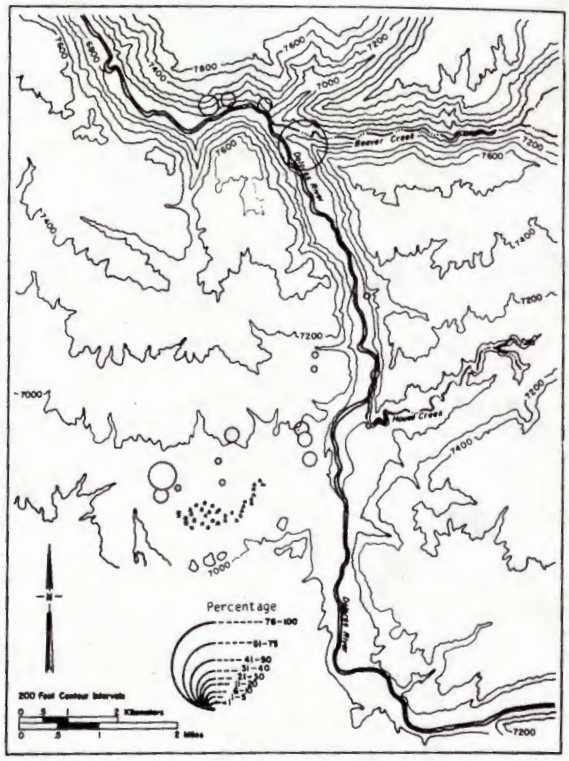


Figure 75. Distribution of quartz sand temper (indeterminate) throughout DAP excavated sites. (Gray wares, N = 111.)

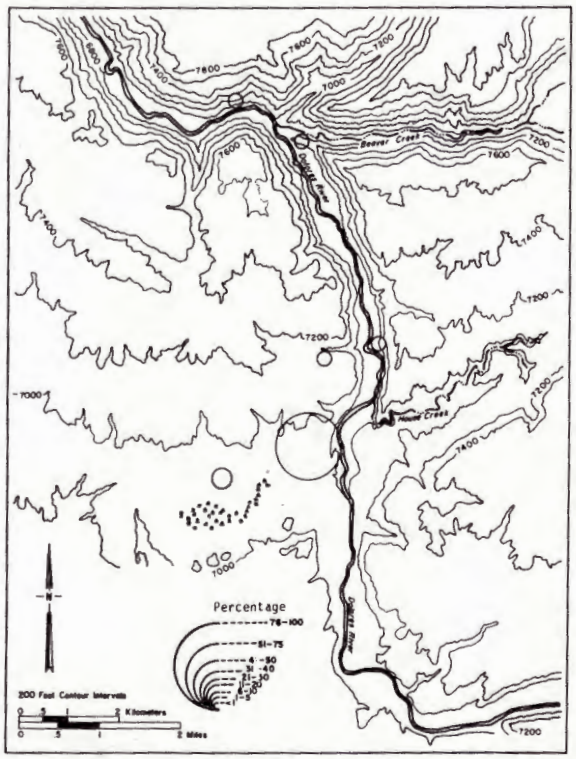


Figure 74. Distribution of quartz sand (Cibola) temper throughout DAP excavated sites. (White wares, N = 62.)

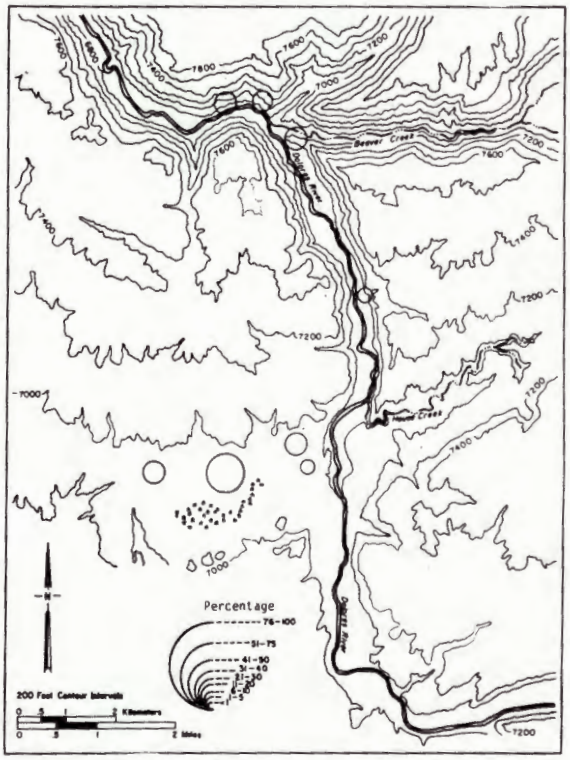


Figure 76. Distribution of quartz sand temper (indeterminate) throughout DAP excavated sites. (White wares, N = 27.)

acting as systemic regulators, which facilitate the continuation of commodities exchange (Pires-Ferreira and Flannery 1976). Also, given the fact that localized ceramic production was almost completely limited to gray utilitarian wares, with the attendant reduction in procurement-production zones, the motivation for engaging in white ware exchange becomes obvious. The latter half of the Dos Casas and all of the Periman Subphase exhibit the dominance of San Juan Tract gray and white wares along with variable amounts of interregional exchange. Any direct interaction with the Kayenta region having long ago disappeared, the emergence of the Chacoan system to the south may be responsible for the exchange of Cibolan and Chuskan ceramics into the Dolores Tract.

The end of the Periman Subphase, McPhee Phase, reveals what appears to be a systemic collapse. Distributional profiles for ware types of sherd and San Juan crushed temper detail a dramatic decline in magnitude, centralization, and directionality of all intra- and interregional exchange. Catastrophic collapse, a complete abandonment, is dictated against, however, by the continuation of locally manufactured gray wares exhibiting sherd and andesite/diorite temper. Exchange mechansims of the much later Sundial Phase are focused upon Site 5MT2235 (figs. 60 and 63) and are integrally related to the emergence of Chacoan outliers such as Escalante Ruin.

A continuous theme of systemic centralization runs throughout the text of this discussion. By using the Shannon-Wiener information measure (fig. 77), it was hoped that a more sensitive picture of temper type diversity, and thus interaction, might be obtained. Unfortunately, little of inferential significance can be seen except a high diversity index for much of the McPhee Village, which would be consistent with the variability of intra- and interregional interaction observed.

In examining the overall complexity of Anasazi interaction in the Dolores River valley, a developmental or formative level of exchange may be visualized — a system both prior to and organizationally less complex than the impressive Chacoan network to the south. Pires-Ferreira and Flannery (1976) have discussed some of the salient features of formative level exchange — exchange dictated by diverse reciprocal relationships.

Of critical importance are observations concerned with exchange between settlements in different environmental

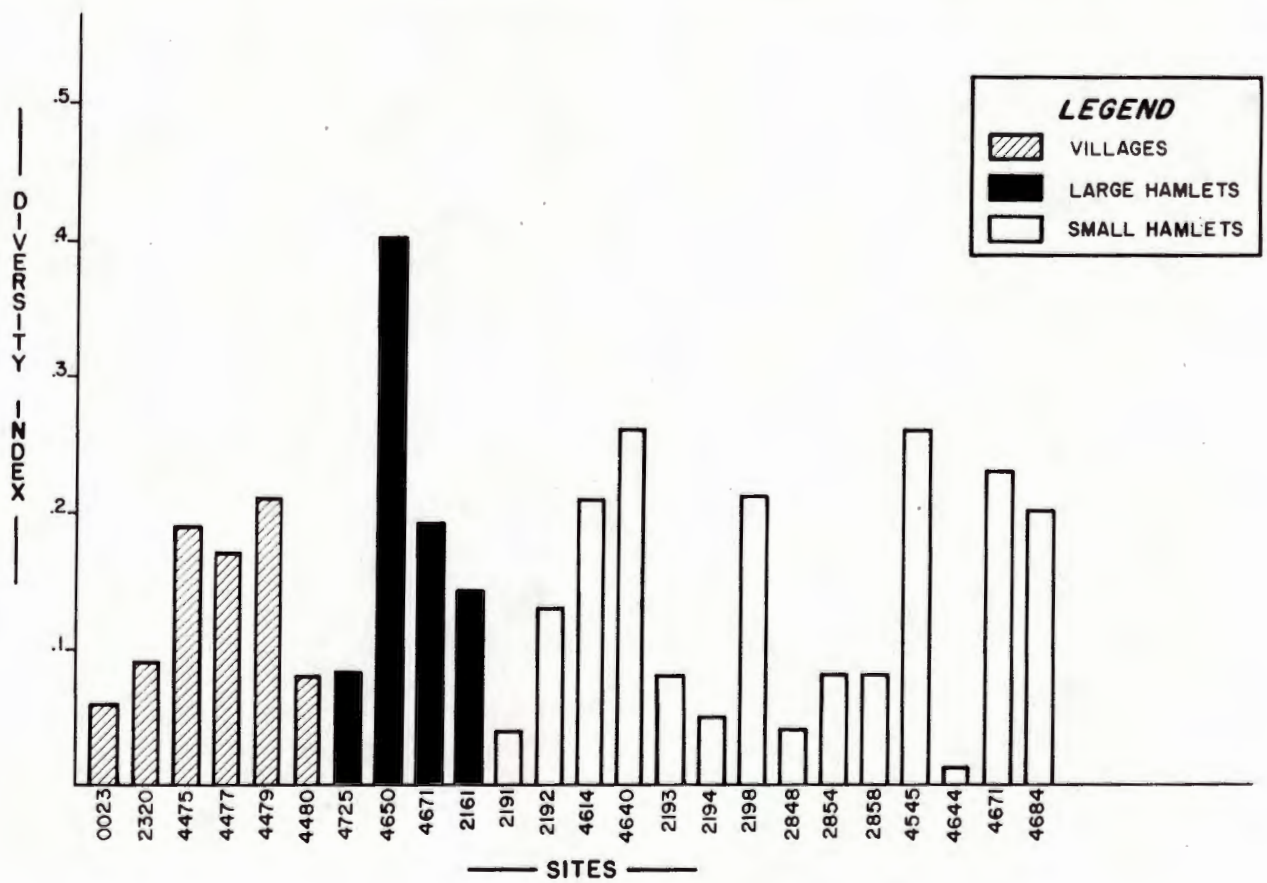


Figure 77. Shannon-Wiener information measure.

zones, reciprocal exchange of utilitarian commodities, the pooling of utilitarian commodities for later distribution to all members of the community, and exchange of materials utilized in ritual contexts (Pires-Ferreira and Flannery 1976). Obviously, these attributes are continuously manifested within the Dolores River prehistoric exchange systems and therefore represent a unique socioeconomic framework on the northern periphery of Anasazi occupation.

DATING WITH NECKBANDS: CALIBRATION OF TEMPORAL VARIATION IN MOCCASIN GRAY AND MANCOS GRAY CERAMIC TYPES[8]

by Eric Blinman

INTRODUCTION

A majority of the archaeological remains within the Dolores Project area are attributed to the Anasazi and to the time period of A.D. 600 to 1000. This relatively short time period encompasses a great deal of cultural change, especially between A.D. 750 and 950. Human population of the Dolores River valley increased dramatically, large villages were formed, and most of the valley was finally abandoned. In the face of these rapid changes, adequate description and interpretation of the prehistory requires a high degree of resolution from archaeological dating techniques.

Tree-ring dates have the best resolution of project dating methods. Each datable sample yields a calendar date for its outermost growth ring, and these dates are inferentially linked to their archaeological context (usually pithouse or room construction). Although this dating technique easily satisfies the need for high resolution, preservation of tree-ring samples in project area archaeological sites has been poor. Few excavated structures have yielded enough datable samples for strong inferences of construction dates, and most structures and other archaeological features remain undated.

Ceramic typology has provided the next best dating tool for project area sites. Change in regional Anasazi ceramic styles has resulted in the definition of temporally distinctive types (Breternitz et al. 1974). Popularity spans of each type have been dated by inferences from tree-ring dated structures and sites from the entire Mesa Verde region, and typological dating has reached a high degree of precision. Unfortunately, resolution of ceramic dating is poor (100- to 300-year time spans), due both to the length of time any one style was popular and to the vagaries of uselife, curation, and depositional processes.

Seriation (Marquardt 1978) of ceramic types or stylistic elements holds potential for greater dating resolution, but these approaches have limited usefulness in the context of project area archaeology. The existence of multiple component sites and the need to document the growth of villages require the dating of small proveniences within sites (e.g., house floors) rather than whole site collections. These small proveniences usually contain few ceramic types (gray wares are common, whereas decorated wares are rare), and variability in sherd abundance by provenience is high. Thus, although seriation approaches could be carried out, the small size of the individual data sets would result in a relatively large uncertainty for each date estimate.

Variation within defined ceramic types is another approach to improving dating resolution (LeBlanc 1975). This approach is dependent on the existence of continuous and unidirectional change through time in one or more dimensions or in frequencies of attributes within a type or types. Design element frequencies within Tusayan White Wares have been used to date sites on Black Mesa with greater degree of resolution than had been possible with typological dating (Hantman and Plog 1978). Unfortunately, although possibly applicable on a site basis, decorated wares are too rare in the smaller DAP proveniences to support a similar technique. Gray wares, however, are abundant, and two gray ware types in particular (Moccasin Gray and Mancos Gray) appear to have potential as dating tools.

MOCCASIN GRAY AND MANCOS GRAY

Moccasin Gray and Mancos Gray are culinary wares that are found in Mesa Verde region sites dating from about A.D. 775 to 900 and A.D. 875 to 900-950, respectively (Breternitz et al. 1974:5,10). They are characterized by unobliterated coil junctures on the neck of each vessel (fig. 78), and vessel shapes are limited to jars of various sizes. Relatively large coils of clay were used to build Moccasin Gray jar necks, and when the coils were applied to the vessel, they were deformed into tall fillets which appear to be stacked. Smaller coils of clay were used to build the Mancos Gray jar necks, and during the application process, the lower part of each new coil was pressed over the top of the previous coil. This technique creates a clapboard appearance that contrasts with the stacked fillets of Moccasin Gray. Sherds with small and undeformed neck coils are also classified as Mancos Gray, but the method of coil application is sufficiently different from either the classic Moccasin Gray or Mancos Gray types that these sherds are not considered in the following discussions.

Although ideal sherds of each type are easily distinguished, there are many sherds that are difficult to classify. Tall

[8]The statistical approaches to this problem were carried out under the guidance of Dr. Allan H. Marcus and Dr. Timothy A. Kohler, Washington State University.

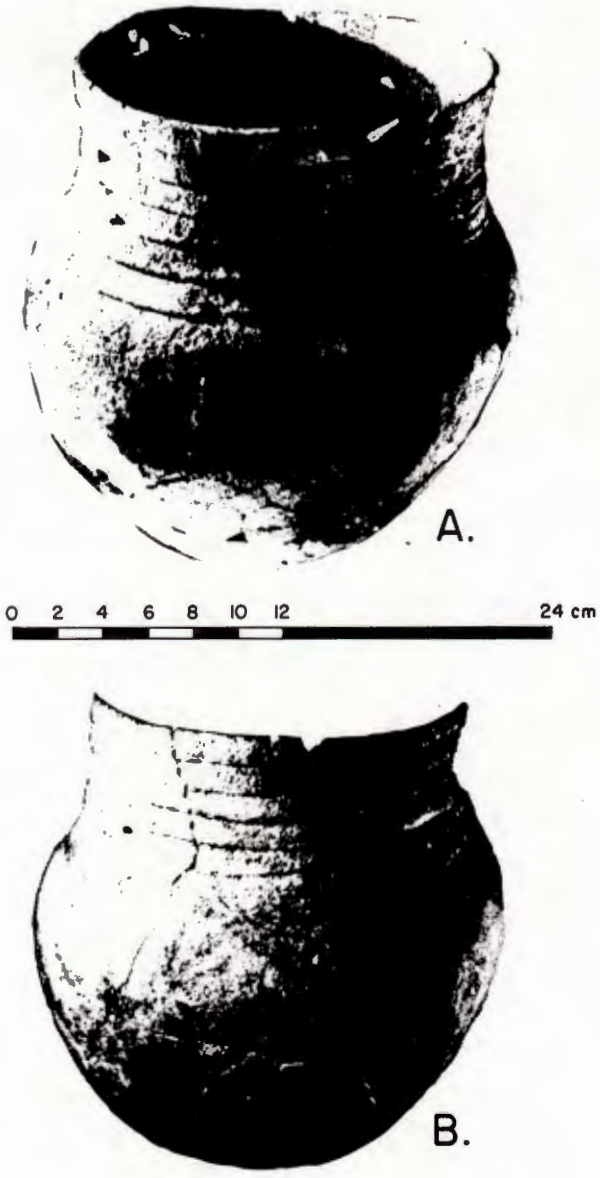


Figure 78. Portions of (A) Moccasin Gray (DAP 038001) and (B) Mancos Gray (DAP 039420) neckbanded jars.

neckbands characteristic of Moccasin Gray sometimes can be strongly clapboarded, whereas the short neckbands of Mancos Gray can often lack any clapboard effect. In many instances, both characteristics are intermediate, and type assignment is arbitrary. These ambiguities have not jeopardized the function of Moccasin Gray and Mancos Gray as pottery types (their temporal spans overlap), but the ambiguities do suggest that these types may represent segments of a continuous distribution of attribute values. This observation provided the impetus for the following analysis.

NECKBAND VARIATION

The first step in the analysis was to confirm that variation in one or more neckband dimensions was continuous, unidirectional, and correlated with time. Dimensions were chosen primarily on the basis of an intuitive evaluation of dating potential, but several were included that were not obviously temporally related. Definitions of the dimensions were stated so that measurements could be made consistently on sherds of both ceramic types (fig. 79). An attempt was made to have each recorded value reflect the mean for that sherd. Where only a single measurement was appropriate per sherd (e.g., rim height), the measurement was made at a point that reflected a visually estimated

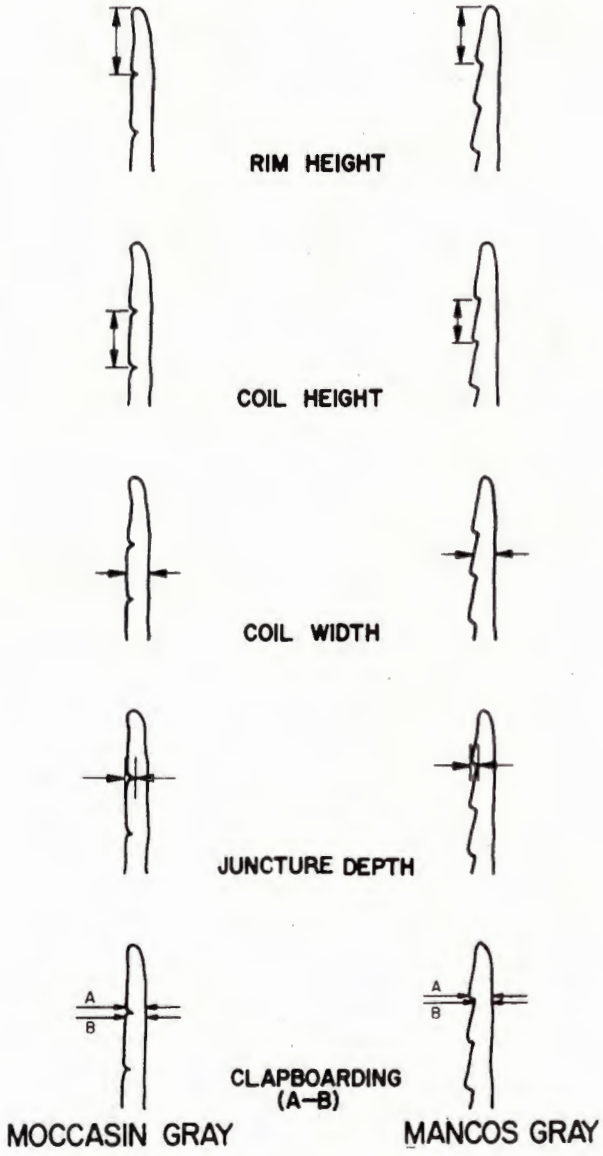


Figure 79. Dimensions of neckbands used in the study of neckband variation.

mean. Where multiple measurements could be made on a sherd (e.g., coil height), a mean was calculated based on a series of measurements, and the mean was recorded along with its standard deviation and the number of measurements used in the calculation. If two or more sherds from a provenience could be identified as having come from the same vessel, they were assigned an identifying vessel number.

Attributes were measured on each neckbanded sherd from 10 dated proveniences from the project area (the 10 proveniences represent 8 different dates of deposition; table 28).

Table 28. Proveniences used in the calibration of neckband variation

Date (A.D.)	Site	Provenience	Remarks*
780	5MT2151	Pithouse 2, floor	Tree-ring dates (482vv and 700++vv) indicate pithouse construction after A.D. 700. Architectural style represents the period before A.D. 770. Ceramic typology (Chapin Gray, Moccasin Gray, Bluff Black-on-red) indicates deposition after A.D. 775.
800	5MT2181	Surface room 9, Pithouse 1, floor	Catastrophically burned room associated with Pithouse 1. Pithouse 1 tree-ring dates (779vv and 780v) and architectural style suggest construction in A.D. 780's. Feature use and remodeling of surface room suggest moderate time lapse before destruction/deposition.
850	5MT2151	Pithouse 1, floor	A tree-ring date (803+vv) and architectural style suggest construction in the first half of the ninth century. Mancos Gray, though present in the fill of the pithouse, is not present on the floor, indicating abandonment prior to about A.D. 860.
860	5MT4725	Pithouse 1, floor	Five tree-ring samples date to A.D. 845 (two v dates, three r dates) and construction at that time is likely. Features in the pithouse were extensively remodeled, suggesting long use prior to deposition.
875	5MT23	Pithouse 10, floor and roof fall	The wingwall post dated to A.D. 867r, and bark was observed on the post by the excavator. The structure was catastrophically destroyed by fire while occupied, and reconstructible vessels were present in the roof fall as well as on the floor. Features in the pithouse had been slightly remodeled, indicating only moderate use prior to destruction.
890	5MT23	Pithouse 2, floor and roof fall	Latest tree-ring date from the structure was A.D. 827++vv, but architectural style suggests construction between A.D. 875 and 900. Ceramic types present include abundant Mancos Gray and Moccasin Gray, but no corrugated wares were recovered from the floor, roof fall, or postoccupational fill. The pithouse was abandoned before its collapse, and both the floor and roof fall contained partial vessels and trash.
915	5MT4475	Kiva 2, floor	The floor provenience was predominantly postoccupational trash. Corrugated wares were present (although not abundant), and both stratigraphy and architectural style suggest construction in the early 900's.
950	5MT4475	Kiva 1, floor	This kiva is stratigraphically later than Kiva 2. Corrugated sherds are abundant, and architectural style suggests a mid-900's construction and deposition. The provenience contains trash.

*Explanation of symbols used with tree-ring dates:

r - less than a full section is present, but the outermost ring is continuous around the available sample 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.

Data were entered into the computer system at Washington State University and were manipulated using the Statistical Analysis System (SAS 1979). Pearson product-moment correlation coefficients (*r*) were calculated for the data, identifying those dimensions that correlated with provenience date (table 29). None of the dimensions was highly correlated with the date, but coil height and rim height had correlation coefficients of -0.45 and -0.36, respectively. Unfortunately, less than 40 percent of all neckbanded sherds have measurable rims, whereas over 90 percent of the sherds have measurable coil heights. For this reason, and for the eventual application efficiency of a univariate solution, subsequent investigations were confined to variation in coil height.

The relationship between coil height and time is presented in figure 80. Mean coil height decreases slightly with time, as would be expected from the correlation coefficient. Low extreme values of coil height decrease much more rapidly (but not in a linear fashion), and high extremes of coil height are relatively stable over time. Except for maximum coil heights, variation does appear to be continuous, and although changes in minimum coil height are nonlinear, change in both means and minima are generally unidirectional. The trends in the extreme values of coil height reflect a marked increase in coil height variance through time (heteroscedasticity) and limit the statistical approaches — specifically regression analysis (Lewis-Beck 1980:28) — that can be directly applied to these data.

MODEL OF NECKBAND STYLE CHANGE AND PRODUCTION

Heteroscedasticity was not anticipated by the implicitly held model of stylistic change under which this study was begun. Change, if present, was expected to be expressed in a relatively unmixed fashion, with relatively little overlap between attribute values of early and late proveniences. This was a naive view, especially given the blurring effects of stylistic competence, variable craftsmanship, uselife/curation behavior, and depositional context.

To better account for the variability in the data and to provide an explicit set of assumptions for subsequent statistical manipulations, a new model was formulated. The model assumes that neckband style changed through time, and that this change was unidirectional and continuous (although not necessarily at a uniform rate). This changing style reflects the trend of the majority of potters at work in the Dolores River valley, but any individual potter could choose any pattern in her/his experience. Slight pattern variation also occurred in a "progressive" direction as well

Table 29. Correlation coefficients, probability of a greater absolute value of *r* (assuming the null hypothesis of no correlation), and sample size for the calibration data set

	Date	Rim height	Coil height	Coil width	Juncture depth	Clap-boarding
Date	1.00000	-0.36081	-0.45080	-0.00056	0.28983	0.20618
	0.0000	0.0001	0.0001	0.9925	0.0001	0.0006
	311	124	285	284	287	274
Rim height		1.00000	0.52749	0.19646	-0.24110	0.06068
		0.0000	0.0001	0.0426	0.0083	0.5232
		124	106	107	119	113
Coil height			1.00000	0.09146	-0.29393	-0.16340
			0.0000	0.1255	0.0001	0.0080
			285	282	273	262
Coil width				1.00000	0.07818	0.05935
				0.0000	0.1987	0.3377
				284	272	263
Juncture depth					1.00000	0.60496
					0.0000	0.0001
					287	274
Clapboarding						1.00000
						0.0000
						274

("progressive" in the sense of smaller coil heights), but such stylistic experiments were less abundant and less deviant in an absolute sense from the prevailing style than were the "nonprogressive" choices available to each potter.

One assumption implicit in the above is that the observed styles of neckbanding reflect local events rather than idiosyncratic intrusions of vessels and styles from outside areas. Gray wares are usually assumed to be less liable than other wares to long distance exchange, but there are notable exceptions (e.g., abundant Chuskan utility vessels in Chacoan sites [Toll et al. 1980:97]). Unfired samples of pottery clay found in archaeological sites in the Dolores Project area have been tempered exclusively with a crushed igneous rock which contains moderate amounts of feldspars in addition to quartz and ferromagnesian minerals (identifications based on 20X binocular microscope examination). All sherds tempered with this material are potentially local, but this same temper is also known to be used in some areas outside the Dolores River valley. Because of this, although all demonstrably nonlocal sherds (those with tempers other than the above) have been eliminated from this study, some of the sherds and, therefore, some of the neckband styles, may reflect extralocal trends. There is no way of estimating the number of such intrusive sherds, but they are expected to be fairly rare.

In addition to variation due to pattern or style choice, variation due to the individual potter's skill or care in executing the style is reflected in each jar. Coil height variation within individual vessels is displayed in figure 81 (vessel data from undated proveniences are presented as well as those from the 10 dated proveniences). Only vessels represented by five or more sherds are included, and vessels are ordered by decreasing mean coil height. Of the 23 vessels, coil height distributions are significantly nonnormal ($p<.05$) in only one case (based on the Shapiro-Wilk W statistic). Weighted mean standard deviation (s_w) of the vessels is 1.06 mm, meaning that 68 percent of the sherds of a given vessel will fall within about 1 mm of the mean value (or style) of that vessel.

Uselife and curation also contribute to the variance of coil height in any given provenience. Foster (1960) and DeBoer and Lathrap (1979: fig. 4.5, table 4.5) suggest that jar uselives are relatively short (about a year or less, depending on

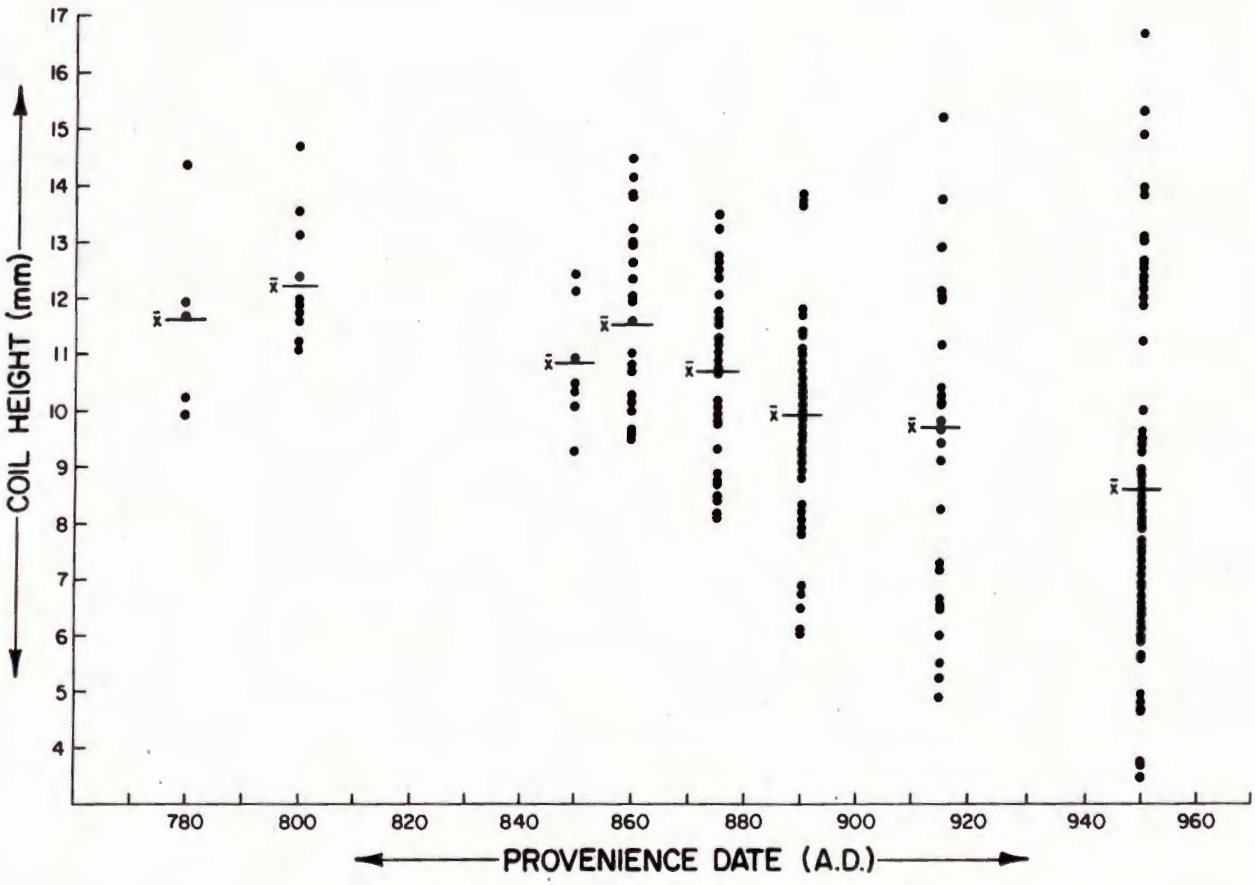


Figure 80. Scatter plot of coil height vs. time for the calibration data set. Dots represent individual sherds and a mean is represented for each time period.

vessel function and degree of child/domestic animal activity in the household). Survivorship curves for most vessels approximate an inverse curve, and the oldest cooking jars in the above studies were 6 years old. If the abundance of domestic animals is as great a factor in breakage as Foster suggests, the uselives of Anasazi vessels may have been longer, creating a greater potential contrast between "old" and "new" style jars in any given household.

A final contributor to coil height variance in a given provenience is depositional context. Instantaneous slices of time such as catastrophically burned pithouses should reflect a narrower range of style than slow accumulations such as midden layers. However, the former contexts can suffer from small sample sizes which may restrict the degree to which the included neckband styles reflect the style prevalent at the time of deposition. Also, whereas the best date estimator for a rapidly deposited context (such as a house floor) would be the most progressive neckband style present, slowly deposited contexts (such as midden layers) would have to be subdivided into early and late strata, and the most progressive style in each stratum would provide the best bracketing date estimates.

CALIBRATION

Based on the model outlined above, the most progressive neckband style in a provenience is the best estimator of its date (or terminal date) of deposition. This makes calibration of the rate of stylistic change difficult, because it is necessary to segregate progressive from nonprogressive sherds. Proveniences that contain a variety of reconstructible vessels could conceivably be evaluated on a vessel by vessel basis, but such proveniences are rare, and in most cases sherd data are all that are available. Thus, the first part of the calibration process was the unmixing of progressive sherds from the rest of each calibration data set.

Since the calibration data sets are variable in terms of sample size and depositional context, a graphical unmixing technique seemed to be the most appropriate. Vessels are the unit within which style is expressed, and the coil heights of sherds of most vessels approximate a normal distribution around the vessel style or mean. In an ideal sense, distribution of coil heights within a provenience can be thought of as a mixture of several vessel distributions, each

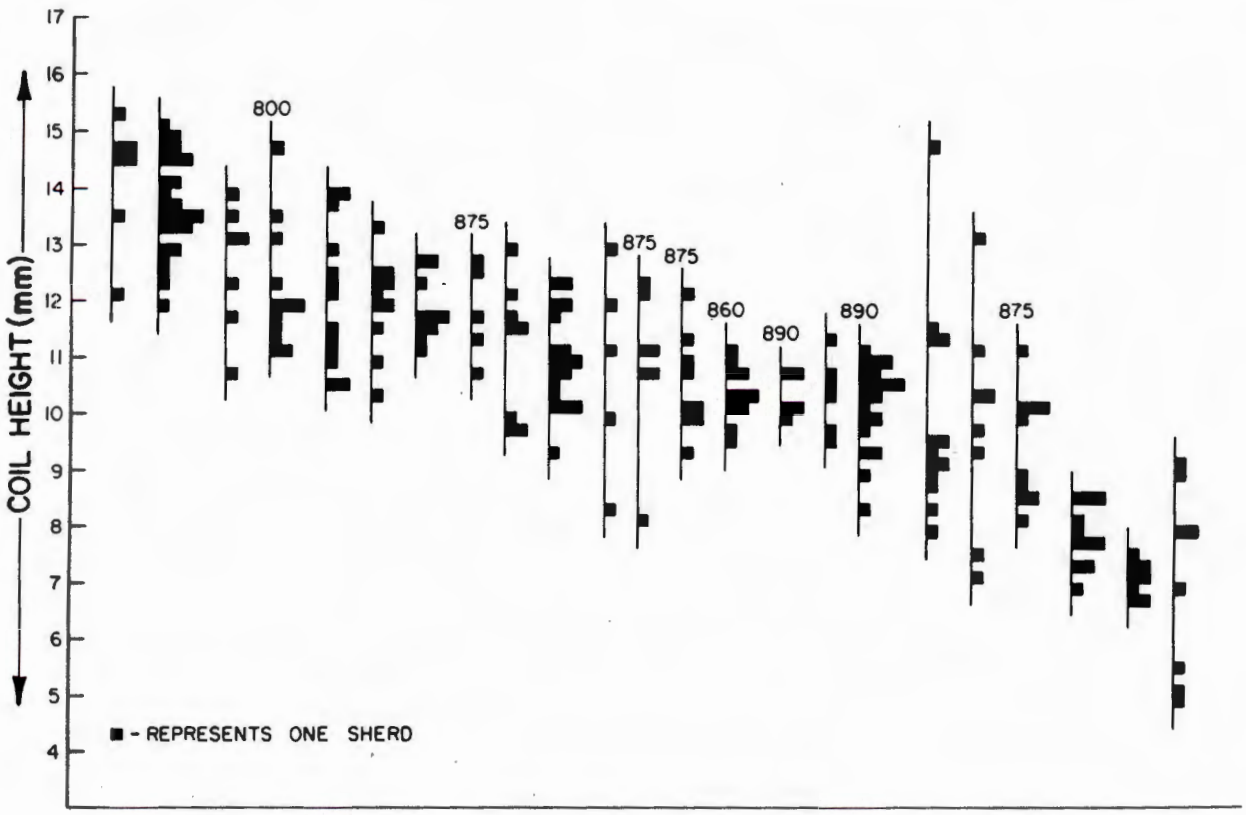


Figure 81. Histograms of coil heights of vessels represented by five or more sherds. Data are ordered by decreasing mean coil height, and vessels that are part of the calibration data set are labeled with their date of deposition.

with a potentially different mean. When cumulative frequencies of normally distributed data are plotted on normal probability graph paper, the resulting plot approximates a straight line. Deviations from a straight line represent deviations from a normal distribution, and can be used to identify where mixing has taken place.

Normal probability plots of coil heights for each deposition date are presented in figure 82. Also presented is the slope expected for coil height distribution for an ideal vessel (s_w = 1.06 mm). Break points in the curves and the slope of the lower tail of each distribution were used to subjectively identify where mixing had taken place. In some cases with small sample sizes (A.D. 780 and 850), there was no reason to segregate any of the sherds as being nonprogressive; in most of the other cases, break points are relatively clearly defined. Such clear definition of break points was not expected (tails of such distributions are highly sensitive to sampling error), but the results are consistent and the tail slopes tend to fall within the expected range of slopes for individual vessels. This is not to imply that this technique successfully isolates the most progressive vessel from the larger group of sherds (sherds from individual vessels were separated by the break point of the A.D. 875 distribution), but it does systematically identify groups of stylistically progressive sherds.

Coil height distributions defined above are plotted against provenience date in figure 83. A simple linear relationship is not an adequate summary of these data. Between about A.D. 850 and 900, there appears to be a much more rapid rate of stylistic change than either before or after. Without an a priori reason to assume any particular form of relationship, the easiest summary is to divide the data into groups that define three intersecting linear segments. Thus, a rate of style change can be summarized for the provenience dates prior to and including A.D. 850, for A.D. 850 through 890, and for proveniences contemporary with or later than A.D. 890.

Linear regression can be used to describe each of these segments, but the previous data manipulation compromises its use for assessing the uncertainty of the description. A conservative approach that is applicable in this situation is the use of a technique called the "jackknife" (Mosteller and Tukey 1977:133-163). Using this technique, an estimate of each regression line and its confidence band can be made without assuming that the data are normally distributed, are strictly homoscedastic, or are necessarily symmetrical.

Coil height values from each provenience were considered as groups, and the groups were used to calculate the jackknifed regression coefficients. A jackknifed variance for each coefficient was also calculated, and it was used to define a confidence band (p=.95) around each regression line (fig. 83). These confidence bands are not strictly appropriate, but they are more conservative than those calculated without the use of the jackknife. Part of the inappropriateness is that once the transition is made from calibration of stylistic change to the application of a dating technique, the problem ceases to be one of regression analysis and becomes one of inverse calibration. This refers to the situation in which measured values of a dependent variable are used to predict values of an independent variable, a process that entails different evaluation of error than applies to regression (Tucker 1979). No attempt has been made in this study to cope with this difficulty, and although the confidence bands provide a visual impression of reliability, they are not used in style date estimation or interpretation.

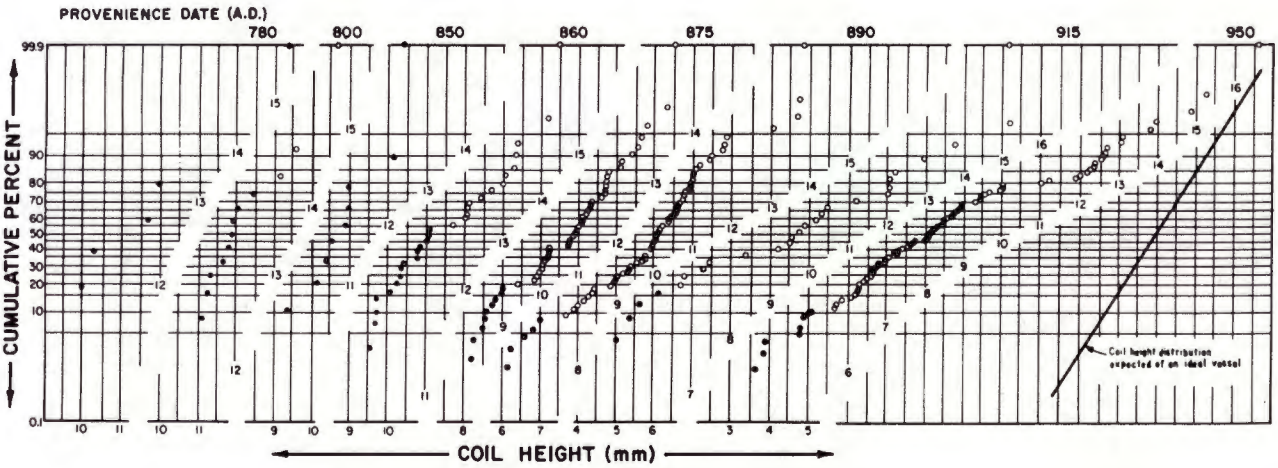


Figure 82. Coil height distribution within calibration proveniences. Data are plotted as cumulative percentages and are plotted on normal probability graph paper. Solid circles represent data points (stylistically progressive sherds) that are used in the final calibration analysis, and the slope expected for an ideal vessel is plotted on the right.

APPLICATION

Three equations result from the calibration process and can be used to calculate an estimated style date for any measurable sherd (table 30). Once a suitable provenience is defined (e.g., house floor, midden layer, surface collection), Moccasin Gray and Mancos Gray sherds with "local" temper are selected and sherds that were derived from distinguishable vessels are grouped. Coil heights are measured as described in the calibration process, and the data are recorded along with vessel information if appropriate. Depending upon the coil height of each sherd, one of the three equations is chosen and a date is calculated. Multiple dates from single vessels are recorded together, and dates from unaffiliated sherds are listed in decreasing date order.

Interpretation of the resulting date lists follows a pattern of assumption and inference similar to that used in the interpretation of noncutting[9] tree-ring dates. Each date estimate refers to the style expresssed by the sherd, and cannot be directly related to either the manufacture of the sherd or the date or deposition of the archaeological context. Unlike tree-ring dates, it is possible for a sample to date later than the actual date of deposition, but such instances appear to be rare, and the best estimator of the provenience date is the latest date cluster. Date clusters derived from vessels are the most secure data sets; vessels are usually more clearly related to a cultural context than are individual sherds, and vessel clusters decrease the estimation uncertainty associated with individual sherds. Confidence in dating inferences based on style dates is directly related to the number of style dates and their dispersion. Unfortunately, there is also a need for evaluation of cultural/depositional context, and, like noncutting tree-ring dates, confidence statements are predominantly subjective.

All but one dated context from the 1978, 1979, and 1980 DAP field seasons were used in the calibration process. The single exception was accidentally overlooked, and consisted of Pithouse 2 from Site 5MT4644. A catastrophic fire destroyed the pithouse while it was in use, and tree-ring samples from structural timbers included one cutting date (A.D. 776r[10]) and 11 noncutting dates that clustered at A.D. 775 and 776. No neckbanded sherds were found in contact with the floor, but one vessel was found in roof fall and was presumably on the roof at the time of destruction.

[9]Noncutting dates are those tree-ring dates determined from samples whose surfaces have been eroded so that the outermost preserved growth ring cannot be related to the date the tree stopped growing (was cut down).

[10]Tree-ring dates followed by "r" are based on an outermost preserved growth ring that does not show evidence of erosion of later rings; the date may reflect the date that the tree stopped growing (was cut down).

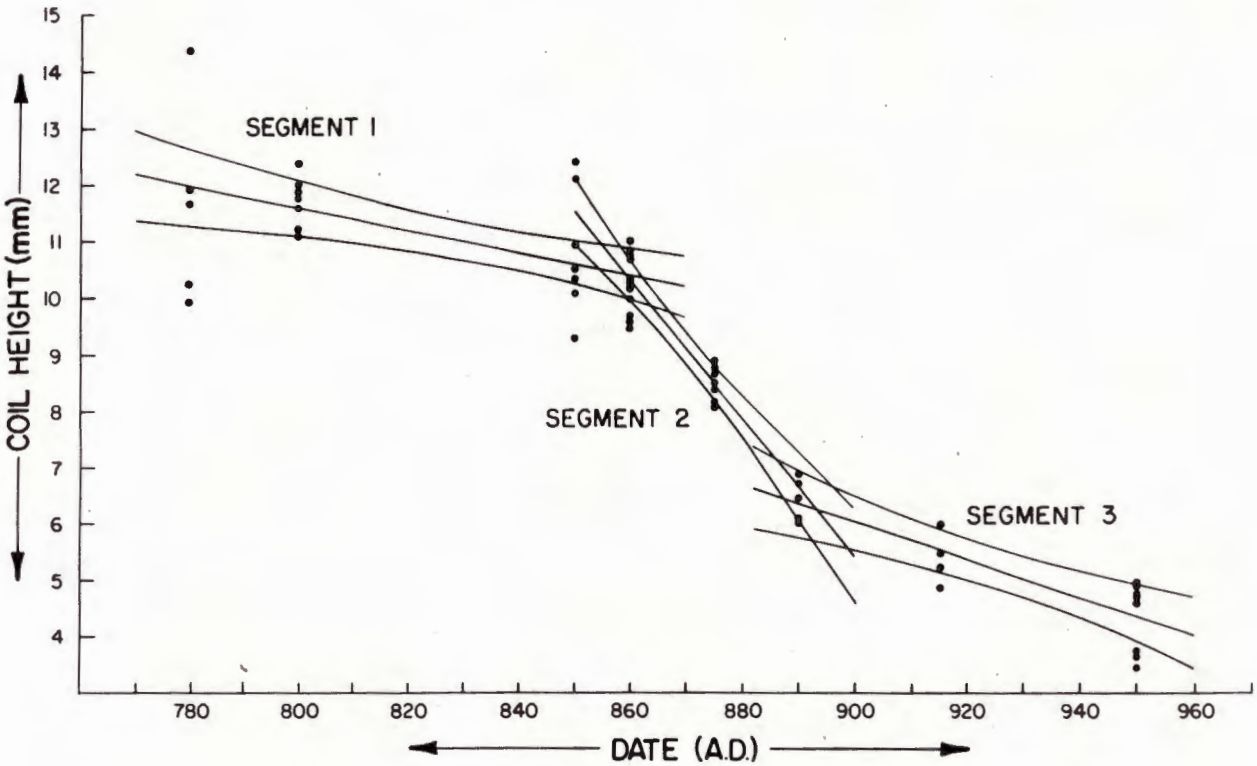


Figure 83. Coil height distributions, jackknifed regression lines, and confidence bands for the final calibration of neckband variation.

Dates based on sherds from this vessel are listed in table 31. Although the sample is small, the style date of the vessel (about A.D. 780-790) agrees well with the likely date of deposition (probably within a generation of house construction in A.D. 776).

Another example of the application of this dating technique is Site 5MT4479. Two pithouses were associated with an arc of surface rooms. Pithouse 1 was spatially associated with Room 8 (a large front room at one end of the arc), and Pithouse 2 was associated with Room 7 (a similar room at the other end of the arc). Stratigraphic and construction data indicate that the two pithouses and their associated surface rooms were contemporaneous. Neckband dates from sherds on the floors of the pithouses and rooms (table 31) support the inference of contemporaneity and place terminal occupation of the site in the A.D. 860-880 time range. In addition, there is greater homogeneity of style dates within each presumed household (pithouse and associated surface room) than between households. This may reflect the individuality of each household's potter(s) (ceramic manufacture is documented for each pithouse), or it may reflect abandonment of Pithouse 1/Room 8 slightly earlier than abandonment of Pithouse 2/Room 7.

CONCLUSION

Variation in neckband style within the Dolores River valley provides a high resolution dating technique for sites occupied between A.D. 775 and 950. Acceptance of this technique hinges on acceptance of a model of stylistic change, stylistic competence, curation/uselife, and depositional context, implying that the most stylistically progressive sherds in a provenience are the best estimators of the provenience date. Calibration of the stylistic change is based on a graphical unmixing of progressive sherds from nonprogressive sherds, and the resulting data were described using jackknifed regressions. The rate of stylistic change was not constant through time, and was accelerated between A.D. 850 and 900. This improves the dating resolution in this time period (coinciding with the population maximum in the Dolores River valley), and it may also be an independent measure of relative cultural stability.

Table 30. Jackknifed regression equations and range definitions for neckband dating

Segment	Jackknifed regression equations (x = style date) (y = coil height)	Applicable range Date (years A.D.)	Coil height (mm)
1	y = 27.361664 + -0.019822x	earlier than 859	greater than 10.412
2	y = 115.041001 + -0.121938x	859 — 893	10.41 — 6.28
3	y = 35.000575 + -0.032048x	later than 893	less than 6.28

Table 31. Neckband dates for selected proveniences from Site 5MT4644 and Site 5MT4479

Site	Provenience	Vessel No.	Coil height (mm)	Style date (A.D.)
5MT4644	Pithouse 2, roof fall	901	12.10	770
		901	12.10	770
		901	13.25	712
		901	15.00	623
5MT4479	Pithouse I, floor	903	10.70	841
		903	11.62	794
		903	12.27	761
		903	13.07	721
		903	13.10	719
		903	13.53	698
		903	13.90	679
		904	9.25	868
		904	10.02	861
		904	10.10	861
		904	10.13	860
		904	10.30	859
		904	10.45	853

Table 31. Neckband dates for selected proveniences from Site 5MT4644 and Site 5MT4479 — Continued

Site	Provenience	Vessel No.	Coil height (mm)	Style date (A.D.)
		904	10.63	844
		904	10.78	837
		904	10.84	834
		904	10.95	828
		904	11.00	825
		904	11.05	823
		904	11.12	819
		904	11.62	794
		904	11.90	780
		904	11.92	779
		904	12.33	758
		904	12.37	756
		905	9.62	865
		905	9.78	863
		905	9.97	862
		905	11.52	799
		905	11.55	798
		905	11.72	789
		905	12.10	770
		905	13.00	725
			11.35	808
			12.18	766
			13.00	725
			13.22	713
			13.30	709
			14.18	665
			14.62	643
5MT4479	Pithouse 2, floor	901	6.67	889
		901	6.70	888
		901	6.93	887
		901	7.02	886
		901	7.11	885
		901	7.22	884
		901	7.35	883
		901	7.52	882
		902	12.15	767
		902	13.52	698
		902	14.42	653
		902	14.60	644
		902	14.70	639
		902	14.75	636
		902	15.40	603
			6.95	886
			7.75	880
			9.05	869
			9.22	868
			11.85	783
			14.58	645
			17.40	503

Table 31. Neckband dates for selected proveniences from Site 5MT4644 and Site 5MT4479 — Continued

Site	Provenience	Vessel No.	Coil height (mm)	Style date (A.D.)
5MT4479	Surface Room 7, floor		6.97	886
			8.30	875
			8.40	875
			8.98	870
			9.82	863
			9.88	862
			9.90	862
			10.20	860
			12.10	770
5MT4479	Surface Room 8, floor		9.03	869
			9.55	865
			9.60	865
			10.08	861
			10.30	859
			10.65	843
			11.12	819
			11.35	808
			11.82	784
			12.78	736
			14.60	644

Section 6

LITHIC STUDIES

by Carl J. Phagan, Carolyn R. Orth, and Robert K. Vierra

PROJECTILE POINT ANALYSIS

by Robert K. Vierra and Carl J. Phagan

INTRODUCTION

This interim report presents preliminary results of an intensive projectile point typological analysis. This analysis grew out of a more general technological and functional analysis in response to questions regarding the temporal and spatial distribution of these high-input items. A complete report on the analysis is being prepared for submission to the Bureau of Reclamation.

The study was undertaken with several objectives in mind. First, if temporally sensitive types could be established, they would be particularly useful in assigning some survey sites to appropriate positions in the project temporal-functional matrix and would provide important settlement pattern data (Problem Domains 1 and 5 [Kane, Lipe et al. 1981]). Second, it was judged that well-defined projectile point types could aid in identifying the degree of group integration of the Dolores Anasazi, as well as the degree of their participation in wider district-level interaction spheres, particularly their interaction with the Mesa Verde Anasazi (Problem Domain 3). Third, such types, once established, may also prove to have functional or site-type significance, or to represent special segments of the lithic technological system of resource procurement and use, especially for some categories of nonlocal materials (Problem Domains 1 and 4). Fourth, such high-input tools would be the most likely items to demonstrate production or distribution patterns suggesting the development of craft specialization (Problem Domain 3). Finally, such types were needed for comparison of the DAP materials with Southwestern archaeological literature.

Very early in the study it was confirmed that all important or detailed projectile point analyses in the available literature dealt exclusively with Archaic time periods and that ceramic period lithic studies in general, and projectile point studies in particular, were virtually nonexistent. Hayes and Lancaster (1975:144-146) have a typically brief and intuitive description of three projectile point types from the Badger House excavations on Mesa Verde. To a great extent, therefore, the study breaks new ground, both topically and methodologically.

DATA SELECTION

Selection of the data set for the analysis was essentially a series of elimination steps. First, only materials through the 1979 field season were available for inclusion, or approximately 750 projectile points or identifiable fragments. In order to confirm the temporal sensitivity of resulting groups, all points from undated proveniences were excluded. This involved all survey items as well as all items excavated from contexts which were not datable at the subphase level by independent means, such as carbon 14, ceramics, dendrochronology, architecture, or archaeomagnetics. To avoid logical circularity, all projectile points assigned an Archaic date on the basis that they "looked Archaic" were also eliminated from the analysis. This resulted in a total of 291 projectile points retained for analysis.

Only about 10 percent of the items were from the later Sundial Phase (A.D. 1050-1200), but it was decided to keep them in the analysis, to recognize the possibility of sample inadequacy, and to interpret cautiously when these items were involved. Ninety percent of the data set was composed of points from the Sagehen (A.D. 600-850) and McPhee (A.D. 850-975) Phases, a combined time span of only 400 years or less. This may also be problematic in that such a short span might not be long enough to recognize temporally sensitive attributes.

ANALYSIS AND RESULTS

All projectile points were submitted to a 13-attribute technological analysis. In addition, a black-and-white slide of each projectile point was projected onto graph paper, its outline was traced, and 10 critical measurement locations were recorded as a series of X and Y coordinates. Appendix 5-1 describes this measurement procedure and the measurement locations. Appendix 5-2 consists of two examples of typical projectile points with measurement locations indicated. Using a variety of basic trigonometric algorithms, 19 plan morphology variables were generated from these 10 measurement locations. A similar procedure was employed by Holmer (1978:6-13). Since the projections are frequently at different scales, a correction factor was generated for each item from an actual length or width measurement and the corresponding computed value. All of the generated plan morphology variables are interval or ratio scale variables. Appendix 5-3 is a list of these generated variables, and appendix 5-4 shows the angles and distances used in the trigonometric algorithms. Appendix 5-5 is an actual example of the graph developed for each item which was used for computer input, and which is maintained as a permanent paper record.

In the next stage of the analysis, frequency distributions were obtained for all variables measured and generated — a total of 32 variables — and an outlier program was run to identify cases of extreme variability. The frequency distributions were examined, and a variable intercorrelation analysis was performed to identify measurement redundancy and to remove variables which seemed to be measuring the same technological or stylistic phenomena. It was at this stage of the analysis that a decision was made to reduce the total variability still further by eliminating all technological variables, many of which were measured on nominal or ordinal scales, and to focus completely on the generated morphologic variables. This would produce purely morphological-stylistic groupings rather than the techno-stylistic types which had been envisioned, but it seemed better not to risk the problems attendant with using multivariate statistical methods on nominal or ordinal data. In addition, and for somewhat the same reason, all cases were eliminated which did not have complete data for all measurement locations and generated variables. The result was a data matrix of 163 cases (projectile points) and 10 generated interval or ratio scale variables. The 10 variables retained in the analysis are marked with an asterisk(*) in appendix 5-3.

Christenson and Read (1977) have defended the position that the concept of a natural taxonomy and the idea of equal character weighting, both important parts of the numerical taxonomy approach, are inconsistent with the purposes of making a classification of archaeological data. They argue further that the use of cluster analysis on raw data lacks the characteristics necessary for the initial analysis of archaeological data (Christenson and Read 1977:163-179). What is needed is a procedure that isolates variable clusters or variable associations. Therefore, a principal component analysis with varimax rotation was performed on the data matrix, and a four-factor solution was obtained which accounted for 82 percent of the variance. No variables loaded highly on more than one factor, and only one single-variable factor was produced. From a logical perspective, the variable associations represented by the factors could readily be interpreted; i.e., the factors seemed to represent logically associated groups of variables.

These four factor scores for each case were then input into a CLUSTAN (cluster analysis) program (Wishart 1969), so that the classification procedure operates on a reduced set of dimensions containing variable associations or clusters, rather than on the raw data. Using Ward's hierarchical fusion method, eight clusters or groups resulted from the CLUSTAN program. One group contained all of the notchless points; another, the few side-notched points; another the barbed "Pueblo" points. With the exception of three groups, items within each group displayed a high degree of intuitive similarity of plan morphology, thus meeting to some reasonable degree the classification criterion of internal cohesion and external isolation.

The output from the cluster analysis program suggested that some of the larger groupings might be further broken

down into subgroups. All points within each group were visually inspected, and it was determined that the existence of subgroups within a few of the large groupings was in fact empirically justifiable. Furthermore, the visual inspection revealed that some items were probably knives, some were broken and reworked, and a few had been incorrectly measured. Removing these points from the analysis, as well as the very small group of the side-notched points (four items), resulted in a total of 129 points retained in the analysis.

Membership in five of the original cluster groupings remained approximately the same. The two remaining groups (after eliminating the small side-notched group) were divided into four subgroups. If the original groupings and the subgroups were real, then most of the 10 variables should exhibit nonoverlapping ranges for the 95-percent CI's (confidence intervals). This would be a check not only for the original groupings but, more important, for the newly created subgroups. Results of this statistical procedure revealed that two of the original groupings could be collapsed into a single group, and that the four subgroups could be combined into two larger groups. This procedure produced six clearly identifiable and separate groupings.

As a further check on these classification procedures, the 129 cases were submitted to a stepwise discriminant analysis program using the six-group typology and the raw data scores for the 10 variables. A very encouraging 96.9 percent of the cases were correctly classified.

The next step in the analysis was to rerun the discriminant analysis with the six groups and 129 cases, plus an unclassified group of 128 broken projectile points. The purpose here was to determine whether the classification functions could assign any of the broken items with missing data to any of the existing groups. The results here were also quite encouraging. Of the 128 points, 110 (86 percent) remained as an unclassified group, and 18 (14 percent) were assigned to five of the six groups. A visual inspection of this classification of broken items showed good agreement with the internal cohesion-external isolation criterion.

The final step in the analysis was to identify for each of the groups the diagnostic variable expressions or range of values that might serve as a useful key in defining and recognizing the groups. This was done by establishing the 95-percent CI's for the 19 generated variables and identifying the nonoverlapping ranges for the 95-percent CI's. The six groups, or types, are listed below, along with the nonoverlapping variable ranges which define each type and the general temporal occurrence of each type.

Type 1

These are notchless points varying in shape from ovoid to triangular (fig. 84). Subtypes within this group may be desirable. The type occurs predominantly within the McPhee Phase contexts, though it is not likely to prove a good temporal indicator.

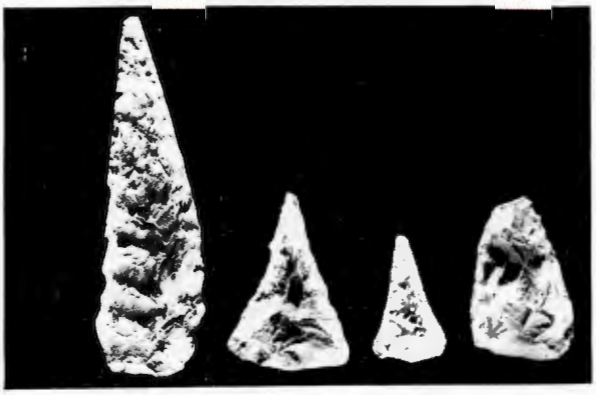


Figure 84. Type 1 projectile points (x1) (DAP 083304).

Type 2

The three points on the left of figure 85 are Type 2 points. They are wide-based with high, wide corner notches and curved blades.

Diagnostics:
- Highest blade curvature index 0.11-0.15
- Notch angle 153°-161°

Type 2 points occur throughout the DAP sequence. The point on the right of figure 85 is an example from the small group of side-notched points. The only four examples of these side-notched points occur in Sagehen Phase contexts, and they may prove to be a temporally significant type. This would be somewhat unusual in a regional context, since side-notched points are recognized in the literature as tending to occur later rather than earlier.

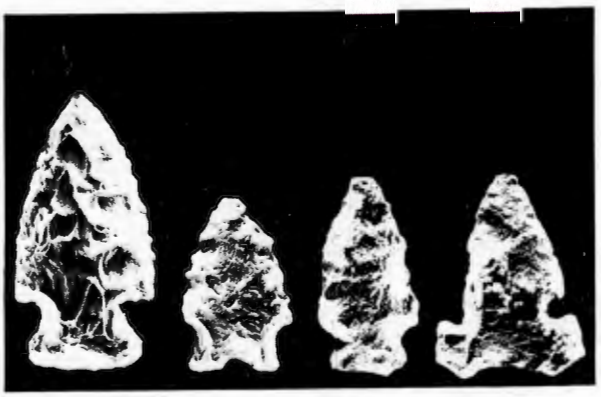


Figure 85. Type 2 projectile points (x0.89) (DAP 083301).

ANASAZI HERITAGE CENTER

Type 3

These are well-shaped items, essentially long and triangular with short, wide bases (fig. 86).

Diagnostics:
- Relatively small notch opening angle 55°-71°
- Highest length-width ratio 2.1-2.4
- Smallest base-length ratio 0.15-0.18
- High position of maximum width value 0.77-0.84

This type tends to occur predominantly in Periman Subphase contexts of the McPhee Phase.

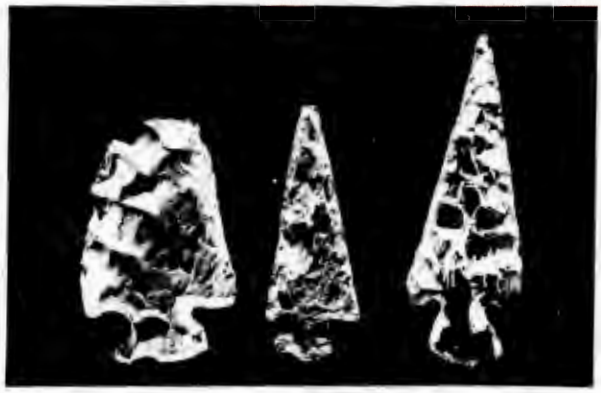


Figure 86. Type 3 projectile points (x1) (DAP 083302).

Type 4

These are straight-sided, round-based points with wider notch opening angles (fig. 87). They occur throughout the temporal sequence.

Diagnostics:
- Blade curvature index 0.07-0.10
- Highest base angle 18°-26°
- Base width 11-14 mm

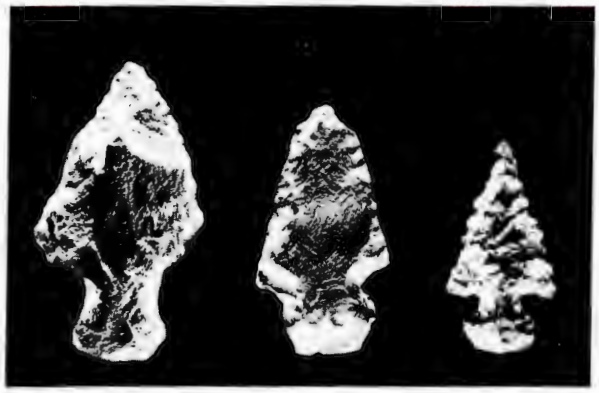


Figure 87. Type 4 projectile points (x1) (DAP 083303).

Type 5

These points are commonly called "Pueblo" points in much Southwestern literature. They are thin, well-made points with straight sides, long tangs, and straight to slightly rounded bases (fig. 88). They occur throughout both Sagehen and McPhee Phases, but are absent from the small sample of Sundial Phase items.

Diagnostics:
- Smallest notch opening angle 50°-57°
- Smallest blade curvature index 0.02-0.04
- Smallest notch angle 115°-122°
- Smallest neck width 5-6 mm
- Largest blade-length ratio 0.88-0.91

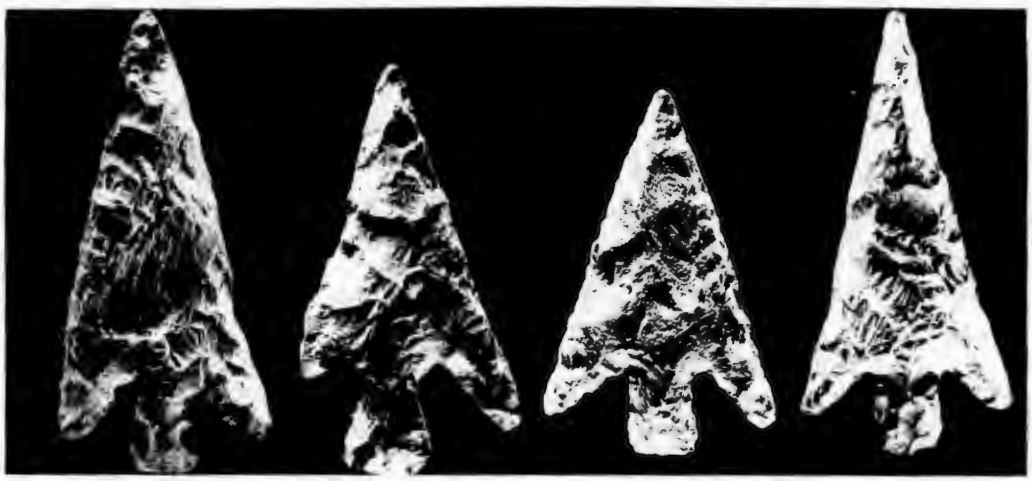


Figure 88. Type 5 projectile points (x2) (DAP 083401).

Type 6

This type is relatively short with short barbs and straight or slightly expanding stems (fig. 89). It occurs predominantly in Sagehen Phase contexts.

Diagnostics:
- Notch angle 123°-132°
- Smallest point length 23-27 mm
- Smallest base width-maximum width ratio 0.31-0.37

Figure 90 illustrates the utility of the discriminant function analysis in assigning broken specimens with missing data to previously established groups. The items in figure 90 were assigned to Type 5, obviously an appropriate classification.

DISCUSSION

The analysis of DAP projectile points is a continuing study. While these preliminary stages are extremely gratifying, particularly from a methodological perspective, the analysis has not yet focused on maximum interpretability of these interim results. Including the 1980 materials in the analysis will be a critical confirming step. This should be done by a discriminant function analysis using the established groups, with the new material included as an unclassified group.

Each type should then be refined in definition by extending the 95-percent CI's to the technological variables as well as the generated morphological variables. Then the temporal, site-type, and specific depositional context of the items in each group should be carefully examined for patterning which would indicate type sensitivities and increase their interpretability. Since time per se is not a causal variable, any temporal sensitivity in the projectile point typology will require explanation on other cultural grounds. Finally, the undated projectile points, including those from the survey materials, should be included in the analysis, again as an unclassified group in a discriminant function program.

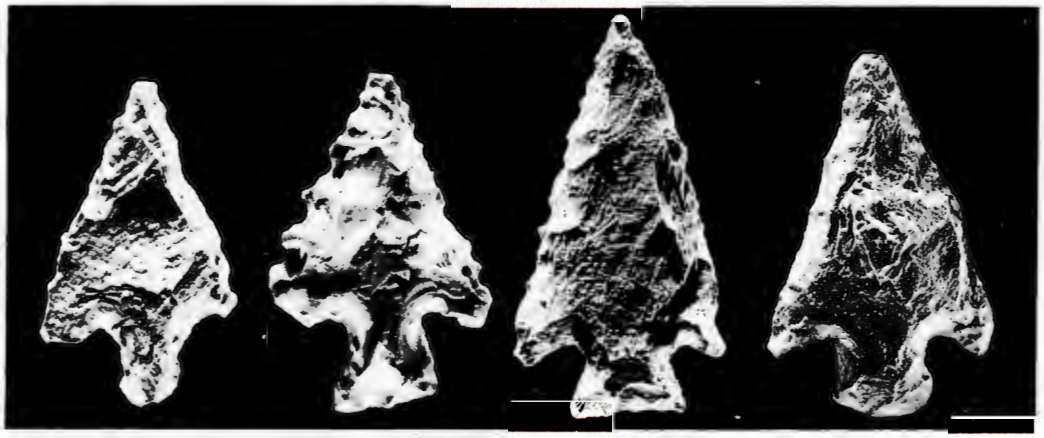


Figure 89. Type 6 projectile points (x2) (DAP 083404).

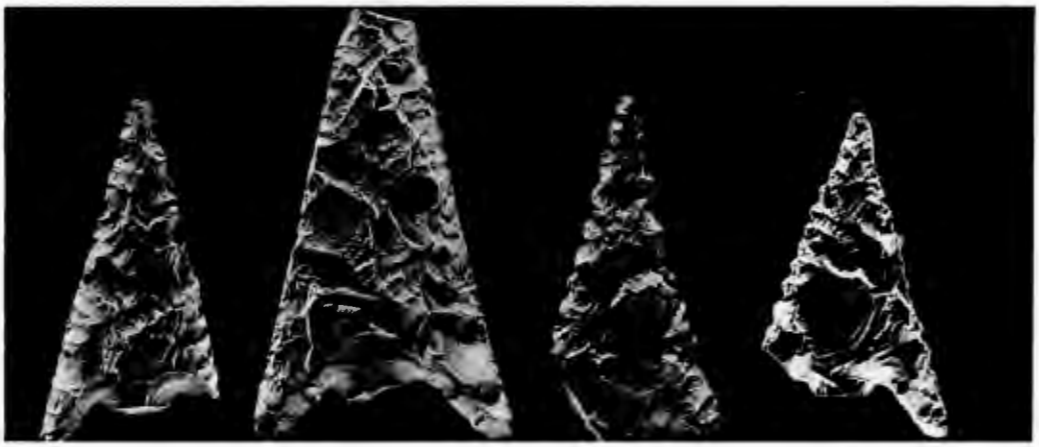


Figure 90. Broken projectile points assigned to Type 5 (x2) (DAP 083402).

These preliminary results show well-defined projectile point types with good indications for temporal, functional, and site-type interpretability. Analytic focus should remain methodological until the 1980 materials can be included. If their inclusion confirms the typology, and intuitive indications are that it will, then the focus of analysis can securely be shifted to interpreting and using the typology.

APPENDIX 5-1

DAP PROJECTILE POINT MEASUREMENT SYSTEM

Item Orientation

The midline of the item in the Y axis: tip to center of base

The lowest point of the item is on the X axis

Symmetry is assumed (evaluated separately elsewhere in analysis)

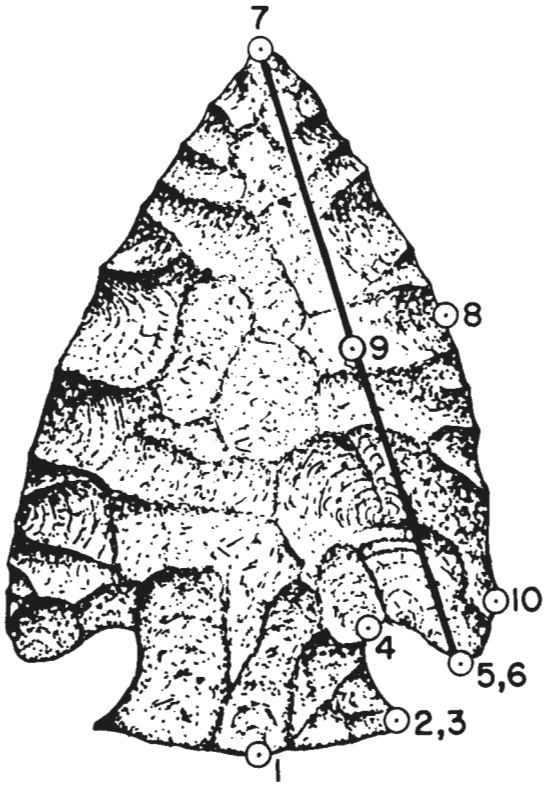
The more regular of the sides is measured

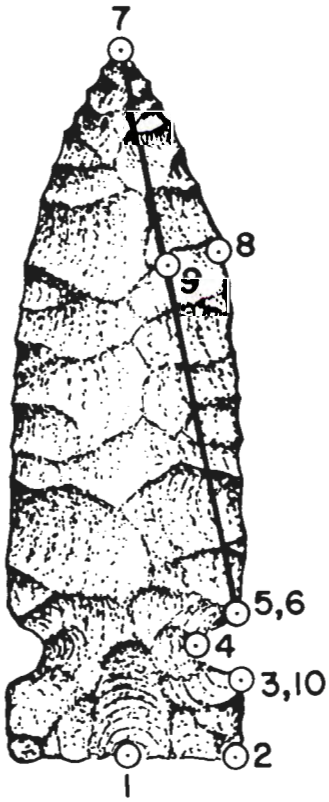
The following 10 points are measured and entered as a three-digit X and Y coordinates. Missing data (broken) are left blank. Inapplicable data are coded as "999."

Measurement Locations (refer to appendix 5-2)

1. Midpoint of base (X axis is always 000)
2. Either (a) the lowest extent of the base (Y axis = 000) or (b) the most lateral extent of the base
3. Lower (proximal) corner of the notch opening
4. Deepest point of the notch opening
5. Upper (distal) corner of the notch opening
6. Lower (proximal) corner of the blade
7. Tip (X axis = 000)
8. Point of maximum deviation (+ or -) of the blade margin from the 6-7 line
9. Point on the 6-7 line at right angles to point 8
10. Point of maximum width

APPENDIX 5-2
DAP PROJECTILE POINT MEASUREMENTS





APPENDIX 5-3

LIST OF GENERATED DAP PROJECTILE POINT VARIABLES

From the 10 measurement locations, the following plan outline variables are generated (see appendix 5-4):

- Point length (Y7)
- Blade length (Y6)
- *Blade-length ratio (Y6/Y7)
- Base length (Y4)
- *Base width-maximum width ratio (2X2/2X10)
- *Base-length ratio (Y4/Y7)
- *Neck width (2X4)
- Base width (2X2)
- Maximum width (2X10)
- *Position of maximum width (Y10/Y7)
- *Length-width ratio (Y7/2X10)
- *Blade curvature index (line 6-7/line 8-9 [+ or -])
- Blade angle (angle f)
- *Base angle (angle a)
- Proximal shoulder angle (angle c)
- Distal shoulder angle (angle d)
- *Notch opening angle (angle e)
- *Notch angle (angle b)

*These variables were retained in the final analysis programs.

LITHIC PROFILES

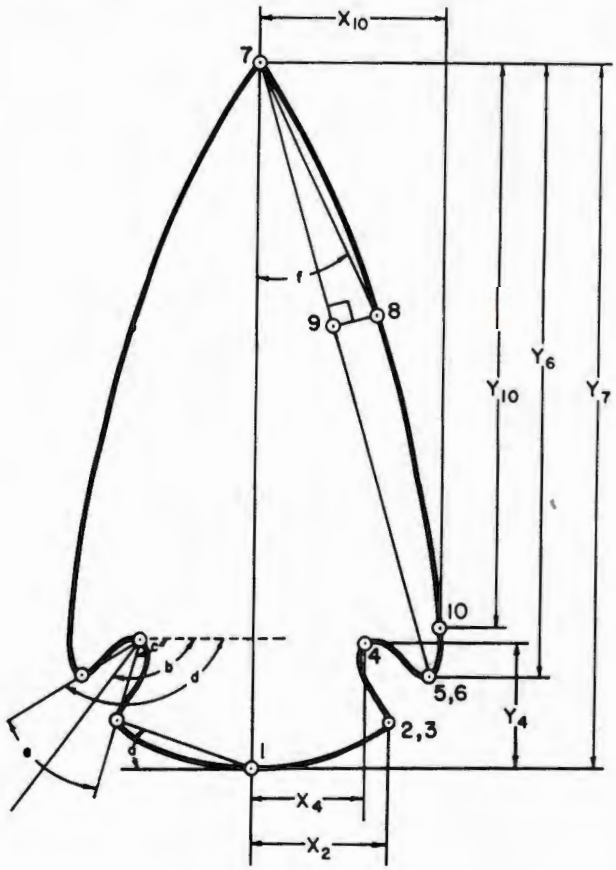
by Carl J. Phagan

The DAP lithic analysis structure consists of several relatively independent observation and recording systems. Each system is designed for a particular category of artifact and a particular level of analytic intensity. All analysis systems share some provenience and item identification characteristics, all are designed for integrated computer manipulation of data, and all are focused on observing attributes of artifacts rather than classifying complete items.

In establishing this analytic structure, the following factors have been carefully considered. A very large and complex data set must be managed in both cost-effective and research-effective ways. The data set must be responsive to a wide range of research questions, many of which may remain unknown until very late in any analytic operation. This demands maximum flexibility in data storage and retrieval. The levels of variability in the data set were anticipated to be high, which argued against a single, all-inclusive analytic routine. The realities of modern archaeological research increasingly demand rigorously defined data groupings and ways to effectively quantify several kinds of

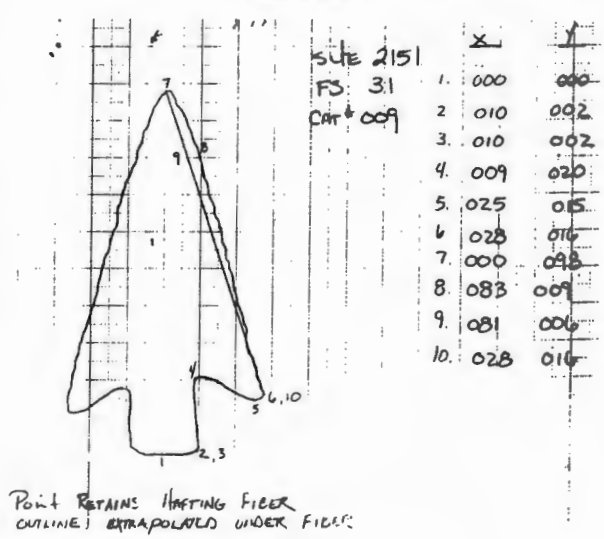
APPENDIX 5-4

PROJECTILE POINT MEASURMENTS: ANGLES AND DISTANCES FOR GENERATED VARIABLES



APPENDIX 5-5

DAP PROJECTILE POINT PERMANENT ANALYSIS RECORD



archaeological variability within and among those groupings.

This interim report section presents both a method for examining preliminary results from the lithic analysis systems, as well as some tentative interpretations of those results. The DAP lithic analysis systems have a combined total of 137 attributes. Some low-input items, such as flaked lithic debitage, may have as few as three or four attributes observed and recorded, while very high production input items may have as many as 30 or 40. When information from such a large number of variables is potentially retrievable, it quickly becomes apparent that a "shotgun" or "fishing trip" analytic approach to data variability is highly wasteful and terribly frustrating. The researcher cannot simply say, "I wonder what kind of interesting stuff is here?" Like it or not, one is practically forced at this point into good scientific method, as follows.

First, what research questions are both archaeologically important and appropriate to ask of this data set? The project Research Design (Kane, Lipe et al. 1981) is crucial for the former, and experience with the data is invaluable for the latter. Second, once appropriate research questions are selected, decisions must be made on two further concerns: which data groupings will be most appropriate to the questions, and which artifact attributes will best deal with these questions? Specific modeling is critical in providing analytic frameworks within which to make these decisions. Finally, a decision must be made on how best to arrange or display the potentially relevant data. The remainder of this report section briefly defines and explains a simple method of arranging data, along with several examples of its utility as a preliminary analytic tool.

The data arrangement discussed here is produced as an initial response to a specific research problem. It is simply a matrix-type display in which appropriate data groups (sites, pitstructures, groups of sites, activity areas) are placed on one axis and relevant lithic variables or attributes (morpho-use tupe, percentage of items with cortex, item weight) are placed on the other. Such an arrangement is by no means novel, but its explicit statement as a preliminary analytic method and its application at the attribute level have proved very effective in producing initial interpretations and in guiding more detailed analysis. The examples which follow have been somewhat simplified and standardized for this presentation and were selected to illustrate both the analytic flexibility of the method and the utility of the results.

The first example deals with a series of questions concerning the nature and extent of the Archaic presence in the DAP area. Several "Archaic-looking" site components have been excavated, but all were, to some extent, mixed with Anasazi materials. In addition, there were a good many "lithic scatter" sites, with few or no ceramics, that might be Archaic or might simply be aceramic Anasazi expressions. Do the more Archaic-looking sites, even though mixed with Anasazi materials, really represent the Archaic? If so, differences in the lithic assemblages should be significant and should be patterned in very definite ways. And if these site situations can be attributed to an Archaic expression, can they be used as baseline data to distinguish Archaic from Anasazi lithic scatters? These were some of the relevant questions and assumptions which directed the formulation of this profiled data arrangement for comparison of lithic variability across broad cultural traditions.

Given two groups of sites representing major cultural traditions, what general lithic variability in tool type, raw material use, or production technology is observable? Figure 91 is a profile of variability in FLT (flaked lithic tool) type between the two data groups, and there is, as expected, considerable difference between them. However, is it the kind and amount of variability one would anticipate if it were due to Archaic versus Anasazi expressions, or might it be due to some other factor such as differential Anasazi site function? In response, it is useful to know that the tool types in figure 91 are generally arranged from those involving the least production input on the left, utilized flakes, to those involving the greatest production input on the right, projectile points. This arrangement of the data allows the very simple and secure interpretation that Archaic-site materials have a higher proportion of high-input tools, while Anasazi materials have a higher production of low-input tools. This difference can easily be quantified by constructing an "index of production input," which is generated by assigning increasing values, such as 1-7, for increasing production input and finding the numerical averages for each site type. Not only does such an index readily distinguish between the two groups in a numerical way, but it tends to confirm the Anasazi-Archaic nature of the difference, in that greater attention to tool production is anticipated in the Archaic system.

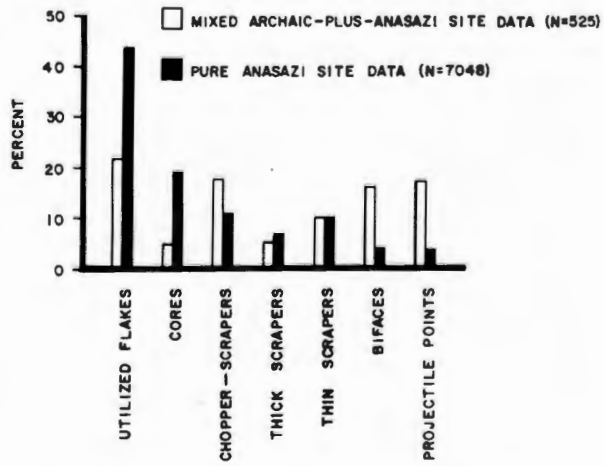


Figure 91. Comparison of FLT morpho-use type between mixed Archaic-plus-Anasazi and pure Anasazi data.

Figure 92 extends the lithic comparison of the same two data groups by including several additional technological attributes of flaked tools. The Archaic material demonstrates greater use of nongranular, probably nonlocal raw material; a much lower proportion of items which retain cortex on their dorsal surface; approximately three times as many items with edges produced with bidirectional flaking; twice as many items on which the entire circumference of the item has been produced with bidirectional or unidirectional flaking; many fewer complete or nearly complete items; much smaller (lighter) items; and an index value for production input into thinning the dorsal faces of items which is nearly seven times greater than that for the Anasazi materials. Only the flaked lithic tool proportion of the total tool assemblage (FLT plus nonflaked lithic tools, or NFLT) demonstrates similarity in the two data groups, which had not been anticipated, and which suggests the need for a slightly revised perception of the anticipated total Archaic tool assemblage or additional information from other variables, or both. Basically, however, production of flaked lithic tools is clearly different in the two data groups, and that difference is strongly in agreement with expectations for Archaic-Anasazi variability.

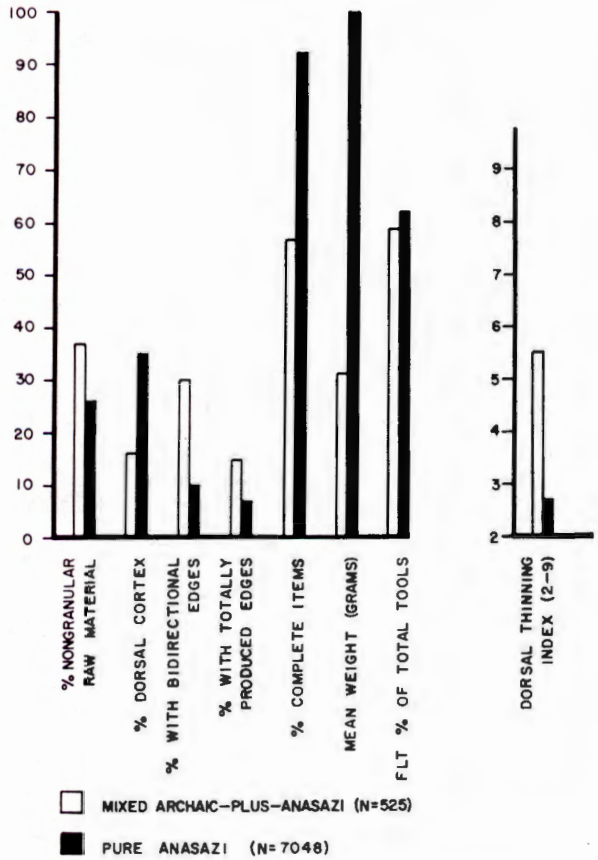


Figure 92. Comparison of FLT technological variables between mixed Archaic-plus-Anasazi and pure Anasazi site data.

Since a great proportion of artifacts found on the survey "lithic scatter" sites are flakes and debitage items, rather than tools, several debitage attributes were selected for comparison across the same data groups. If the Archaic-Anasazi distinction extends to these items as well, it would help settlement pattern studies considerably by allowing evaluation of lithic scatter sites with an adequate sample of debitage items, but not of worked tools. Figure 93 demonstrates that two attributes, percent of dorsal cortex and mean weight, are quite useful in this regard, and perhaps the percent of nongranular raw material as well; percent with platform and the number of debitage items per flaked tool are not useful in this way.

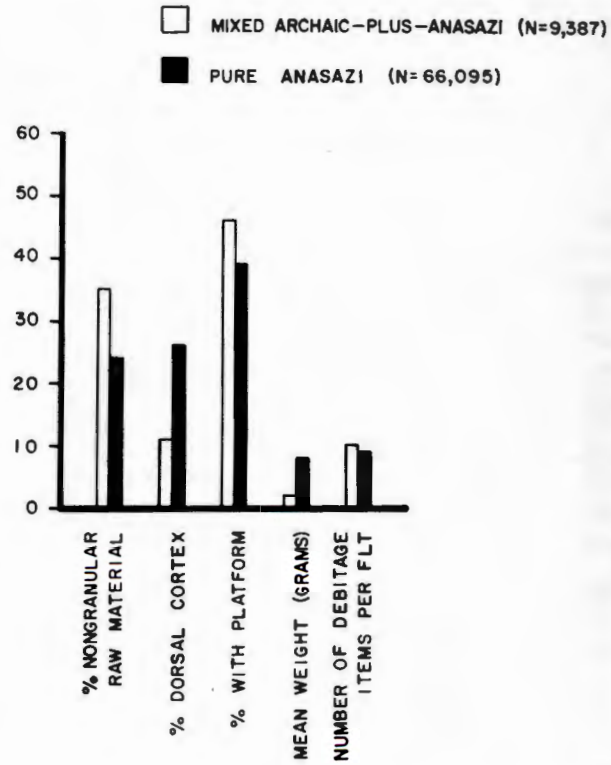


Figure 93. Comparison of FL debitage technological variables between mixed Archaic-plus-Anasazi and pure Anasazi site data.

From these profiles of lithic data for the two groups, it can be argued convincingly and quantifiably that Archaic and Anasazi assemblages have in fact been defined, and that this variability can readily be used to distinguish Archaic from Anasazi lithic scatters, even in cases where the survey collection consists predominantly of flakes and debitage. In addition, examination of the profiled data suggests further analysis which could strengthen the identification or the quantification of the data group variability, as well as make it more efficient. For example, the group of Anasazi data might be reduced by removing village sites, thus improving

comparability between the two. The surprisingly high proportion of nonflaked lithic tools in the Archaic group could be further explored by profiling several nonflaked tool variables. The Archaic data group itself could be subdivided into site groups to determine the probable proportion of Archaic-to-Anasazi matierals in each. In fact, one of the six Archaic-plus-Anasazi sites appear to have very little, if any, Archaic expression with regard to the variables presented here, which could make the distinction between the two groups even stronger.

A second example of using lithic profiles to define and interpret variability in the DAP assemblage focused on the attempt to identify small-scale, temporally associated variation within a single site type. In this case, given successive subphase groupings of Sagehen Flats Locality unit hamlet sites, what general lithic variability in tool type, raw material use, or production technology is observable? The Dos Casas and Sagehill Subphases of the Sagehen Phase were selected for comparison. It was anticipated that very little, if any, variability would be evident on the subphase level since, as expressed elsewhere in this volume, systems of lithic tool production and use are very stable cultural patterns.

Figures 94, 95, and 96 profile this subphase variability. Figures 95 and 96 indicate that, as anticipated, patterns of flaked lithic tool production are extremely similar in both tool and debitage technological variables. Of the 13 variables displayed, only one demonstrates possibly significant

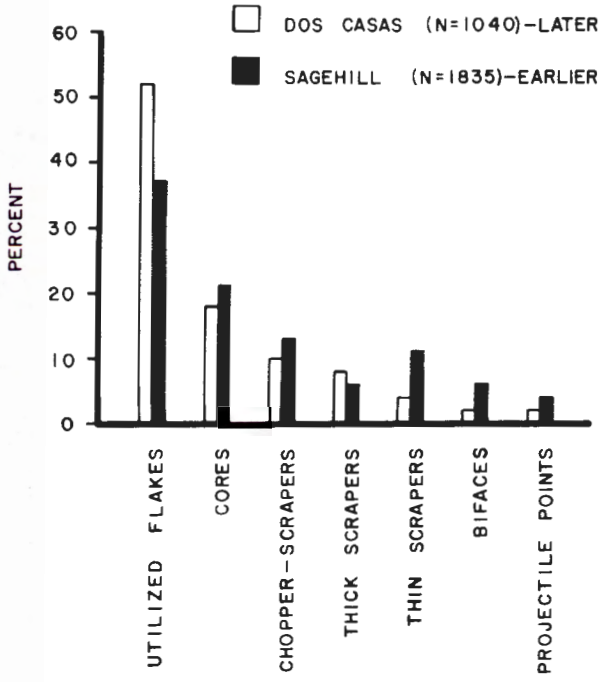


Figure 94. Comparison of FLT morpho-use type between Dos Casas and Sagehill Subphases (Sagehen Phase) unit hamlet site data.

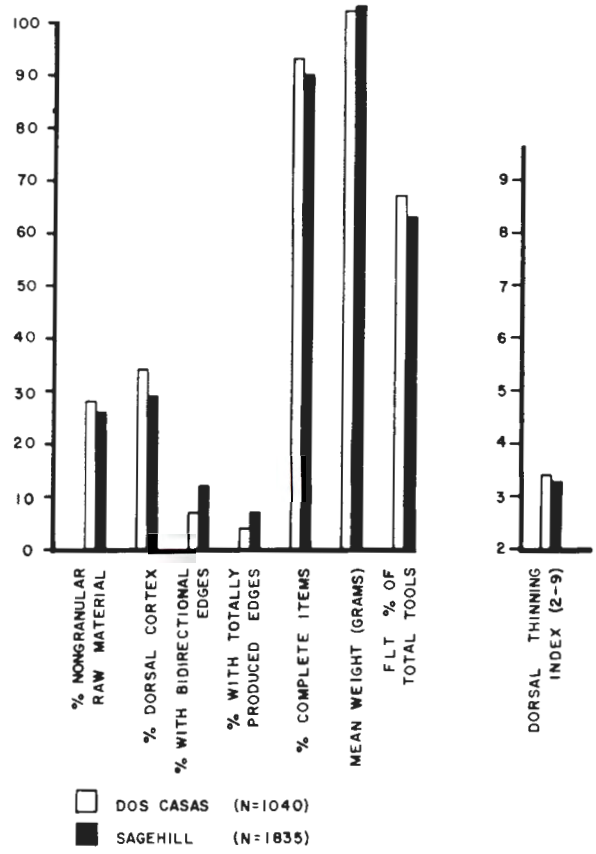


Figure 95. Comparison of FLT technological variables between Dos Casas and Sagehill Subphases (Sagehen Phase) unit hamlet site data.

variation for the two data groups, the proportion of debitage items retaining dorsal cortex. However, figure 94 demonstrates that, within this basic tool production system, a somewhat different tool assemblage was being produced in the two subphases, suggesting a rather rapidly changing pattern of behavior or site function at the sites. Further, the earlier Sagehill Subphase, while it is definitely Anasazi, is much more similar to the Archaic tool assemblage proportions than is the later Dos Casas Subphase. The implications are not for a transition from Archaic to Sagehill to Dos Casas, but simply that, of the two Anasazi Subphases, the earlier is more similar to Archaic, and probably represents a subsistence pattern somewhat more similar to Archaic than the latter. Upon reflection this is, of course, not surprising or unreasonable.

Another example of the profile approach identifies lithic variability between two site types within a single temporal phase. Since variation in lithic assemblages, both technologically and functionally, is much more likely to be associated with site type than with temporality, it was anticipated that profiles of two such groups would display considerable variability. The data groups selected were

permanently occupied McPhee Phase village sites and seasonally occupied McPhee Phase field house sites.

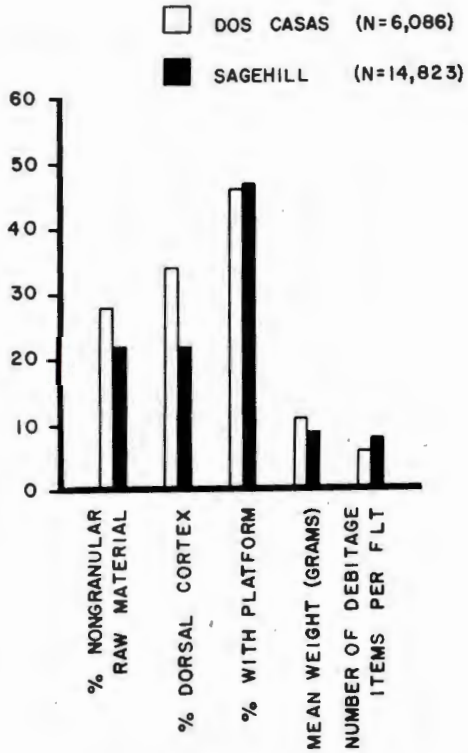


Figure 96. Comparison of FL debitage technological variables between Dos Casas and Sagehill Subphases (Sagehen Phase) unit hamlet site data.

Figures 97, 98, and 99 profile the same sets of lithic variables as the previous examples, and again produce very interpretable results. For both the tool assemblages produced (fig. 97) and the technological patterns of production (figs. 98 and 99), the two data groups demonstrate a mixed pattern, with some variables indicating strong similarities and others indicating marked differences. Apparently somewhat different segments of the total tool production technology were being emphasized at the two site types, and differing tool assemblages were being manufactured and used. Without going into great interpretive detail, it appears technologically that raw material usage patterns are quite different, that fewer and larger flakes are produced at field house sites, that somewhat more production input per item was invested at field houses, but that a smaller percent of the field house total assemblage consisted of flaked tools. Within the flaked tool assemblage, the field house sites display a low proportion of utilized flakes, a high proportion of heavier chopper-scraper items, a low proportion of thin scrapers, and a high proportion of projectile points. This may indicate rather specialized resource procurement activities involving flaked lithic tools

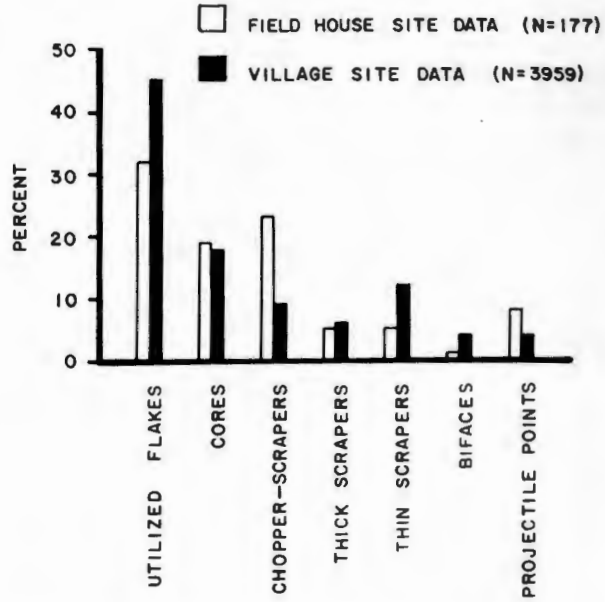


Figure 97. Comparison of FLT morpho-use type between McPhee Phase village and field house site data.

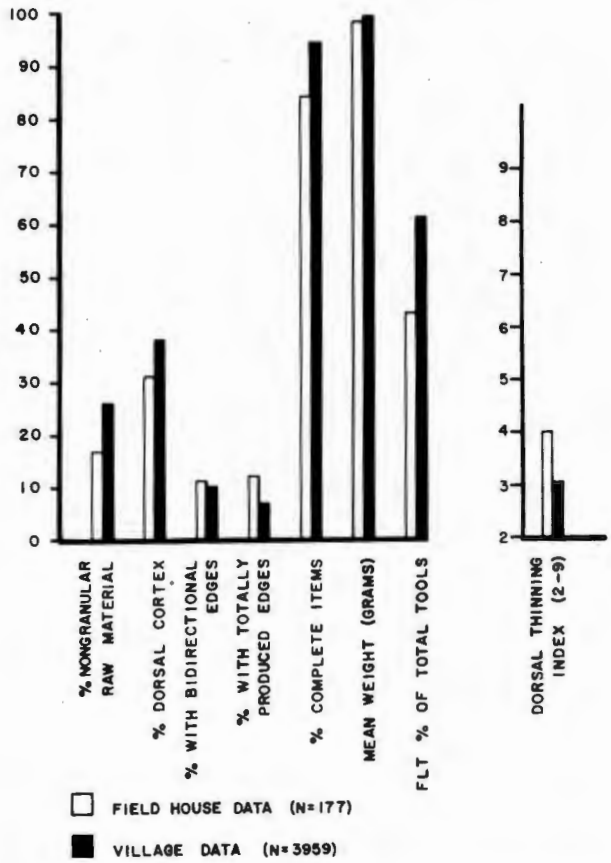


Figure 98. Comparison of FLT technological variables between McPhee Phase village and field house site data.

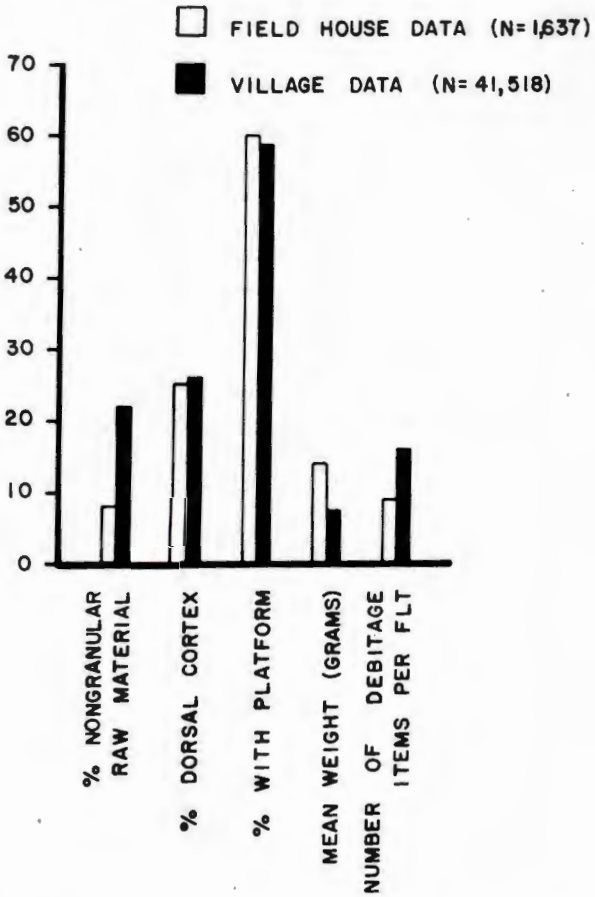


Figure 99. Comparison of FL debitage technological variables between McPhee Phase village and field house site data.

at these seasonally occupied sites, such as felling and trimming construction timbers and "garden hunting," while corn processing activity focused more on nonflaked lithic items. Certainly a series of nonflaked lithic variables should be profiled to confirm these very preliminary interpretations.

The final example of lithic data profiles illustrates the nature and extent of variability among large McPhee Phase village sites. For this comparison, many of the same technological variables for flaked tools have been selected, plus the proportions of manos and metates from the nonflaked tool variables. Flaked debitage variables have not been included. A major DAP research question has been the nature of possible interrelationships among these apparently contemporaneous village sites in the settlement pattern of the Escalante Sector. Do they all have roughly equivalent positions in the pattern, or are some different from others?

Figures 100 and 101 strongly indicate that while some variables such as the proportions of utilized flakes, cores, projectile points, and manos are very similar, others such as thin scrapers, bifaces, and metates are quite different. In addition, all of the technological variables selected demonstrate at least potentially significant variability. While no specific site distinction is apparent which would readily

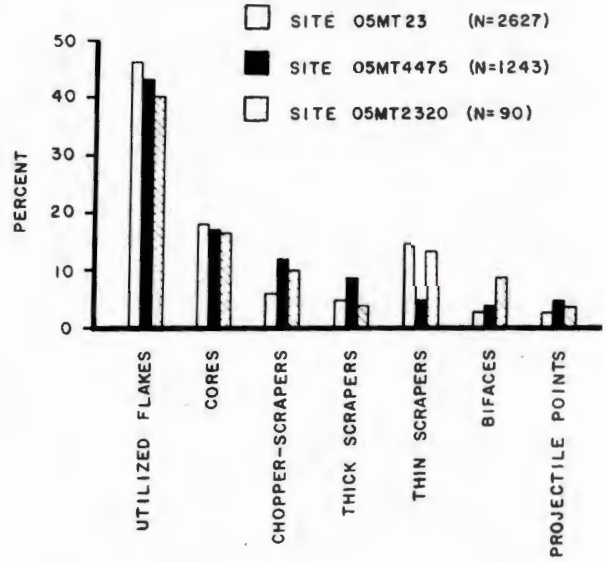


Figure 100. Comparison of FLT morpho-use type among individual McPhee Phase village sites.

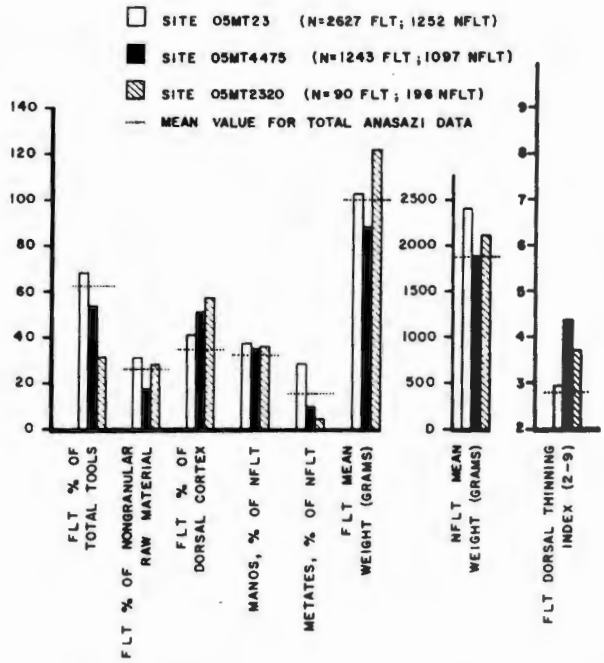


Figure 101. Comparison of several FLT and NFLT lithic variables among individual McPhee Phase village sites.

explain these similarities and differences, it is difficult to imagine how functionally equivalent sites within a settlement system could display such marked lithic variability. If, for example, the relative proportions of flaked lithic to nonflaked lithic tools are associated with the intensity of plant food processing, then the three sites display quite distinct patterns of basic subsistence. Differences in the percent of nongranular raw material perhaps represent a technological focus on the most immediately available raw material. And at this point there are not even any good guesses as to why, when proportions of manos are so similar, proportions of metates are so drastically different.

In all of these examples the data groupings have been given or preestablished for various analytic reasons, and the lithic attributes have been the basis for interpreting those groups. Redundant or extraneous attributes are eliminated from the analysis for the sake of efficiency, or additional attributes are added as the analysis progresses; but the focus of attention remains on using the best possible attributes to interpret the groups. In multivariate terms, this is essentially a discriminant analysis approach.

Other types of analysis programs in progress at the DAP, rather than starting with the data already arranged in predetermined groups, have as their goal the formation of those groups. Beginning with a set of related attributes, the data are grouped in the most effective way(s) for ordering the total variability of attribute expression. This is essentially a factor/cluster analysis approach. The projectile point analysis (Vierra and Phagan, this volume) and a lithic site-type analysis are examples of this analytic approach. Here, too, profiled lithic data have proved very useful in the early stages of analysis to evaluate and make decisions about attributes, data cases, or groups of data cases.

NONFLAKED LITHIC AND FOOD PROCESSING ANALYSIS

by Carolyn R. Orth and Carl J. Phagan

This report section briefly summarizes the DAP NFLT (nonflaked lithic tool) analysis, with particular emphasis on understanding patterns of plant-food processing and preparation. Archaeological literature of the Southwest has tended to neglect the detailed analysis of ground stone implements in favor of flaked stone and ceramics. It is obvious, however, that ground stone tools represent a great deal of human energy in both production and use; such high-input items should be extremely informative of prehistoric behavior. One major reason they have often failed to yield this information has been the lack of adequate behavioral models to structure their analysis and interpretation. Without explicit models, attributes cannot be clearly defined or recognized as significant, hypotheses cannot be confirmed, and implement assemblages are simply described in general or implicitly understood terms. The DAP Reductive Technology Laboratory has generated a theoretical model of ground stone tool production and use which structures the analysis of nonflaked lithic tools. Consistent with other DAP lithic analyses, this model focuses on attributes of artifacts rather than complete items and distinguishes between production and use attributes.

The horticultural nature of Anasazi culture indicates the importance of food processing and cooking, with its associated behavioral and artifactual complex. Little is known about either the behavior or artifacts associated with Anasazi food processing. An ethnographic literature summary of Puebloan food processing techniques was prepared with special attention to recipes, utensils, features, personnel, and spaces involved. An earlier DAP study by J. Southward (1981) was extensively used in this literature summary. Several basic assumptions were then explicitly formulated using both the literature review and recently published data on a cross-cultural perspective of human diet. These assumptions then became the foundation for a specific model of Anasazi food processing, food preparation, and diet which is being used to direct the DAP analysis.

Basic assumptions underlying the specific model include: (1) humans are quite conservative with respect to diet, and changes occur either very slowly or in response to rather severe stress; (2) dietary variety is important and adaptive, and if it is not achieved from a variety of available foods it will be achieved from a variety of preparation techniques; (3) diet changes will be reflected in processing and preparation utensils, in features such as hearths or ash pits, and in the spatial arrangements of these artifacts and features.

From these basic assumptions, a more specific Dolores Anasazi model was developed against which DAP nonflaked lithic data are being compared. Some elements of this model are the following:

1. It is expected that the 400-year time span of the DAP archaeological sequence is insufficient for major dietary changes to have developed among the Dolores Anasazi. In addition, there are no obvious indications of severe environmental or external cultural stresses on the population during at least most of this sequence. It is therefore expected that dietary changes would not have been extreme, and that they would have been changes in degree or amount rather than changes in kind.

2. It is expected that the Dolores Anasazi developed an increased reliance on horticulturally produced plant foods, primarily corn, and a corresponding decreased reliance on gathered native plant foods. This can be viewed as a progression from a more generalized pattern of plant food exploitation to a more specialized one.

Processing utensils should also have undergone a transition from generalized to specialized, and increased tool specialization should be recognizable in several nonflaked lithic tool analysis variables. Both manos and metates should demonstrate greater production and maintenance input, and they should show modification in size and shape which reflects their greater specialization and efficiency as corn processors. Processing tool use should demonstrate a transition from multiple-use to single-use attribute states, and such tools should constitute an increased proportion of both nonflaked lithic tools and total tools.

Further, as the variety of exploited plant foods decreased, it is anticipated that dietary variety would have been maintained by preparation techniques; this should be archaeologically observable as an increased variety of specialized preparation utensils and of features such as hearths, cooking pits, ash pits, boiling stones, pot lids, griddle stones, *piki* stones, *comals,* and a variety of ceramic, wooden, bone, or basketry items.

3. As corn became more central to the subsistence pattern of the Dolores Anasazi, it is highly likely that many aspects of its growth, storage, processing, and consumption became imbedded within Anasazi ritual-ceremonial behavior. Ethnographically, the Zuni say that corn is life (Cushing 1979:25), and corn ceremonialism is entrenched in all phases of Puebloan existence. Implements associated with ceremonial activity are often distinctive in some way, such as being unusually large or small, of unusually fine raw material, produced with exceptional skill or care, or found in unusual contexts. If these items can be identified in the archaeological record, they should occur with greater frequency in the later portions of the Anasazi sequence.

At the risk of being premature, some very tentative results, generated from hand-tabulated data, will be cautiously presented. It should be stressed that both the model and the methods employed in this analysis are constantly being refined as data become available. Seventeen DAP sites have so far been included in this analysis, representing both permanently and seasonally occupied sites, and selected from Sagehen, McPhee, and Sundial Phases of the temporal sequence. Some of the tentative results are as follows:

1. Multipurpose nonflaked lithic tools decrease from 22 percent of the total site assemblage in the Sagehen Phase to 10 percent in the McPhee Phase.

2. Lower input, one-hand manos also decrease, from 29 percent of manos and fragments in Sagehen to 12 percent in McPhee contexts.

3. Conversely, two-hand manos with high production input increase from 32 percent of manos and fragments during Sagehen to 58 percent during McPhee Phase times.

4. There appears to be some increase through time in grinding surface area for both manos and metates.

5. The number of household clusters was estimated from the full site equivalency figures, and there appears to be a sharp decrease in the number of nonflaked lithic tools per household from 173 in Sagehen to 49 in McPhee Phase contexts.

6. Seasonal occupation sites have six manos per metate, while permanent habitation sites have only two-and-one-half manos per metate, a significiant difference, but one which is not yet clearly interpretable.

The preliminary results presented here, as well as others which have not yet been even hand-tabulated, are extremely promising. The DAP system of nonflaked lithic analysis, the model on which it is constructed, and its results will make a significant contribution to the DAP and to Southwestern archaeology.

Section 7

ACTIVITY AREA ANALYSES

by Cory D. Breternitz, William D. Lipe, Meredith H. Matthews, John L. Montgomery, and Judith L. Southward

AN OVERVIEW OF THE ACTIVITY AREA CONCEPT

by John L. Montgomery

INTRODUCTION

Archaeologists use the activity area concept to interpret patterns of artifacts excavated at archaeological sites. This study, which examines the activity area concept from published materials located in the University of Colorado Norlin Library, provides a base from which archaeologists can apply the activity area concept to archaeological materials recorded by the DAP. The history of the activity area concept is briefly reviewed, and then the theory behind the concept is examined. Next, natural and cultural transformational processes are documented. Finally, some considerations for further use of the activity area concept are put forward.

HISTORY OF THE ACTIVITY AREA CONCEPT

Struever was the first archaeologist to define the activity area explicitly. His discussion incorporated the activity

area within a hierarchy of settlement system concepts in the Lower Illinois River valley. The concept is site specific.

> [Activity areas] will have a formal definition based on the correlations of material culture elements, . . .defined on the basis or the spatial clustering of certain artifact types, . . .kinds of life-maintenance by-products, . . .and structural feature types, . . .In addition, each activity area can be expected to have spatial extension, since activities tend to be localized and to a degree spatially segregated within the areas of a community. The analysis of kind, number, and distribution of material elements recovered from an archaeological site, therefore, enables the archaeologist to define . . . activity areas (Struever 1968a:287).

The usefulness of the concept encouraged its application in archaeological reports. New field methods and techniques were used to obtain activity area data. At Hatchery West, Binford et al. (1970) incorporated systematic surface collections with a careful excavation strategy and were able to isolate several activity areas. Large horizontal excavation strategies are a way to document prehistoric activity areas. Paleoindian kill sites (Wheat 1972) are often excavated in this manner, and the information from faunal butchering activity areas has expanded knowledge of Paleoindian subsistence activities. Within the DAP area, pithouse, surface storage rooms, and pueblo rooms provide optimal contexts for large horizontal excavations.

At this point it is important to consider the theory and methods behind the activity area concept. Two distinct lines of evidence are used: experimental replication and statistical approaches.

RELATING THEORY TO MATERIALS

One of Binford's lasting contributions to archaeological theory is his classification of material culture into the technomic, sociotechnic, and ideotechnic realms. This framework is a way to link material products of behavior to past social systems. This fundamental contribution (cf. Grebinger 1978:7) is the basis for determining activity areas. Binford's taxonomy was combined with Struever's work to form the basic theory of the activity area. An explicit effort to tie the activity area concept to excavated material culture was the logical next step. Two lines of inquiry were followed: replicative and statistical.

Replicative research was generally applied, but not limited to, lithic material culture. The research centered on the production of certain tool types and on the byproducts left from the manufacturing process. As a result, archaeologists could indentify lithic manufacturing areas within sites, such as bifacial reduction areas (Shafer 1969) and primary reduction areas (Hester 1975). Controlled field laboratory experiments (Crabtree 1972; Speth 1974) provided information concerning the expected results of certain lithic technological reduction processes. In the American Southwest, ceramic materials are generally given priority over lithic materials in the definition of activity areas (cf. Hill 1970; Longacre 1970). Unfortunately, the two technologies are rarely integrated for their combined information, but are treated separately in most reports.

The replicative research uses laboratory and ethnographic information to postulate the cultural meaning of artifact patterns. However, the verification of these meanings cannot be assessed until there is more control of the ethnographic record. This gap is beginning to be filled by ethnoarchaeological studies.

The statistical approach to activity area definition followed Binford's and Struever's earlier work. Most frequently this line of analysis uses large, horizontally exposed areas in archaeological sites to search for statistically significant patterns of artifacts (and patterns of co-occurring artifacts). Statistical techniques such as nearest neighbor analysis (Whallon 1974), elliptical analysis (Dekin 1976), dimensional analysis of variance (Whallon 1973), and factor analysis (Downer 1977; Healan 1972) are used to derive the patterns within archaeological contexts. These patterns are examined and behavioral counterparts, frequently activity areas, are postulated.

Despite its quantitative appeal, the statistical approach is hindered by its assumption that statistically significant artifact patterns are culturally significant patterns. Recent ethnoarchaeological studies have been most critical of the use of the statistical approach for describing activity areas. In addition, the tests themselves may not be accurate. An instructive account is provided by Vierra and Carlson (1981). They applied a factor analysis to a randomly generated (dummy) data set. The factor analysis produced statistically significant patterns despite the randomness of the original data. Such an example bodes ill for activity area analyses based on factor analysis. One must carefully assess multivariate techniques which are assumed to extract meaningful information about activity areas (cf. Schiffer 1976) from large data sets.

OBSCURED BY CLOUDS: THE EFFECTS OF CULTURAL AND NATURAL TRANSFORMATIONS

Doubts concerning the direct correspondence between archaeological remains and past human behavior were raised by Schiffer (1972, 1976). It is apparent that there are a host of cultural and natural factors (termed C- and N-transforms by Schiffer) which can potentially obscure archaeological contexts and muddle interpretations. Many of these transformations have been documented by recent ethnoarchaeological studies.

Site formation process is the key element to Schiffer's critique of earlier theory. Fehon and Scholtz (1978) and Hildebrand (1978) offer additional variables which must be applied to models of site formation. The impact of this new model for archaeological interpretation is explored by Sullivan (1978) in an extensive review article. Natural processes which can distort the archaeological context of activity areas are summarized by Wood and Johnson (1978). In addition, Turnbaugh (1978) addresses the effect of floods on archaeological sites. These articles present most of the factors which can affect the distribution of artifacts at archaeological sites. They all point out that prehistoric activity areas are not completely documented until the appropriate factors are taken into account.

Ethnoarchaeological studies around the world also indicate that much care must be taken in interpreting activity areas. Binford indicated why such studies are important when he wrote the following about his Nunamiut Eskimo studies: "It was possible to study the dynamics of an ongoing technological system in the context of an essentially self-sufficient subsistence economy" (1977a:24). Ethnoarchaeology is the best available method to provide a link between materials and behavior (for example, Gould [1978a]; Kramer [1979]).

Beginning with Gould (1968), many archaeologists have studied contemporary societies to record the material correlates of behavior within specific problem areas (for example, lithic technology, settlement patterns, ceramic manufacturing). There are simply too many studies which apply to activity areas for a thorough review, but the few accounts provided here illustrate the diversity of societies and geographic areas discussed in the literature.

Ethnoarchaeologists characteristically describe cultural transformations more often than natural transformations. Gould (1968, 1977, 1978b, 1980) has extensively studied Western Australian Aborigines from an ethnoarchaeological perspective. Among many contributions (explanation by anomaly instead of analogy, for example) his Principle of Interference applies most directly to the concept of the activity area. His explanation is long, but instructive.

> The problem in relation to the horizontal patterning of task areas within . . . sites is . . . subject to . . . a factor that one can see operating among contemporary Western Desert Aborigines. I shall call this factor the Principle of Interference, and it can be decisive in our appreciation of the way in which any habitation base camp . . . may turn out to be a poor place to look for evidence of workshops, food processing areas, or other task-related loci. The Principle of Interference can be stated as follows: The wider the range of different general activities performed at a particular site, the greater the likelihood is that the by-products of each task performed in relation to each of these activities have become detached from the original locus where each task was carried out (Gould 1980:196-197).

Other researchers have also reported that cultural factors often affect the patterns of material culture. In Africa, Yellen has studied the !Kung Bushmen activity patterning within camps. His results are primarily negative.

> I would argue that this rather complex set of interactions precludes the simplistic notion that a straightforward correlation exists between a specific activity and a unique location (Yellen 1977:85-86).

Yellen goes on to indicate that his findings are most damaging to the statistical analyses of artifact patterning (1977:86, 96-97).

Ethnoarchaeological work in North America is diverse, but much of the results are also cautionary. Longacre and Ayers (1968) found through their analysis of an Apache wickiup that a priori assumptions about tool functions were too simplistic. At the historic site, Millie's Camp, Bonnichsen (1973) faced similar problems. His interpretations of tool clusters and locations were proved false after the former occupants were interviewed.

Not only are tools and tool clusters (activity areas) misidentified, but there is evidence that the material culture left at a site may never reflect most of the cultural activity which once occurred there. Gould's (1980) description of the daily life of Western Desert Aborigines is contrasted to the sparse material remains left when the site was later abandoned. Quantitative analysis of a north Kenyan pastoral tribal site (Turkana) by Robbins (1973) show that 63 percent of the "archaeological" items left at sites are perishable and lost to archaeology.

Cultural factors such as settlement location, tool curation and discard, and technology also affect the integrity of activity areas. Gifford (1978:92-94) observed that Dassanetch (Kenya) occupation sites are usually located in geomorphologic settings (lake margins, stream margins, lake shore) which are unfavorable for slow deposition and preservation. Instead, the various sites she monitored were all but destroyed within 2 years of abandonment. In Yellen's (1977) monograph, he notes that most tools were never left behind when camps were abandoned. Yellen also documents how cultural practices (cooking techniques, bone smashing, food sharing) can affect patterns of faunal remains at !Kung Bushmen sites.

Binford's work among the Nunamiut Eskimo provides additional information concerning activity area formation. His conclusions are numerous and complex, but he shows that whether tools are culturally expendable or curated leads to different materials being left at sites (and activity

areas) (Binford 1978a). While he confronts Yellen concerning the identification of activity areas within sites, the structure and interpretation of activity areas is affected by numerous cultural variables (Binford 1978a, 1978b). Lastly, the overall technology and settlement-subsistence characteristics (foragers, collectors, degree of residential mobility) of a cultural group affect the variability of artifact types left when sites are abandoned (Binford 1980).

Despite a flurry of recent research, ethnoarchaeology provides results which are limited and usually cautionary in nature. More analytical work must be done toward the meaningful correlation of activity areas with human behavior. Dunnell's criticism is appropriate.

> It appears as if too much effort has been devoted to the polemical issue of developing the field of "ethnoarchaeology" and too little effort devoted to exploring the intellectual limits of the relation between ethnographic and archaeologic data. . . . For the most part, ethnoarchaeology is a method without theory (1980:471).

THE FUTURE

It is apparent that the activity area concept is useful for describing, at a general level, prehistoric cultural behavior. At the same time, the assumptions and inferences archaeologists make about activity areas must be explicitly described, and supporting data clearly presented. In some instances, it may prove more instructive to analyze site assemblages rather than activity areas. Perhaps most important is the consideration of potential cultural and natural processes which can affect the deposition and ultimate recovery of archaeological items. Archaeological interpretation and explanation is strongest when these factors are recognized.

TEMPORAL AND FUNCTIONAL VARIABILITY AMONG DOLORES ACTIVITY AREAS[11]

by Cory D. Breternitz and William D. Lipe

OBJECTIVES

The objectives of this study are (1) to identify and characterize activity areas in and around pithouses and surface rooms from Anasazi sites dating from approximately A.D. 650 to 900 in the Dolores River valley, southwest Colorado; (2) to assess functional variability among activity areas; and (3) to determine whether this variability correlates with differing time periods and/or differing types of structures. This report addresses these objectives in only a preliminary fashion.

The archaeological sites included in the study have all been excavated as part of the DAP. The study examines 179 separate activity areas identified in pithouses, surface rooms, and outdoor work/activity areas associated with habitation structures. The data come from nine sites representing 11 temporal elements (fig. 102). These occupations are distributed temporally as follows:

Sagehen Phase
- Tres Bobos Subphase (Site 5MT4545)
- Sagehill Subphase (Site 5MT2198, Site 5MT2194)
- Dos Casas Subphase (Site 5MT2193, Site 5MT2192)

McPhee Phase
- Periman Subphase (Sites 5MT23, 5MT2191, 5MT2320, and 5MT4512)

The study was conceived to focus certain of the Research Design questions on specific DAP data. In particular, it has the potential to contribute to several general questions

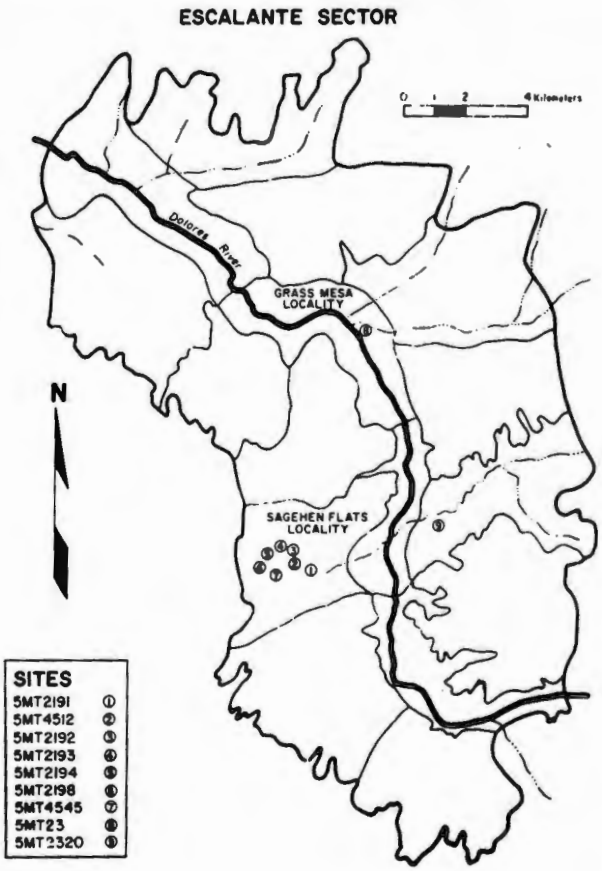


Figure 02. Sites included in activity area study.

[11]This portion of the report was prepared during late 1979 and early 1980 and reflects the terminology and temporal designations in use at that time rather than the most current usage. Further, this report reflects the state of the data base in late 1979.

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posed in Problem Domain 3, which deals with the social, economic, political, and ideological organization of society. To the extent that activites associated with major status types (e.g., male-female, old-young) or intrahousehold groupings (e.g., individual versus group) can be inferred, contributions can be made to the study of prehistoric social organization in the area. There is a greater likelihood that the study can contribute to questions of economic organization — what economic production, consumption, or distribution activities were carried out at the household level? In addition to addressing questions derived from the Research Design, the study can also serve to check the reliability and utility of activity area characterizations made independently by a variety of workers using standard recording and classification formats.

METHODS

The study relies initially on the identification and characterization of activity areas made by DAP crew chiefs and set forth in standard data recording formats, as well as in descriptive site reports. DAP procedures for collecting artifacts and recording data from occupation surfaces are designed to ensure detailed provenience control and comparability of recording from surface to surface and site to site. In addition to providing formats for recording the evidence of activity areas, DAP recording formats also require interpretation in the sense that activity areas must be identified and differentiated from scatters of secondary refuse. Low-level inference must also be attempted by the crew chief in the form of assigning a preliminary functional label. Results presented in this report depend largely on the characterizations made by the crew chiefs, which are already in DAP records. Activity areas are also being analyzed "from the bottom up" by systematically comparing the composition and distributions of artifacts and features from the selected sample of probable activity areas. This comparative approach is expected to provide a more fully documented basis for interpretation of activity areas than do the preliminary characterizations made by individual crew chiefs at each site. Results of the comparative study will be presented in the final report. For this preliminary report, however, the activity area characterizations already in the record will be used to address the study objectives.

Temporal affiliation, totality of excavation, and the completeness of the site records were the major criteria in selecting a sample of sites from which to draw activity area information. Completely excavated sites, or sites with a complete household cluster represented, were favored, since entire household clusters and the spaces between them could be examined. In some instances, pithouses and surface structures could not be correlated except on an inferential level. Many sites provided tantalizing information, but were not included in this study due to the incompleteness of their excavation.

Data on each activity area were obtained from a standardized activity area form. The activity area form allows the crew chief in charge of the excavation to group floor-associated artifacts (point locations) and features into proposed activity areas. Ideally, the activity area forms are at least partially filled out in the field in order to flag areas believed by the excavator to have potential for activity area identification and analysis. The form is completed, and may be revised, during the process of writing a descriptive report of the fieldwork. As one of the entries on the form, the crew chief codes his/her inference as to the probable main activity represented by the designated activity area. A list of 99 possibilities is provided, including "not applicable," "indeterminate," and "other." Hence, the activity area form itself represents a certain amount of synthesis, in that it requires the crew chief to make an initial interpretation of the function of the activity area. The basic functions of the form are, however, to flag the occurrence of archaeological phenomena having potential for activity area interpretation and to provide a convenient pointer with which to associate individual feature, occupation surface, and architectural unit descriptions with one another, as well as with the laboratory identifications of point-located artifacts.

Point locations are important components of the activity area as it is conceptualized by the DAP. The point location is a device for precisely mapping and inventorying items believed by the excavator to be associated with a prehistoric occupation surface.

Activity areas occupy an important position in the DAP spatial systematics. An activity area may be constructed during short-term periodic behavior, and this type of activity is independently verifiable through the reconstruction of steps in a technological sequence: for example, through examination and/or replication of individual lithic, ceramic, or bone artifacts. Even though an activity area may in some circumstances record an individual episode of tool manufacture, food processing, or the like; more frequently, and more important for the objectives of the DAP, activity areas have a potential for identifying loci that are regularly favored for the completion of routine tasks and for recording the various features and archaeological residues associated with such tasks. Furthermore, by examining the distribution of activity areas, their internal composition, and the diversity of functions which they represent, insights into several aspects of prehistoric culture can be obtained.

CHARACTERISTICS OF ACTIVITY AREAS

The characteristics of an activity area are to a degree defined by the investigator. For the purposes of this study, an activity area is defined as an archaeologically identifiable locus where one or more episodes of human behavior have taken place (Kane 1979). It is recognized archaeologically by an artifact/ecofact scatter and/or a feature or

group of features. These must occupy a spatially delimited area on an occupation surface or floor in a context indicating association with the use of the surface. One use of a surface, of course, is for secondary refuse discard, and it is useful for excavators to record this interpretation. The focus of this study, however, is on materials associated with primary use of the surface, rather than those which record its use as a repository for secondary or transported refuse.

Minimally, then, an activity area can be defined on the basis of a single feature (e.g., hearth, metate bin) or a simple artifact cluster (e.g., a cluster of debitage thought to result from tool production or maintenance in that locus). Many, however, will include both features and/or groupings of a variety of artifacts and/or ecofacts. Activity areas can also overlap, and this increases the difficulty of defining their discrete components. Activity areas occurring within a bounded space such as a pitstructure or surface structure are usually limited to the confines of the structures in which they occur. However, activity areas occurring outside formal structures may be more ambiguous, but can often be considered in aggregate to define the limits of prehistoric use areas.

PRELIMINARY RESULTS

As previously noted, the DAP activity area form has 99 possible values (including "other") for activity area type. The 179 activity areas included in this study represent 25 of these categories. Six of these types, however, are represented by only one activity area each (table 32). In addition, the activity area category "indeterminate" contains only two entries, both from the same site. Therefore, only 18 discrete activity area types, containing 173 entries, are represented by two or more examples. The two most frequently encountered activity area types are "food processing, not further specified" and "food storage," represented by 33 and 30 examples, respectively. Only four of the 16 remaining activity area types contain 10 or more entries from the nine sites: "storage, not further specified" (21); "economic, not further specified" (12); "domestic and/or economic, not further specified" (10); and "mealing areas" (10).

Two possible explanations for the distribution of activity area types observed in the sample are proposed. First, the ambiguity of many of the type categories themselves and the number of different individuals assigning descriptive types to activity areas, combined with the lack of a formal set of definitions, may have resulted in a bias toward the use of the more ambiguous activity area types. A second explanation may be that the relatively small number of activity area types represented in this study, compared with the range of potential types, may be a reflection of cultural phenomena. These 18 activity area types represented by two or more activity areas may be the ones most representative of Pueblo I household clusters for the Anasazi in the Mesa Verde Region.

One way of resolving some of the ambiguities is to lump the activity areas into broad functional categories. The 179 activity areas dealt with in this study can be grouped into four functional categories (table 32). The first group consists of eight types that can all be characterized as domestic activity areas. A second broad functional category, composed of six activity area types, is tool manufacturing. A group of four activity area types representing storage activity makes up the third group. The fourth group, composed of seven activity area types, has been defined as a miscellaneous category into which all of the activity area types that do not fit neatly into one of the other three categories have been placed. This group never has more than four activity areas from any one site.

Generally, those activity areas occurring inside structures are from Group I or Group II. Many occur along the walls, evidently so as not to restrict movement in the center of the structure. Often the walls of the structure or ancillary architectural features such as wingwalls will bound the activity area on one or more sides and isolate it from other areas within the structure. Less discrete boundaries consisting of an imaginary line encircling a cluster of similar point-located artifacts may serve to delineate additional limits to activity areas. Features within domiciliary structures, especially storage bins or cists, permanent mealing stone complexes, and the central hearth, often serve as nuclei for the location of activity areas.

In the category of storage activity areas (Group III) the spatial boundaries are formed by the feature or structure boundaries. In surface structures the occupation surface may be devoid of features, in which case the storage activity may be inferred to have occurred across the entire surface. Storage activity areas occurring in open use areas are generally defined only on the basis of the storage feature. Most storage activity areas lack an internal assemblage of artifacts, such as would characterize a tool manufacturing area, for example. In summary, storage activity areas are for the most part defined by storage features, or by small surface structure occupation surfaces devoid of any features, and usually of any point locations as well.

Examining the types of activity areas occurring only in pithouses reveals a predominance of domestic activity areas (Group I). Of the 59 activity areas identified in pithouses, 25 are of the domestic type. There are 10 formal mealing areas and 6 are classified as "domestic complex" consisting of the central hearth and one or more associated storage pits. Thus, the activity areas occurring in the pithouses reflect a predominance of domestic activities, principally those of food preparation. The remaining three groups of activity areas are present in much reduced numbers. The tool manufacturing activity areas (Group II) identified in the sample of pithouses number 12. Storage activity areas (Group III) are poorly represented, with only 14 identified; 6 of these are classified as "storage, not

Table 32. Activity area frequencies grouped by broad functional categories

	Number	Percentage
Group I - Domestic activity areas		
Food processing, NFS*	33	18.3
Economic, NFS	12	6.7
Domestic and/or economic, NFS	10	5.6
Mealing area	10	5.6
Domestic complex	7	3.9
Domestic, NFS	2	1.1
Cooking area	2	1.1
Indeterminate[1]	2	1.1
	78	43.4
Group II - Tool manufacturing activity areas		
Tool manufacturing, flaked lithic, processing	5	2.8
Tool manufacturing, lithic, NFS	6	3.3
Tool manufacturing, NFS	3	1.7
Tool manufacturing, composite	3	1.7
Ceramic manufacturing, NFS	1	0.6
Tool manufacturing, nonflaked lithic, processing	1	0.6
	19	10.7
Group III - Storage activity areas		
Storage, food	30	16.7
Storage, NFS	21	11.7
Storage, lithic	5	2.8
Storage, complex	1	0.6
	57	31.8
Group IV - Miscellaneous		
Ritual, NFS	9	5.0
Sheet discard	6	3.3
Construction, borrow pit	5	2.8
Pit discard	3	1.7
Heating	1	0.6
Burial	1	0.6
Discard, NFS	1	0.6
	26	14.6

*NFS - not further specified

[1]These were judged by inspection of the data to be more clearly associated with this group than with any other.

further specified" and 5 are "food storage." The "miscellaneous" category (Group IV) consists of only eight activity areas, seven of which are defined by the presence of sipapus. The sipapus occur only in the pitstructures from the Sagehill and Dos Casas Subphases. No sipapus (ritual activity areas, table 32) were identified for the McPhee Phase pithouses. This is surprising in light of the frequent reference to pithouses of this time period as "protokivas." True kivas appear in the Dolores area during the Cline Subphase (late McPhee Phase). During the Periman Subphase (early McPhee Phase), from which the examples here come, there are exceptionally large pitstructures at some of the village sites at which ritual activities may have been carried out. In any case, the disappearance of sipapus from our sample of Periman Subphase sites may indicate that certain ritual activities which previously had been carried out at the household level had shifted to a different level of group integration, or at east that they were no

longer being carried out in the main domestic residential locus. On the other hand, some of the late Dos Casas and Periman Subphase pithouses excavated in 1980, and not included in this study, have evidence of other types of ritual activity in the locus north of the central hearth. This evidence, in the form of numerous small sand-filled holes, may indicate use of "pahos," or a similar ritual activity.

The surface structures from all sites have fewer activity areas represented. To some extent this may be a function of the poorer preservation of occupation surfaces in rooms than in pithouses. Preservation tends to be especially poor in the earlier sites, which also have fewer surface rooms. By far the majority of activity areas identified in the surface rooms of all time periods were storage areas. The 34 storage activity areas (21 "food storage" and 13 "storage, not further specified") and general lack of positive evidence for other uses argue strongly that these structures functioned as surface storerooms associated with pithouse domiciles. A few surface structures exhibited activity areas from the other broad functional categories: five domestic activity areas (Group I), all of which were hearths; four tool manufacturing areas (Group II); and one "miscellaneous" area (Group IV) classified as sheet trash, which was probably not associated with the primary use of the structure, and which does not conform to the definition of activity area used here.

A large number (77) of activity areas occur in outdoor use areas outside the confines of formal structures. Most of the activity areas in this category occur as Group I (49) or domestic activity area types. The breakdown is as follows: 33 "food processing, not further specified"; 11 "economic, not further specified"; and 5 "domestic and/or economic." All of the 49 activity areas are outdoor hearth areas. The domestic and/or economic category implies storage facilities, but these activity areas include a hearth as their primary attribute. The outdoor Group I activity areas do not have associated artifact scatters but are recognized only by the presence of a hearth feature. It seems likely that in some cases the difficulty of defining an occupation surface in the outdoor context might have made crew chiefs reluctant to claim association for particular artifacts or ecofacts with use of the feature. Activity areas from the other three broad functional categories are poorly represented in the outdoor use areas. Group II, tool manufacturing areas, is represented by only three instances, all from one site (Site 5MT2192). Group III, storage activity areas, accounts for only nine situations from five different sites. The "miscellaneous" categories (Group IV) include 16 entries, primarily indicative of construction (e.g., 5 borrow pits) or secondary refuse disposal.

Changes in activity area types or distributions through time are not as obvious as might be expected. This may be due in toto to the small sample size for any given type and the number of relatively ambiguous and sometimes overlapping activity area type categories. When the categories are similar or overlapping, it is difficult to determine whether the assignment of activity areas depends more on the crew chief's perspective, derived from background experiences, or from actual differences in the archaeological manifestation. Despite these potential sources of error, several trends through time are recognizable (cf. table 33).

In Group I, domestic activity area types, there is an apparent increase in the frequency of both mealing areas and the "domestic complex" type of activity area during the Dos Casas and Periman Subphases. The latter type refers to an activity area having evidence of cooking, heating, and food processing, and is usually centered around a hearth. This trend is evident in both the total activity area distribution and for those activity areas present only in pithouses. The more generalized "food processing, not further specified" activity areas, on the other hand, occur throughout the complete time range with no clear trends in frequency. This situation suggests that through time there was an increase in the establishment of formal grinding areas in the pithouses. The fact that this trend parallels the increase in "domestic complex" activity areas may indicate greater specialization or differentiation of food grinding and the preparation of its byproducts. The presence of "food processing, not further specified" areas may reflect the more general culinary activities that would be expected to take place in domiciliary structures.

Because Group I activity area types are poorly represented in surface structures from all time periods, it is difficult to make any statements about trends through time. It is interesting, however, that this in itself challenges the traditional interpretation that during the Pueblo I period (approximately A.D. 700 to 900) surface structures gradually became transformed into the main loci of domestic activities. The limited data reviewed here suggest that this change may have occurred rather at the end of or just after the Pueblo I period, and that in any case, it does not appear to be strongly represented even in the Periman Subphase (approximately A.D. 850 to 900). As already noted, the traditional view that there was a concurrent gradual transformation of pithouses into kivas during Pueblo I also does not appear to be supported by the results of this study so far.

Continuing with a review of the Group I evidence, it appears that "food processing, not further specified" activity area types are common throughout the investigated time range in outdoor use areas. This parallels the situation noted for pitstructures.

There are not sufficient data to ascertain any trends in the temporal distribution of Group II, tool manufacturing activity areas. The "tool manufacturing, lithic processing" activity area type appears to occur throughout the time

Table 33. Distribution of activity area types by phase and subphase

Activity Area Group	Phase									Totals	
	Sagehen					McPhee					
	Subphase										
	Tres Bobos[1]	Sage-hill[2]		Dos Casas[3]		Periman[4]				Group	Type
I. Domestic											
Indeterminate									2		2
Domestic/economic, NFS*			2	3	3				2		10
Economic, NFS					10		1		1		12
Domestic, NFS					1				1		12
Food processing, NFS	20	2		1		9	1			78	33
Cooking area		1	1								2
Mealing area			1		4	2			3		10
Domestic complex				1	2		1		3		7
II. Manufacturing											
Tool, NFS		1							2		3
Tool FL,** processing			2			1		1	1		5
Tool NFL,*** processing								1		19	1
Tool maintenance, NFS				5				1			6
Tool composite		1						2			3
Ceramic, NFS					1						1
III. Storage											
NFS	1	1		3	7		5	1	3		21
Food	14	3	1	3		4	1	4		57	30
Lithics				2			1		2		5
Complex					1						1
IV. Miscellaneous											
Construction, borrow pit	2			1		2					5
Ritual, NFS	1		1	3	4						9
Heating						1					1
Burial	1									26	1
Discard, NFS											11
Discard, pit	2						1				3
Discard, sheet	2	1			2				1		6
TOTALS:	43	10	8	23	35	19	11	10	21	180	

*NFS = Not further specified
**FL = Flaked lithic
***NFL = Nonflaked lithic
[1]The column under Tres Bobos is Site 5MT4545.
[2]The columns under Sagehill are Sites 5MT2194 and 5MT2198, respectively.
[3]The columns under Dos Casas are Sites 5MT2192 and 5MT2193, respectively.
[4]The columns under Periman are Sites 5MT4512, 5MT2191, 5MT2320, and 5MT23, respectively.

sequence when only the pithouse data are examined. However, the remainder of the activity area types occur in such low frequencies (i.e., one or two) in the surface structures and outdoor use areas that interpretation is impossible.

Examination of the totals for the Group III, storage activity areas, show that both the "storage, not further specified," and "food storage" activity types are highly represented in all time periods. In the pithouses, "storage, not

further specified" areas (probably storage pits or bins) are common during the Sagehill and Dos Casas Subphases and in pithouses at Grass Mesa (Site 5MT23), but are absent from the later McPhee Phase sites. Contrastingly, the activity areas labeled "food storage" occur only in the McPhee Phase pithouses. Whether this reflects a real difference in kinds of evidence remains to be checked. In the surface structures, "storage, not further specified" does not occur until the Dos Casas Subphase (9) and the McPhee Phase. "Food storage" is common in the surface structures throughout the Tres Bobos (14) and Dos Casas (3) Subphases and in the McPhee (4) Phase. Again, it seems likely that there is overlap in the evidence for these two types. Activity area types from Group III did not occur in high enough frequencies in the outdoor use areas to make any statement about temporal trends. "Lithic storage" shows signs of increasing during the Dos Casas and McPhee Phases but only when all of the activity area data are lumped together. This trend is not observable individually in the pithouse or surface structure data.

Ritual activity areas subsumed under the title of Group IV, or "miscellaneous" actitvity areas, occur only in the Sagehill (2) and Dos Casas (7) Subphases. No ritual activity areas have been identified from this sample of McPhee Phase sites. Such areas have been tentatively identified, however, in some of the more recently excavated McPhee Phase structures. Sipapus as indicators of ritual activity do seem, however, to be confined to the Sagehill and Dos Casas Subphases. The remaining Group IV activity area types occur only as single episodes, or in the circumstance of the trash disposal and construction activity areas, occur throughout the temporal span of the study.

CONCLUSIONS

The 179 activity areas representative of 25 discrete activity area types can be grouped into four broad functional categories: domestic activity, tool manufacturing, storage, and miscellaneous. The groups also represent a decreasing rank of activity area complexity in terms of their individual attributes. Group I or domestic activity areas, occur most often in pithouses and as outdoor hearths. Those present in the pithouses are more likely to incorporate artifact scatters as well as features, and to occur in a formally bounded area.

The Group II, tool manufacturing activity areas, again occur primarily in the pithouses as artifact clusters, but lack features as one of their major components. The Group III storage activity areas, occur predominantly in the surface structures and generally lack any artifact associations whatsoever. These activity areas are defined primarily by the presence of storage features such as cists, or by the occurrence of small, featureless surface rooms. The last category, Group IV, consists of a variety of manifestations about which it is impossible to generalize.

This report has been based primarily on information derived from the interpretive categories assigned to activity areas by crew chiefs when they filled out the activity area forms for their sites. The purpose of these forms is to flag the probable occurrence of activity area evidence, to provide a directory to the features and point locations involved, and to enable the crew chiefs to make a subjective assessment of probable activity area function, through use of a coding sheet which lists potential assignments. It was not anticipated that these interpretive assignments would be final. The use of these data here have shown that they document some interesting trends. Not surprisingly, the study reveals some problems with these preliminary interpretive assignments. The main problems appear to be (1) the list of potential functional assignments may be "oversplit," with many categories being rather similar to one another; (2) because of the similarities among, and lack of formal definition of, categories, many appear ambiguous; and (3) assignment of a particular archaeological manifestation to a particular category may be fairly strongly influenced by the varying perspectives of the different crew chiefs, based on their differing backgrounds in archaeology.

The portion of this study which depends on systematic comparison of activity area attributes instead of the preliminary interpretive assignments has not yet been completed, but should serve to determine if the patterns noted above hold up under more intensive analysis. Furthermore, it should also help resolve some of the methodological problems with the activity area form. If a coding sheet which allows crew chiefs to express their preliminary functional interpretations is to be used in the future, the results of this study should be useful in designing a less ambiguous set of categories and a set of formal definitions for them.

Extension of systematic activity area analysis to a larger sample of occupation surfaces should also help overcome the effects of biases in the data at any single site. A larger sample would also allow the inclusion of more examples of occupation surfaces that were "catastrophically abandoned" (burned while in use). Contrasts and similaritites between these and surfaces abandoned in other ways should permit better understanding of the artifact and ecofact scatters on occupation surfaces. Interpretations of these are currently more problematical than interpretations of features. Crew chief activity area identifications should also be assessed in reference to total feature and point location data from occupation surfaces — especially the ones suddenly abandoned. Finally, fuller provision of ecofactual identification, including data from bulk soil flotation, should improve activity area characterization.

IDENTIFYING FOOD PROCESSING ACTIVITIES: USE OF THE ETHNOGRAPHIC RESOURCE BASE[12]

by Judith L. Southward

INTRODUCTION

The objectives of this research are to survey characteristics of food processing activities as reported in the Puebloan ethnographic literature and to review and assess DAP procedures for identifying food processing areas in light of the ethnographic findings. In the longer report on this work (Southward 1981), the nature of ethnographic analogy and the propriety of using recent Pueblo analogs for early Anasazi situations was discussed. Although it was recognized that cultural, social, and environmental differences exist between Pueblo I Dolores Anasazi and the recent Zuni and Hopi, it was believed that the latter remained an appropriate source of analogy, provided that the parallels and differences were judiciously interpreted and archaeological evidence independent of the analogy was employed as well.

Prior to carrying out the literature search, a general "model of inquiry" for inferring food processing activities was developed as an aid to identifying the component elements of such activities and to specifying their ethnographic and archaeological manifestations. The results of the research can be summarized under four headings:

1. The model
2. Characteristics of Puebloan food processing activities
3. Characteristics of DAP archaeological food processing activity areas
4. Summary and recommendations

THE MODEL

Food processing activities can be conceived of as a system consisting of both human and nonhuman element sets (Schiffer 1976:50). Conceptually, the human elements include the status composition of the individual or task group as it relates to the allocation of food processing activity to that individual or group; the size of the task group; and the behavioral patterns employed to alter the food resource being processed. Nonhuman elements are of several kinds. There are tangible elements such as the resources themselves, the tools used in processing, the place where the processing is carried out, and the products and byproducts of the processing. There are also intangible elements, such as the season or time of day involved, the frequency of processing activity, and the length of time required for each processing episode. Human behavioral factors also impinge on some of the nonhuman elements; for example, in ownership of tools and of the places where activities are carried out.

This set of elements applies to both archaeologcial and ethnographic instances of food processing. It is at least theoretically possible in both fields to define these conceptual elements in terms of measurable variables and, in turn, to relate these variables to the value states of particular kinds of data. These data value states will be different in archaeology and ethnography, but theoretically, at least, they should be equitable with one another; that is, it should be possible to specify the archaeological data state that correlates with the ethnographic data state "grinding," and vice versa. The logical relationships between conceptual elements and tangible data should mirror one another in archaeology and ethnography, even though the data states and data sources may differ in form in the two fields. The examples in table 34 should clarify these relationships.

CHARACTERISTICS OF PUEBLOAN FOOD PROCESSING ACTIVITIES

The principal items of literature relating to Pueblo food processing activities were surveyed for information relevant to the elements outlined in the model of inquiry. Cushing's (1920) work on the Zuni and Nequatewa's (1943) work on the Hopi were the most informative, although information was gleaned from a number of other sources as well. Application of the model permitted evaluation of the usefulness of the literature in providing information relevant to understanding the various elements of food processing activity. As might be expected, the literature coverage is quite uneven. In general, documentation of the tangible nonhuman elements (specific foods, specific utensils) is stronger than the documentation of the human elements (who and how many) or the time (when, how often, how long) or place (where) elements.

Not much direct information is available on the primary locus of food processing activity. In some cases, however, it is possible to infer whether an activity takes place in a structure, outside of it, or at some distance from the domicile. There are a greater number of specific references to associations of food processing activities with fires or ovens, mealing areas, kitchens, and the like. Such associations can also sometimes be inferred from contextual evidence.

The specific activity used to process a food item is usually recorded (e.g., baking, boiling, grinding), as is the application of fire. The use of water and wind as processing aids

[12]This portion of the report was prepared during late 1979 and early 1980 and reflects the terminology and temporal designations in use at that time, rather than the most current usage. Further, this report reflects the state of the data base in late 1979.

Table 34. Portion of a model of inference of food processing activities

Ethnographic realm				Archaeological realm			
Conceptual elements	Definition of element sets as measurable variables	Sources	Data set value states	Data set value states	Sources	Definition of element sets as measurable variables	Conceptual elements
Use of processing utensils	How are utensils used? Describe motor patterns, tool placement, angle, etc. Input: Human energy	Ethnographic and ethnohistoric literature Ethnoarchaeology	Grinding, cutting, boiling, scraping, etc.	Use-wear patterns	Use-wear analysis Replicative studies Residue analysis	What wear patterns are present on recovered tools? What residues are present on recovered tools?	Use of processing utensils
Byproducts of processing activity	What are the byproducts? Output: Waste, discard, recycle	Ethnographic and ethnohistoric literature Ethnoarchaeology	Spilled food resources Nonconsumed food Unprocessed raw material Broken/worn-out utensils	Resource residues (pollen, carbonized seeds) Broken/worn-artifacts Locational concentration of residues, broken tools	Paleobotanical, faunal analyses Artifact analyses Occupation surface mapping	What food residues are present? What broken artifacts are present? What is locational patterning of residues/artifacts?	Byproducts of processing activity

(i.e., in washing or winnowing) is seldom mentioned. The best and most consistently available information is on which food resources were selected for processing and on which kitchen utensils were used in the process. Much of the literature is concerned with the processing of corn, but considerable information is available on wild products as well. There is some information on the sequence of steps in food processing episodes, but, unfortunately, little on byproducts. The information on kitchen utensils usually consists of a list or description of the items involved, and sometimes, of the sequence in which they are employed. There is a disappointing lack of attention to variation in numbers of utensils, volume of containers, contextual placement of utensils, motor habits involved in use, maintenance and reuse patterns, or discard of broken or wornout items.

Approximately 120 ethnographic entries documenting food processing activities were abstracted from Cushing (1920) and Nequatewa (1943). Many of these activities (or portions of them) appear to have taken place inside structures, although there is little direct mention of this. From these examples, it is possible to extract considerable data on the main feature associations in the area where the food processing took place. These associations overlap to a considerable extent; that is, a particular episode of food processing might be associated with both a fire and mealing area. These associations are summarized in table 35.

In most of the accounts surveyed, the food processing episode was essentially presented as part of a recipe for producing a particular kind of food, with a focus on the end product. Consequently, the percentages presented in table 35 should be taken as no more than very general indicators of the relationships between food processing and various associated features or kinds of areas. Food storage areas, for example, are almost certainly underrepresented if the table is used as a guide to these types of associations.

Keeping in mind the above caveat, some additional observations can be drawn from the ethnographic review of food processing episodes. One generalization is that most food processing activities appear to involve multiple features and/or areas. Fire areas are associated with the "generalized food processing, not further specified, " areas in 49 percent of the documented episodes and with mealing areas

Table 35. Feature and area associations of ethnographic food processing episodes

Percent of episodes[1]	Type of association
78	Fire areas (total)
54	Fire features, NSD*
18	Kitchen fireplaces
5	Ovens
0.8	Fireboxes
0.8	Roasting pits
58	Food processing areas, NFS** (generally involve mixing, kneading, slicing, etc., but not given a particular designation)
35	Mealing areas
22	Limited activity loci, located outside the main domicile (distances vary)
21	Domestic meal consumption areas
6	Food storage areas

[1]Percentages cannot be added to equal 100 as some episodes are associated with more than one type of features or area.
*NSD = Not specifically defined
**NFS = Not further specified

in 34 percent. Although data on the duration of activities and on the sequence in which the various areas are used are poor, it can be determined that in 9 percent of the cases, fire and mealing areas are directly involved in a food processing activity at a given point in time. Fire, mealing, and generalized food processing areas are associated in 21 percent of the entries. It has already been noted that the generalized food processing areas are commonly associated with fire areas; they are associated with mealing areas in 39 percent of the cases analyzed. Limited activity loci (which are involved in 22 percent of the episodes) are located outside, and in some cases at some distance away from, the domicile. They most frequently represent areas where plant resources are procured and where some form of processing also takes place. Also, some of these areas are centered around ovens which lie outside the house. Fire features are commonly associated with limited activity areas.

Another generalization that can be drawn from these data is that, as defined by the informants, episodes of food processing often involve fairly large spaces. At least, they are generally not confined to the area around only a single feature. The generalized areas mentioned in the survey often appear to occupy spaces not only adjacent to, but between, both fire and mealing areas.

With regard to utensils, the accounts refer frequently to vessels and other utensils. Vessels were most frequently made of ceramic or basketry materials. Other utensils were generally objects used actively to grind, pound, or stir. They tended to be either of stone or of vegetal material. If a food processing sequence included toasting, grinding, and boiling or baking, it appears that at least three to five vessels or other utensils were associated with the activity. Where there were data on utensils, the number of vessels or other utensils for any particular food processing activity was found to range between 2 and 11 objects.

CHARACTERISTICS OF ARCHAEOLOGICAL FOOD PROCESSING ACTIVITY AREAS

A total of 64 activity areas which had been identified by DAP archaeologists as probably being related to food processing was examined. Activity areas defined only on the basis of an associated storage structure or feature were not included in the study. The sample came from nine sites. Most (70 percent) of the proposed activity areas were from nonstructural use areas, i.e., from outside of pithouses or formal surface rooms. Although hearth features, storage pits, and other evidence that might lead to identification of food processing areas are relatively common on outside use areas at Dolores area sites, impressions are that they generally are not as heavily represented as they are in this sample. Hence, outdoor activity areas may be somewhat overrepresented.

In the sample of archaeological activity areas, 86 percent were labeled as "food processing, not further specified." Nine percent were regarded as mealing areas, and 4 percent as cooking areas. Features (a total of 103) were associated with most of the activity areas, as shown in table 36.

Forty-five percent of the identified activity areas had multiple associated features; 46 percent had only single features

Table 36. Feature associations of archaeological food processing activity areas

Percent of total*	Type of associated feature
75	Fire areas (total)
39	Hearths
27	Heating pits
6	Fireplaces
1	Firepits
1	Cooking pits
12	Pits, not further specified
6	Warming pits
2	Cists
1	Storage cists
1	Ash pits
1	Collecting basins
1	Indeterminate cultural features

*Percentages cannot be added to equal 100 because some activity areas are associated with more than one type of feature.

associated; and 9 percent, all mealing areas, had only artifactual associations. Mealing areas were defined by the presence of a metate; only one in five had a feature association, which in that case was a cist. It appears that the presence of certain types of features (e.g., fire areas, warming pits, storage pits) or metates, are primary criteria used by the archaeologists in a decision to recognize a possible food processing activity area.

Relatively few of the activity areas had associated artifactual or botanical remains, the latter undoubtedly due more to the unavailability of laboratory analysis results than to the actual presence or absence of remains in the archaeological record. The most common artifactual remains were flaked lithic items and sherds. With the exception of one area at which 26 items were recorded, the range of associated artifacts was from 2 to 12. Botanical remains were identified from only five areas; at all but one area, they were associated with hearths. Both cultigens (maize, beans) and wild plants (*Opuntia* sp., *Atriplex* sp., *Chenopodium* sp., *Portulaca* sp.) were represented. Seeds or kernels were the most common plant parts, suggesting that a food processing association was indicated.

The ethnographic survey indicated that the archaeologists' practice of considering fire areas and mealing areas to be focal points for food processing was an inference supportable by ethnographic analogy, to the extent that these features were in fact included in most ethnographic food processing episodes. This does not mean, of course, that all fire features are therefore indicators of food processing activity; there may well be such features that are primarily involved in other types of activity. This would appear to be especially true for the outdoor activity areas. The ethnographic survey did suggest, however, that main domiciliary hearths did regularly function in food processing. The question of uses of fire features not involved in food processing, or of multiple uses of those that were, was not addressed in this study with respect to either the ethnographic or archaeological data sets; however, it is a question that needs further consideration. The use of mealing areas as primary indicators, rather than just as likely components, of food processing areas seems better justified. Again, a study was not made of the uses of mealing equipment for activities other than food processing. It seems likely that even if mealing equipment had multiple functions, food processing is very likely to have been among those functions. The ethnographic survey also indicated, however, that the mere presence of a metate and manos does not necessarily indicate presence of a "mealing area." These tools may be in storage or may be in a particular locus for use in nonfood processing functions.

The archaeologists' tendency to recognize only a single feature or tight cluster of features as the focus of a food processing area may be too restrictive. In episodes described by informants and reported in the literature, the food processing activity tended to extend over a larger area and to use more than one feature-based focal point. In other words, the archaeologists' activity areas probably tend to be smaller than those recognized by the ethnologists' informants, or at least than those implied by the informants' accounts.

The plant residues reported from the archaeological record tended to be of a sort that would agree with a food processing interpretation, but the sample was very small. Since spillage and byproducts were not discussed in the ethnographic literature, interpretation of the archaeologically recovered botanical remains was not aided by specific ethnographic analogy. The assumption seems reasonable that botanical items spilled or discarded in food processing areas were among those involved in the food processing. With the exception of metates, utensils of the sort represented in the ethnographic record were not cited as part of the archaeological activity area characterizations. Many of the ethnographic examples were of perishable materials, and many of the archaeological artifacts appeared to be debitage, sherds, and other discarded or waste products, which are not dealt with in the ethnographic record. Nonetheless, there is the potential for ceramic containers and some other ethnographically mentioned utensils to appear in both records. Such items may not appear, however, in archaeological contexts representing gradual abandonment with removal of useful tools.

SUMMARY AND RECOMMENDATIONS

This report has focused on the use of an ethnographic resource base for the identification of food processing activities. Food processing activities identified in this manner were then compared to activities identified by the DAP.

The ethnographic literature indicates that food preparation takes place both within and outside of household residences. The number of activity areas identified by the DAP as located in both nonstructural and structural use areas is probably correct. The spatial extent of the archaeological activity areas may be too restricted. Information from the ethnographic sources suggests that a food processing sequence usually consists of gathering a food item; preliminary preparation by toasting or parching, and grinding; secondary preparation by mixing, kneading, and dough raising; and final preparation by boiling or baking into breads, cakes, mushes, or stews. Such a sequence often involves repeated usage of at least two main focal points: a fire area and a mealing area. Kitchen vessels or utensils for such a sequence probably include at least three to five items. It is suggested that the areal extent of food processing areas identified by the DAP could be extended to include not only a fire and mealing area, but also the areas adjacent to and between these features. This may be especially true for activity areas identified within structures; the areal

extent may include as much as one-quarter of a pitstructure. Roofs of structures should also be considered as likely food processing areas. An entire food preparation activity area with two or more focal points as described above, may be best coded simply as "food processing area," without attempts to make finer discriminations.

The ethnobotanical, pollen, and faunal studies being completed by the DAP appear to be quite comprehensive and will probably prove generally helpful in identifying food processing activities, although, to the extent that these materials represent spillage or byproducts, the ethnographic literature is likely to offer little specific help. The strengths of these studies may be improved by focusing on structures which have been catastrophically abandoned.

Both technological and functional studies of artifacts should be used in identifying food processing activities. At present there is a lack of focus towards a functional interpretation of recovered artifacts from the DAP. Although this is due to the descriptive focus of the preliminary analysis program that must be completed, final inferences about food processing activities should be partially based on the results of functional analysis.

The importance of detailed distributional maps and photographs of artifacts, features, and structures can hardly be stressed enough.

As mentioned above, the behavioral elements of who and how many individuals/groups participate in food processing activities could not be comprehensively documented from the ethnographic literature within the time limits of this study. These elements are an important part of food preparation activities and can possibly be inferred from general societal patterns recorded in ethnographic sources.

Food processing activity areas now being defined by the DAP are identified by a combination of empirical observations by the excavators, previously accepted archaeological inferences, and ethnographic analogy, all of which represent valid methods of identifying food processing activities.

INFORMATION RETRIEVAL ON A MICROLEVEL OF INQUIRY: BULK SOIL ANALYSIS FROM FOOD PROCESSING ACTIVITY AREAS IN TWO HABITATION UNITS[13]

by Meredith H. Matthews

INTRODUCTION

As Struever noted (1971:11), a prehistoric subsistence-settlement system will create a structure of material culture that is discernible within various frameworks. One such framework is encompassed within the concept of the activity area and has become one focal point of inquiry with the DAP investigation of the Escalante Sector Anasazi. According to Sackett (1968:70), analysis of the artifactual and paleoenvironmental constituents of an activity area should enable identification and interpretation of the activity performed, the cultural-environmental system utilized, and the composition of the performing group. Minimally, for the purposes of the DAP, investigations of activity areas are essential for describing and interpreting the organization and use of space by prehistoric occupants of the sites under mitigation. This report is concerned with the utility of bulk soil samples in providing a microlevel of information in the examination and interpretation of food processing activity areas within habitation units. An important assumption behind this study is that:

> plants from archaeological sites are a by-product of specific human cognitive patterns of behavior and the accidental inclusions from the local plant environment. Plants are not selected at random. . . . The context for the use of each plant is culturally prescribed, and the associated artifact and resulting plant debris reflect that activity for the archaeologist. In some instances, however, nothing may be preserved archaeologically of these activities except the microscopic evidence left from decayed or burnt plants (Ford 1979:286).

Therefore, botanical materials extracted from bulk soil samples collected from assumed food processing areas should support the DAP investigations about the spatial organization and behavioral correlates of food processing activities in habitation structures. The three major issues addressed in this study are (1) whether botanical remains from assumed food processing areas are recoverable through the sampling technique employed on the DAP; (2) the interpretability of such remains with respect to identification and investigation of food processing areas; and (3) whether the spatial patterning of activity areas within a habitation structure is discernible at this microlevel of inquiry.

Studies by Hill (1970) and Schiffer (1976) indicate a significant association between particular features in structures and space utilized for habitation functional activities. Southward's study (1981) specifically illustrates the ethnographic association of food processing activities with domiciliary hearths and in situ metates. In this study, it is assumed that these two features represent elements of activity assemblages of food processing/preparation activity areas in prehistoric habitation units. These features, therefore, were subject to intensive sampling procedures. This report deals with the results of analysis of 45 samples collected from two hearths and associated occupation surfaces of two pitstructures excavated during the 1979 DAP field season.

[13]The author wishes to acknowledge the assistance of Robert Bye, William Litzinger, and Steve James in formulating the original proposal for this study and to thank the DAP for continued support throughout the completion of this report.

A concept which was not considered at the time of formulation of this study, but which has become instrumental in its results, is site abandonment mode. This concept was developed during the 1980 field season (Kane and Robinson 1980) as the basis for the modification of bulk soil and pollen sampling strategies. Four abandonment modes were designated according to a preservation continuum of poor to excellent and based upon the assumption that:

> abandonment modes and subsequent depositional processes positioned along the upper (good to excellent) end of the continuum will yield data more representative of the full range of variability originally present in the prehistoric record. Abandonment modes and processes that result in poor preservation states are less likely to produce remains suited to answering questions in the D.A.P. research design (Kane and Robinson 1980).

Although the structures for this study were sampled with equal intensity before the implementation of the abandonment mode guidelines, in retrospect, the concept provided means to categorize the structures independent of other typological systems. All sampled structures could be referred to by this abandonment mode or preservational situation, a more appropriate characteristic for the focus of this study.

Among the prehistoric structures excavated by the DAP to date, the majority are classified as Case 1 abandonment mode (leisurely abandonment, implying minimal preservation of artifactual [botanical] material) or Case 2 abandonment mode (deliberate abandonment, burning within 5 to 10 years after abandonment; moderate preservation potential). All of the sampled structures for this study are included within one of these two categories. Neither of the structures for this study was classified as Case 3 abandonment mode (ritual abandonment), nor was any unquestionably a Case 4 abandonment mode structure (catastrophic abandonment, allowing optimal preservation of materials). Incorporation of the abandonment mode concept has increased the specificity of this study by focusing upon the more frequently encountered abandonment mode situation.

It also investigates the preservation opportunities and recovery potential of botanical materials from structures on the lower end of the continuum. This study tests the assumptions of the abandonment mode concept and its appropriateness in regulating ethnobotanical sampling of Escalante Sector Anasazi structures.

METHODOLOGY

During the 1979 field season, 13 pitstructures from 8 sites were sampled. Bulk soil samples were collected from occupational surfaces in a cruciform transect design, using central hearths and in situ metates as focal points of the configuration (fig. 103). Samples were also collected from the discrete strata of hearth fills. The sampling design was established with the intent of (1) extracting a microlevel of information concerning the density and distribution of remains; (2) defining the spatial extent of remains from the features in order to define the spatial extent of activity; (3) comparing the remains from feature fills to those retrieved from occupation surfaces; and (4) controlling for cojoined, interfeature activity areas and activity sets. This design was an extension of the DAP standard bulk soil sampling procedures for hearths and in situ metates (refer to Litzinger [1980b] for explanation of standard procedures).

In the optimal situation, when context and floor preservation were suitable, the following sampling procedures were implemented:

1. Hearths: cruciform transect, about 1 m long, bisecting the hearth in the cardinal directions, with 0.5-L bulk soil samples collected from the standard sample locations at 25-cm intervals along the transect line (fig. 103a).

2. In situ metates: the same sampling pattern as above with the cruciform configuration following the orientation of the in situ metate (fig. 103b).

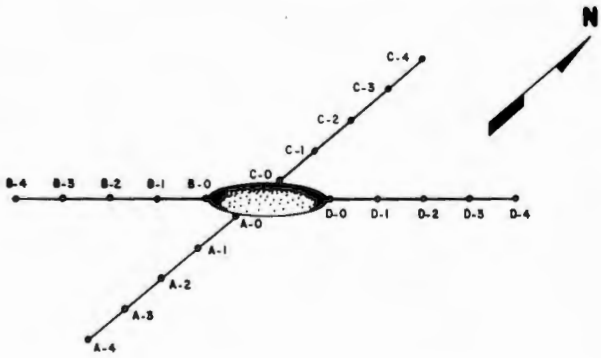


Figure 103a. Cruciform transect sampling design for central hearths.

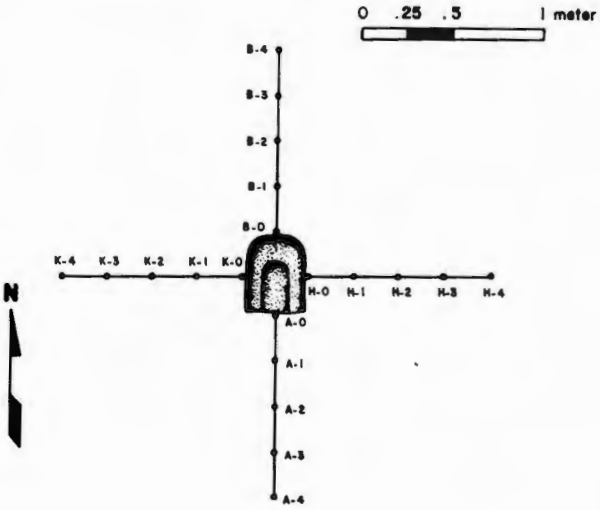


Figure 103b. Cruciform transect sampling design for in situ metates.

3. If both features occurred within a structure, transect samples collected between the two, (0.5 L), collected 25 cm apart.

4. Retrieval of a maximum of one-half of the hearth fill and/or mealing basin, maintaining the discrete fill sequence.

5. Samples labeled according to an alpha-numeric system that described the spatial relationship of the sample to the central feature (fig. 103).

Samples were processed using a water separation technique that allowed retention of discrete light and heavy fractions. Application of this technique assumes that most vegetal remains will be retrieved in the light fraction while nonvegetal remains will be retrieved in the heavy fraction. Sorting and analytical procedures were in close accord with those used by the DAP Environmental Studies staff for standard samples. Identification of vegetal remains was attempted to the level of genus, with tentative species identifications made when possible. Wood charcoal was identified only if the fragments were greater than or equal to 2 mm. While identification was possible below this size, confidence in identification decreased with smaller size. In addition to the comparative botanical collection derived from the Project area, published plant manuals (Brown 1928; Brown and Panshin 1934; Delorit 1970; Knight 1978; Martin and Barkley 1961), and the assistance of R. Bye (Environmental, Population, and Organismic Biology, University of Colorado, Boulder) were used in the identification of plant remains.

Originally, 3 pitstructures of the 13 sampled were designated for analysis; however, results of only 2 of the 3 sample sets are included in this report. Pitstructure 1 at Site 5MT23 is a Case 2 abandonment mode structure. Although the structure contained both types of activity loci, the metate was found leaning up against the west wall of the structure (a position similar to the way Tarahumara Indians of Chihuahua, Mexico, have been observed to leave their metates when they temporarily vacate a home), so the locus was not sampled. The structure was occupied during the McPhee Phase, about A.D. 875.

Pitstructure 2 of Site 5MT4644 is also classified as a Case 2 abandonment mode structure. The structure was occupied during the Sagehen Phase, about A.D. 776. A major factor in using Pitstructure 2 in this study is its association with Pitstructure 1 of Site 5MT4644. Pitstructure 1 is a Case 4 abandonment mode structure that was perhaps constructed by the same kin group associated with Pitstructure 2.[14]

[14]Joel M. Brisbin, DAP, Dolores, Colo., personal communication.

Pitstructure 1 (Site 5MT4644) was also occupied during the Sagehen Phase (about A.D. 789), in relatively close temporal accord with Pitstructure 2. The entire floor of Pitstructure 1 was intensively sampled and is presently in the final stages of analysis by the Environmental Studies staff of the DAP. The selection of Pitstructure 2 was made partially for its eventual comparative value to Pitstructure 1. It is assumed that similar pedoturbative and environmental variables may have affected these two structures, which are located close to one another. The similarity in influential variables may allow a more controlled study of the interactive forces affecting two different abandonment mode structures and their actual recovery potential.

RESULTS

The results of analysis are presented in tables 37 and 38. Remains retrieved from the samples are represented in table 37. The analyzed samples contained predominantly vegetal materials, with minimal occurrence of bone (assumed to be nonhuman) and lithic debris. The term "Indeterminate plant material" refers to items that are clearly vegetal in nature but are degraded to an extent that precludes more specific identification. The format of table 37 is similar to the standard output format used for data reporting by the DAP Environmental Studies laboratory. Table 38 delineates the alpha-numeric designation of each bulk soil sample and its distance from the central hearth. Figures 104 and 105 illustrate the information in table 38.

By comparing the results in table 37 to figures 104 and 105, a perspective as to the density and distributional patterning, if any, is provided. Generally, return from the floor samples was exiguous, with many samples containing nothing more than rootlets, insect parts, and minute flecks of charcoal and silt. The remains from the hearth fill samples appear prodigious in comparison. When the sample design was initiated, it was with the expectation that a greater density of materials would be extracted from samples collected closer to the hearth than from those collected farther away, reflecting a density gradient of botanical materials based upon optimal space utilization relative to the central hearth. This expectation was not as strongly verified as hoped, in light of the paucity of remains and their dispersed locations along the collection transects. The possible cultural-noncultural factors responsible for the configuration of remains are discussed later in this report.

As can be seen in table 37, *Zea mays* represents the only domesticate recovered from the samples. The remainder of botanical materials consisted of nondomesticated reproductive parts (seeds, fruits), and wood charcoal and other nonreproductive parts. The wood charcoal is considered to be either debris from burned roof fall or possibly fragments of fuel or other construction resources that were incorporated into the floor during occupation.

Table 37. Contents of analyzed samples (page 1 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
5MT23, Pitstructure 1		
Hearth		
BS101 (Stratum 1)		773
Chenopodiaceae		
Chenopodium sp., seed	7/ch	
Compositae		
Artemisia sp., wood	1.7 g/ch	
Helianthus type, fruit	2/ch	
Cupressaceae		
Juniperus sp., scale	2/ch	
Fagaceae		
Quercus sp., wood	-1 g/ch	
Gramineae		
Zea mays, kernel fragment	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	1/ch	
Dicotyledoneae		
Indeterminate, wood	-1 g/ch	
Indeterminate plant material		
unknown, seed	1/ch	
unknown, seed	1/ch	
unknown, fruit fragment	1/ch	
Nonhuman bone	2	
Residue	+1 g	
BS102 (Stratum 2)		779
Cupressaceae		
Juniperus sp., strobali	3/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Indeterminate plant material		
unknown, seeds	3/ch	
Nonhuman bone	2	
Residue	+1 g	

NOTE:
ch - charred
nch - noncharred
mod - modern
-1 g - less than 1 gram of material
+1 g - greater than 1 gram, but less than the 10 grams of material

Table 37. Contents of analyzed samples (page 2 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
BS103 (Stratum 3)		781
Cactaceae		
unknown, spine	1/ch	
Chenopodiaceae		
Cheno-am, seed	2/ch, nch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Cruciferae		
Sysimbrium type, seed	1/ch	
Fragaceae		
Quercus sp., wood	-1 g/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Solanaceae		
Physalis sp., seed	1/ch	
Indeterminate plant material		
unknown, seed fragment	1/ch	
unknown, flower	1/ch	
unknown, wood	-1 g/ch	
Nonhuman bone	3	
Residue	+1 g	
BS104 (Stratum 4)		782
Chenopodiaceae		
Cheno-am, seed	1/ch	
Malvaceae		
unknown, mericarp, fruit fragment	1/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Indeterminate plant material		
unknown, seed	1/ch	
Residue	-1 g	
South (A) Transect		
BS124 (5 cm)		780
Pinaceae		
Pinus edulis, needle fragment	2/ch	
Residue	-1 g	
BS125 (35 cm)		780
Residue	-1 g	
BS126 (65 cm)		775
Gymnospermae		
unknown, wood	-1 g/ch	
Salicaceae		

Table 37. Contents of analyzed samples (page 3 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Populus sp., wood	-1 g/ch	
Residue	-1 g	
BS127 (90 cm)		775
Residue	-1 g	
BS128 (115 cm)		776
Residue	-1 g	
West (B) Transect		
BS80 (15 cm)		631
Pinaceae		
Pinus edulis, needle fragment	1/ch	
Pinus ponderosa, needle fragment	1/ch	
Indeterminate plant material		
unknown, fruit fragment	1/ch	
Residue	-1 g	
BS81 (40 cm)		631
Rosaceae		
Cercocarpus montanus type, wood	-1 g/ch	
Residue	-1 g	
BS82 (65 cm)		631
Residue	-1 g	
BS83 (90 cm)		631
Residue	-1 g	
BS84 (135 cm)		628
Pinaceae		
Pinus sp., wood	-1 g/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Residue	-1 g	
North (C) Transect		
BS119 (10 cm)		637
Gymnospermae		
unknown, wood	-1 g/ch	
Residue	-1 g	
BS120 (50 cm)		634
Pinaceae		
Pinus sp., wood	-1 g/ch	
Indeterminate plant material		
unknown, leaf	1/ch	
Residue	-1 g	

Table 37. Contents of analyzed samples (page 4 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
BS121 (110 cm)		634
Graminae		
unknown, lemma	1/mod	
Indeterminate plant material		
unknown, seed fragment	1/ch	
Residue	-1 g	
BS122 (135 cm)		634
Cupressaceae		
Juniperus sp., scale	1/nch	
Gramineae		
Elymus cinereus type, fruit	1/nch	
Residue	-1 g	
BS123 (165 cm)		778
Residue	-1 g	
East (D) Transect		
BS75 (15 cm)		637
Chenopodiaceae		
Cheno-am, seed	3/ch	
Gramineae		
Zea mays, cupule	1/ch	
Residue	-1 g	
BS76 (35 cm)		637
Amaranthaceae		
Amaranthus sp., seed	1/ch	
Chenopodiaceae		
Chenopodium sp., seed	1/nch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Fagaceae		
Quercus sp., wood	-1 g/ch	
Gramineae		
Zea mays, cupule	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Pinus edulis, needle fragment	12/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Residue	-1 g/ch	
BS77 (55 cm)		636
Residue	-1 g	

Table 37. Contents of analyzed samples (page 5 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
BS78 (75 cm)		636
Compositae		
Artemisia sp., wood	-1 g/ch	
Pinaceae		
Pinus edulis, needle fragment	1/ch	
Residue	-1 g	
BS79 (100 cm)		636
Pinaceae		
Pinus edulis, needle fragment	1/ch	
Residue	-1 g	
5MT4644, Pitstructure 2		
Hearth		
BS731 (Stratum 1)		712
Chenopodiaceae		
Cheno-am, seed	1/ch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Cupressaceae		
Juniperus sp., scale	2/ch	
Gramineae		
Zea mays, kernel	4/ch	
Indeterminate, fruit	2/ch	
Loasaceae		
Mentzelia sp., seed	2/ch	
Monocotyledoneae		
Indeterminate, leaf	1/ch	
Pinaceae		
Pinus sp., wood	+1 g/ch	
Portulacaceae		
Portulaca sp., seed	1/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	2/nch	
Residue	+1 g	
BS732 (Stratum 3)		714
Chenopodiaceae		
Chenopodium sp., seed	1/ch	
Cheno-am, seed	1/ch	
Compositae		
Artemisia sp., leaf	1/ch	
Cruciferae		
Indeterminate, seed	1/ch	
Cupressaceae		
Juniperus sp., scale	9/ch	

Table 37. Contents of analyzed samples (page 6 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Cyperaceae		
Scirpus sp., fruit	1/ch	
Indeterminate, fruit fragment	1/ch	
Fagaceae		
Quercus sp., wood	-1 g/ch	
Gramineae		
Zea mays, kernel fragment	7/ch	
Zea mays, cupule fragment	7/ch	
Indeterminate, fruit	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	5/ch, nch	
Residue	+1 g	
BS733 (Stratum 4)		715
Amaranthaceae		
Amaranthus sp., seed	1/ch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Fagaceae		
Quercus sp., wood	-1 g/ch	
Gramineae		
Zea mays, cupule	3/ch	
Indeterminate, fruit	1/ch	
Loasaceae		
Mentzelia sp., seed	10/ch	
Portulacaceae		
Portulaca sp., seed	4/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Indeterminate plant material		
Indeterminate, seed	1/ch	
Residue	+1 g	
BS734 (Stratum 9)		720
Amaranthaceae		
Amaranthus sp., seed fragment	1/ch	
Chenopodiaceae		
Chenopodium sp., seed	1/ch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Helianthus type, fruit	2/ch	
Cupressaceae		
Juniperus sp., scales	5/ch	
Dicotyledoneae		
Indeterminate, wood	-1 g/ch	

Table 37. Contents of analyzed samples (page 7 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Gramineae		
Zea mays, kernel fragment	8/ch	
Zea mays, cupule fragment	8/ch	
Indeterminate, fruit	1/ch	
Loasaceae		
Mentzelia sp., seed	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Portulacaceae		
Portulaca sp., seed	1/ch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Indeterminate plant material		
Indeterminate, seeds	3/ch	
Indeterminate, fruit	2/ch	
Residue	+1 g	
West (B) Transect		
BS710 (5 cm)		565
Gramineae		
Zea mays, kernel fragment	3/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Polygonaceae		
Polygonum sp., fruit fragment	1/ch	
Portulacaceae		
Portulaca sp., seed	1/ch	
Solanaceae		
Nicotiana sp., seed	42/ch, nch	
Nonhuman bone	1	
Residue	-1 g	
BS711 (25 cm)		656
Chenopodiaceae		
Chenopodium sp., seed	7/ch	
Cupressaceae		
Juniperus sp., scale	1/ch	
Leguminosae		
Indeterminate, cotyledon	1/ch	
Malvaceae		
Indeterminate, seed fragment	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Portulacaceae		
Portulaca sp., seed	9/ch	

Table 37. Contents of analyzed samples (page 8 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Solanaceae		
Nicotiana sp., seed	29/ch, nch	
Indeterminate plant material		
Convolvulus type, seed	4/ch	
Indeterminate, fruit	1/ch	
Nonhuman bone	3	
Residue	-1 g	
BS665 (55 cm)		659
Compositae		
Artemisia sp., wood	-1 g/ch	
Residue	-1 g	
BS666 (75 cm)		659
Compositae		
Indeterminate, fruit	3/mod	
Dicotyledoneae		
Indeterminate, wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	6/nch	
Indeterminate plant material		
Indeterminate, seed	1/nch	
Residue		
BS667 (105 cm)		659
Chenopodiaceae		
Chenopodium sp., seed	1/ch	
Compositae		
Artemisia sp., wood	-1 g/ch	
Gymnospermae		
Indeterminate, wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	15/nch	
Residue	-1 g	
North (C) Transect		
BS682 (5 cm)		595
Residue	-1 g	
BS683 (20 cm)		595
Compositae		
Artemisia sp., wood	-1 g/ch	
Gramineae		
Indeterminate, fruit	1/ch	
Gymnospermae		
Indeterminate, wood	-1 g/ch	

Table 37. Contents of analyzed samples (page 9 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Portulacaceae		
Portulaca sp., seed	2/ch	
Solanaceae		
Nicotiana sp., seed	2/ch	
Residue	-1 g	
BS684 (40 cm)		595
Amaranthaceae		
Amaranthus sp., seed fragment	1/nch	
Malvaceae		
Malvastrum sp., seed	1/nch	
Salicaceae		
Populus sp., wood	-1 g/ch	
Solanaceae		
Nicotiana sp., seed	4/ch	
Indeterminate plant material		
Indeterminate, seed	3/ch	
Residue	-1 g	
BS609 (65 cm)		596
Pinaceae		
Pinus sp., wood	-1 g/ch	
Residue	-1 g	
BS610 (90 cm)		596
Compositae		
Artemisia sp., wood	-1 g/ch	
Indeterminate, fruit	1/ch	
Gramineae		
Panicum sp. type, fruit	1/ch	
Gymnospermae		
Indeterminate wood	-1 g/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Pinus edulis, needle fragment	1/ch	
Residue	+1 g	
East (D) Transect		
BS590 (5 cm)		598
Pinaceae		
Pinus sp., wood	-1 g/ch	
Pinus edulis, needle fragment	1/ch	
Portulacaceae		
Portulaca sp., seed	2/ch	

Table 37. Contents of analyzed samples (page 10 of 10)

Site No., Structure Sample type Sample No. (distance from hearth) Content	Quantity/Condition	F.S. No.
Nonhuman bone	1	
Residue	-1 g	
BS563 (25 cm)		598
Amaranthaceae		
Amaranthus sp., seeds	2/ch	
Cupressaceae		
Juniperus sp., scale	1/ch	
Gramineae		
Zea mays, cupule	1/ch	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Pinus edulis, needle fragment	4/ch	
Pinus ponderosa, needle fragment	2/ch	
Portulacaceae		
Portulaca sp., seed	1/ch	
Residue	-1 g	
BS591 (50 cm)		646
Gramineae		
Indeterminate, culm	1/ch	
Pinaceae		
Pinus edulis, needle fragment	1/ch	
Residue	-1 g	
BS592 (75 cm)		646
Compositae		
Indeterminate, fruit	1/mod	
Pinaceae		
Pinus sp., wood	-1 g/ch	
Pinus edulis, needle fragment	17/ch	
Residue	-1 g	
BS593 (100 cm)		646
Gymnospermae		
Indeterminate, wood	-1 g/ch	
Pinaceae		
Pinus edulis, needle fragment	8/ch	
Residue	-1 g	

Table 38. Spatial relationship of samples to central feature

Site No.[1]	BS No.	Alpha-numeric designation	Distance from feature[2] (cm)
5MT23			
A-Transect	124	A-0	5
	125	A-1	35
	126	A-2	65
	127	A-3	90
	128	A-4	115
B-Transect	80	B-0	15
	81	B-1	40
	82	B-2	65
	83	B-3	90
	84	B-4	135
C-Transect	119	C-0	10
	120	C-1	50
	121	C-2	110
	122	C-3	135
	123	C-4	165
D-Transect	75	D-0	15
	76	D-1	35
	77	D-2	55
	78	D-3	75
	79	D-4	100
5MT4644			
B-Transect	710	B-0	5
	711	B-1	25
	665	B-2	55
	666	B-3	75
	667	B-4	105
C-Transect	682	C-0	5
	683	C-1	20
	684	C-2	40
	609	C-3	65
	610	C-4	90
D-Transect	590	D-0	5
	563	D-1	25
	591	D-2	50
	592	D-3	75
	593	D-4	100

[1]Neither pitstructure was sampled in total accordance to the specified design of this study. Factors such as poor floor preservation, disturbance or features in the transect line required deviating from the sampling design.
[2]Measurements were recorded from the mapped outer edge of the feature to approximately the center of the mapped sample.

Both charred and noncharred remains are reported here. There has been extensive discussion in the archaeobotanical literature concerning the recovery of noncharred botanical remains from cultural contexts and the cultural association of these remains (Adams 1980a; Bohrer and Adams 1977; Dennell 1976; Doebley 1976; Ford 1979; Keepax 1977; Minnis 1978, 1981; Munson et al. 1971). Are noncharred remains from open air sites contaminants or well-preserved byproducts of prehistoric activity? Keepax (1977:226) lists five criteria for differentiating between

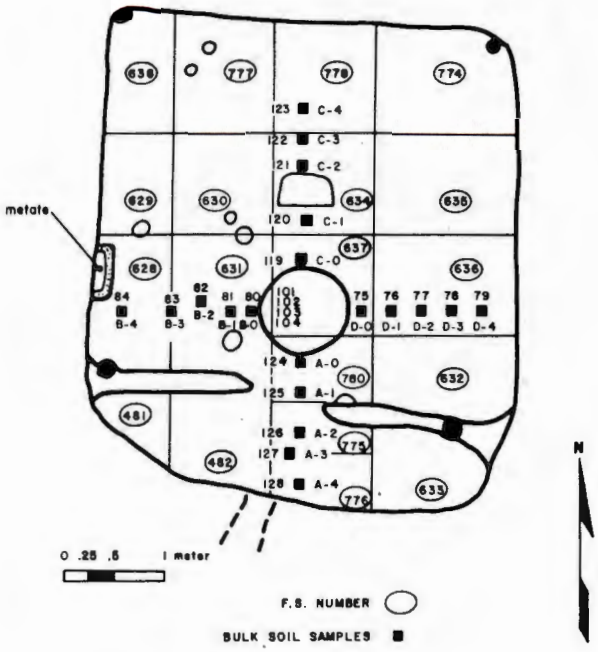


Figure 104. Location of bulk soil samples relative to the central hearth, Pitstructure 1, Site 5MT23.

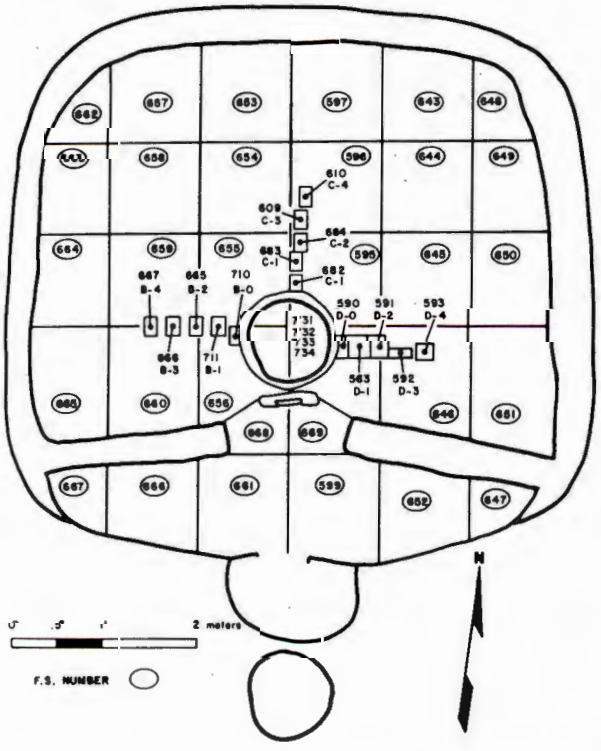


Figure 105. Location of bulk soil samples relative to the central hearth, Pitstructure 2, Site 5MT4644.

modern and prehistoric botanical remains, although she concludes that, "it is often a simple matter to reject all uncharred seeds as modern in origin and to retain only the charred material as genuine." Some noncharred materials from the samples were clearly modern in origin. Nonetheless, remains such as the noncharred *Nicotiana* sp. seeds from Pitstructure 2 (Site 5MT4644), BS No. 677, 710, and 711, are not as easily categorized because of their association with charred specimens of *Nicotiana* sp. in the sample suite. Two possible explanations can be suggested here. The first explanation is that the *Nicotiana* sp. seeds recovered probably do not represent the domesticated species of tobacco plant (Benz, appendix B), but a colonizer or volunteer weed of disturbed habitats. The noncharred seeds could represent intrusion into the structure after post-abandonment burning, with the charred seeds already interred in the structure. Conversely, *Nicotiana* sp. may have been intentionally or accidentally brought into the structure during occupation, the two conditions representing differential charring depending upon location within the floor stratum. Regardless of which explanation is accepted, the occurrence of *Nicotiana* sp. (or other colonizing plants) is significant for reasons discussed below.

DISCUSSION

Incorporation of botanical material into an archaeological context occurs through culturally deliberate inclusion or natural intrusion. Culturally deliberate inclusion here implies that the prehistoric occupants knowingly brought a particular item into a structure, although they may have unwittingly incorporated a part of it into a feature or the floor stratum. Cultural factors influential in incorporation are use, processing and preparation techniques, the part of the plant used, and context of use and disposal. Minnis (1981:145) describes direct resource utilization and indirect resource utilization as sources of seed remains. The former includes collection, processing, and use/consumption of seeds, while the latter involves the use of the plant itself for such functions as food, material objects, and roofing material. Indirect utilization, although not always immediately involved in subsistence practices, can leave remains that could be misinterpreted as subsistence items.

Preparation and consumption activities can potentially withdraw plant materials from inclusion in the archaeological record in any significant occurrence. Some modes of preparation, e.g., boiling, would not leave evidence of the plant unless through accidental spilling. Other activities such as parching, grinding, and drying are more likely to leave botanical residues. A point made by Dennell (1976:232) is that since the cultural use of a plant affects its archaeological visibility, it is a "disturbing possibility that much of our archaeobotanical evidence might provide a more accurate indication of what was thrown away than what was actually used."

Incorporation is also affected by the physical characteristics of plants and their preservation potential. Munson et al. (1971:427) divide food plants into three categories based on declining preservation potential:

1. "Those foods which have rather dense, inedible parts" (maize cobs).

2. "Plants foods which are somewhat dense but which are normally ingested in their entirety" (small seeds and maize kernels).

3. "Non-dense foods with a high water content" (tubers and greens).

Obviously, plants in Categories 1 and 2 have a greater potential for preservation than those in Category 3. It is also assumed that the size of a botanical item affects its incorporation into a floor. Larger materials like bean or squash seeds are more visible than amaranth or purslane seeds (measuring in length 1.2 to 1.7 mm and 0.5 mm, respectively). Therefore, the larger items would more likely be retrieved if dropped and either recycled or disposed of while smaller items may be incorporated into the occupation surface (Baker 1978:290; Bohrer 1980:168; Hildebrand 1978:277).

Natural inclusion of botanical materials in a structure can occur during occupation or after abandonment. Keepax (1977:224) and Adams (1980a:255) list a variety of ways materials are naturally incorporated in archaeological strata such as by insects, rodents, wind/water action, or by being unintentionally carried in on the prehistoric occupants. Adams (1980a:256) points out that the morphological and physiological characteristics of some seeds enhance their probability of being unintentionally carried into the structure. Such small items could then be incorporated into the floor or some other area of the structure. The natural seed rain of a site creates the opportunity for perpetual inclusion into the archaeological record. Naturally occurring plant parts that are not conducive to being carried in on clothing can blow into a structure while it is being occupied. After abandonment, natural inclusion into the archaeological situation increases because of natural disturbance processes (Minnis 1981:145; Wood and Johnson 1978) and cessation of structure maintenance.

The nondomesticated plant remains (seeds and fruits) extracted from the archaeological samples are considered volunteer weeds, colonizers, or disturbance plants (plants that enter and propagate successfully in a disturbed environment). Areas of human disturbance provide suitable habitats for these types of plants. It can be assumed that the higher the level of technological development and the more extensive the archaeological remains, the greater the intensity of prehistoric disturbance (Yarnell 1970:215). Some disturbance vegetation has economic value and is believed to have been actively exploited in its natural state or incorporated into the subsistence system as a nondomesticated encouraged "crop" (Dennell 1976; Ford 1979; Minnis 1978; Yarnell 1965). Most of the recovered botanical material from this study has ethnographically documented economic value (Beaglehole 1937; Castetter 1935; Cushing 1920; Elmore 1944; Stevenson 1915; Whiting 1939). Since it is not the purpose of this report to describe the ethnographic uses of the plants recovered in this study, one should refer to these authors for more information. It should be noted that economic value does not exclusively refer to subsistence resources but includes ceremonial, medicinal, construction, and fuel resources as well. A problem arises when potential economic colonizers occur in a cultural context. The presence of these remains could indicate cultural use and discard, or represent natural dispersal of disturbance vegetation.

Many colonizing plants will continue to thrive in a disturbed habitat after active disturbances cease, growing on, in, or near a structure and contributing seeds into post-occupational deposits. Considering the time lag between terminal occupation and burning and collapse, Case 2 abandonment structures are susceptible to increased contamination by disturbance plants which would be charred during roof burn. This phenomenon intensifies interpretational problems of archaeobotanical remains. Their inclusion in a cultural context, even in a charred condition, cannot always be explained by human economic exploitation.[15]

Nonetheless, occurrence of these plants in the archaeological record is an important documentation of prehistoric human-environmental interaction systems (see Benz, appendix B). Insight into this interaction system through the occurrence of disturbance seeds allows not only an understanding of prehistoric environments and transition, but also allows postulates of behavioral sequences to be formulated concerning human disturbance and exploitation activities. Establishment of the cultural significance of disturbance plant remains in the archaeological record affords a better understanding of the subsistence-economic pattern of the prehistoric occupants and of the immediate environment within which they existed.

The presence of a potential economic plant in a cultural context, regardless of ethnographic correlates, does not necessarily determine the remains as an actual economic plant or define the actual use of the plant. This phenomenological viewpoint relies too much upon single interpretation correlates to generate explanation, and cannot always be considered adequate (Sullivan 1978:189). Adams (1980a:255) has described a system of analysis for determining how botanical material is incorporated into an archaeological stratum by reviewing multiple pathways of evidence.

[15]Robert A. Bye, University of Colorado, Boulder, personal communication.

Elimination of incidental pathways of incorporation and clear evidence of human modification, e.g., parching, increases the likelihood of a particular plant having economic value.

A major line of evidence that can be used in this study to determine economic significance of recovered material is the comparison of hearth remains to floor remains. Remains from the hearth are considered indicative of food preparation activities and are probably the byproducts of accidental spilling. The interpretational problems with floor remains have already been discussed. However, a stronger case is built for the inclusion of remains in a floor through cultural activities, if the remains occur concurrently in the hearth.

A second line of evidence is the condition of the material recovered. The preservation situation exhibited by the two structures sampled does not lend itself to long-term preservation of botanical materials. Considering this situation, the disturbed character of the sites and the increased potential for postoccupation contamination in a Case 2 abandonment mode, charred material is more likely to be culturally significant than noncharred. Table 39 lists the taxa of plants common to both the hearth and the floor samples of the two structures. Table 40 shows the taxa found only in the floor samples. For the purposes of this study, discrepancies in occurrences of wood taxa between the two sample types is not considered significant. Assuming occurrence of wood indicates either a primary or secondary fuel or construction resource (secondary if used after other

Table 39. Shared taxa within the sample types

Site 5MT23, Pitstructure 1
- Chenopodiaceae
  - Cheno-am, seed/fruit
- Compositae
  - *Artemisia* sp., wood
- Fagaceae
  - *Quercus* sp., wood
- Gramineae
  - *Zea Mays,* cupule
- Pinaceae
  - *Pinus* sp., wood
- Salicaceae
  - *Populus* sp., wood
- Solanaceae
  - *Nicotiana* sp., seed

Site 5MT4644, Pitstructure 2
- Amaranthaceae
  - *Amaranthus* sp., seed
- Chenopodiaceae
  - *Chenopodium* sp., seed
- Compositae
  - *Artemisia* sp., wood
- Cupressaceae
  - *Juniperus* sp., scales
- Gramineae
  - *Zea mays,* kernels, cupules
- Pinaceae
  - *Pinus* sp., wood
- Solanaceae
  - *Nicotiana* sp., seeds

NOTE: Only taxa that were charred in both types of samples (hearth and floor) are listed here. In both structures, *Nicotiana* sp. appeared in charred and noncharred conditions within both types of samples.

Table 40. Taxa recovered from floor samples only

Site	Taxa	Charred	Noncharred
5MT23	Amaranthaceae		
	Amaranthus sp., seed	X	
	Gramineae		
	Elymus cinereus type, fruit		X
	Leguminosae		
	Indeterminate, cotyledon	X	
	Pinaceae		
	Pinus edulis, needle	X	
	Pinus ponderosa, needle	X	
5MT4644	Compositae		
	unknown, pappus		X
	Gramineae		
	Panicum sp. type, fruit	X	
	Leguminosae		
	Indeterminate seed, cotyledon	X	
	Malvaceae		
	Malvastrum sp., seed		X
	unknown, seed	X	
	Pinaceae		
	Pinus edulis, needle	X	
	Polygonaceae		
	Polygonum sp., fruit	X	

materials, e.g., berries, were removed), then the wood taxa need not necessarily be shared between sample types.

Comparison in recovery between the pitstructures used in this study and the aforementioned catastrophically abandoned Pitstructure 1, Site 5MT4644 (data on file, DAP), shows a large discrepancy in quantity and diversity of botanical material. This descrepancy is a byproduct of cultural and natural site formation processes (Schiffer 1976:14) that regulate not only what is left behind in the archaeological record, but also how the record is altered through time. Accidents in food preparation activities can transfer materials from their systemic context into an archaeological context (Schiffer 1976:28). Concurrently, methods of preparation can remove all evidence of some plants from incorporation (Dennell 1976).

Besides preparation techniques, the next major cultural process believed responsible for the paucity of remains is cleaning. The ethnographic and ethnoarchaeological literature does not offer much information concerning habitation maintenance. How often is a floor swept or a hearth cleaned out? Where are floor sweepings discarded? Did the Anasazi clean out their homes prior to vacating them seasonally or permanently? Figures 106 and 107 show the floor maps of Pitstructures 1 (Site 5MT23) and 2 (Site 5MT4644). The area around each hearth appears relatively clear of artifactual debris. It is not possible to determine whether this indicates hearth area maintenance or, contrary to prior assumptions, location of primary preparation activities away from the immediate vicinity of the hearth. The paucity of artifactual debris, however, mirrors the paucity of botancial remains recovered.

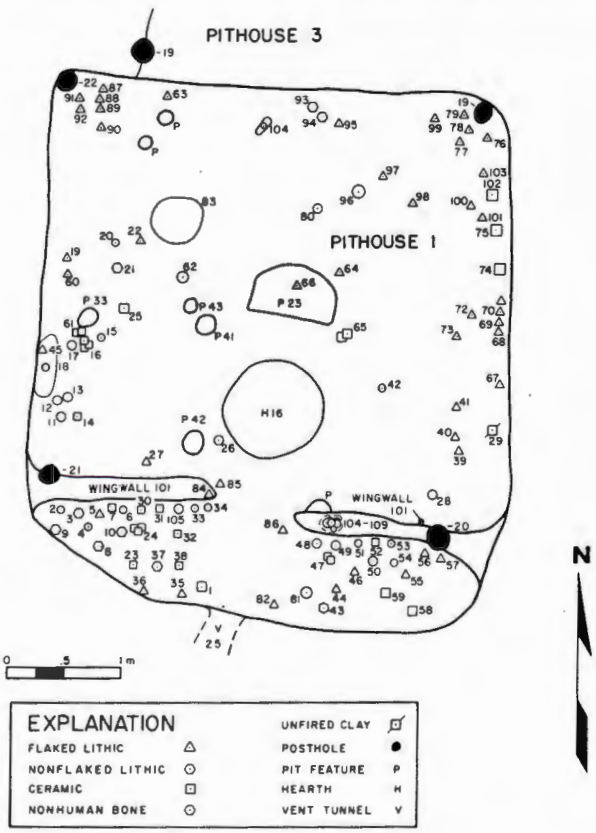


Figure 106. Features and point-located artifacts on the occupation surface of Pitstructure 1, Site 5MT23.

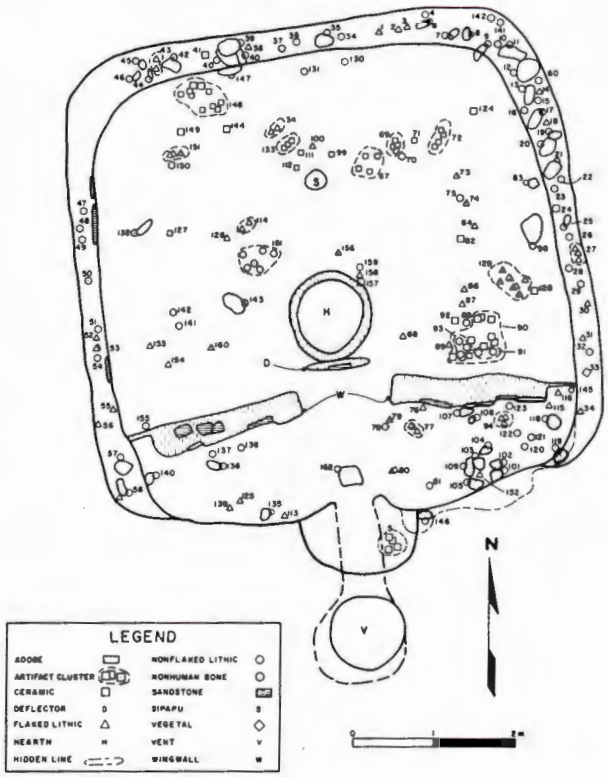


Figure 107. Features and point-located artifacts on the occupation surface of Pitstructure 2, Site 5MT4644.

Regardless of what is incorporated into the archaeological record, natural processes affecting preservation will destroy part of this record. Botanical materials are highly susceptible to disintegration and predation, although charring decreases this susceptibility. Open-air sites lend themselves to a range of deleterious natural processes (Wood and Johnson 1978) that affect the botanical remains. The noncatastrophic abandonment mode of Pistructures 1 (Site 5MT23) and 2 (Site 5MT4644) increased the deterioration potential for botanical materials. Therefore, the materials recovered represent "a differential assemblage based upon the prehistoric cultural pattern of disposal, the nature of the material, and the geochemical history of the archaeological deposit" (Ford 1979:299). This assemblage of botanical remains, while offering insight into prehistoric behavioral pathways, is biased towards those botanical remains that are fortuitously preserved through time.

SUMMARY

Given a moderate preservation situation (Case 2 abandonment mode) the return of botanical remains from floor strata is judged to be minimal. However, as the results of analysis showed, a moderate preservation situation still allows productive recovery from features such as the central hearth. Under the sampling design of this study, a definite spatial patterning of botanical debris was not discernible, which decreased the utility of the remains for providing direct behavioral correlates of food processing activity areas.

Two explanations are suggested for this lack of a density gradient of botanical materials away from the central feature of the activity area. As the previous discussion indicates, there exists a range of natural processes that prove deleterious to preservation of botanical materials in archaeological sites. The paucity of remains from floor samples may be a reflection of poor preservation. Conversely, it is suggested that cultural activities such as cleaning may have removed much of the evidence that was sought in this study to substantiate assumptions concerning food processing activity areas. Therefore, assumptions about food-processing behavior cannot be adequately reinforced in the context of a Case 2 abandonment mode situation, based upon the microlevel of information generated by this study.

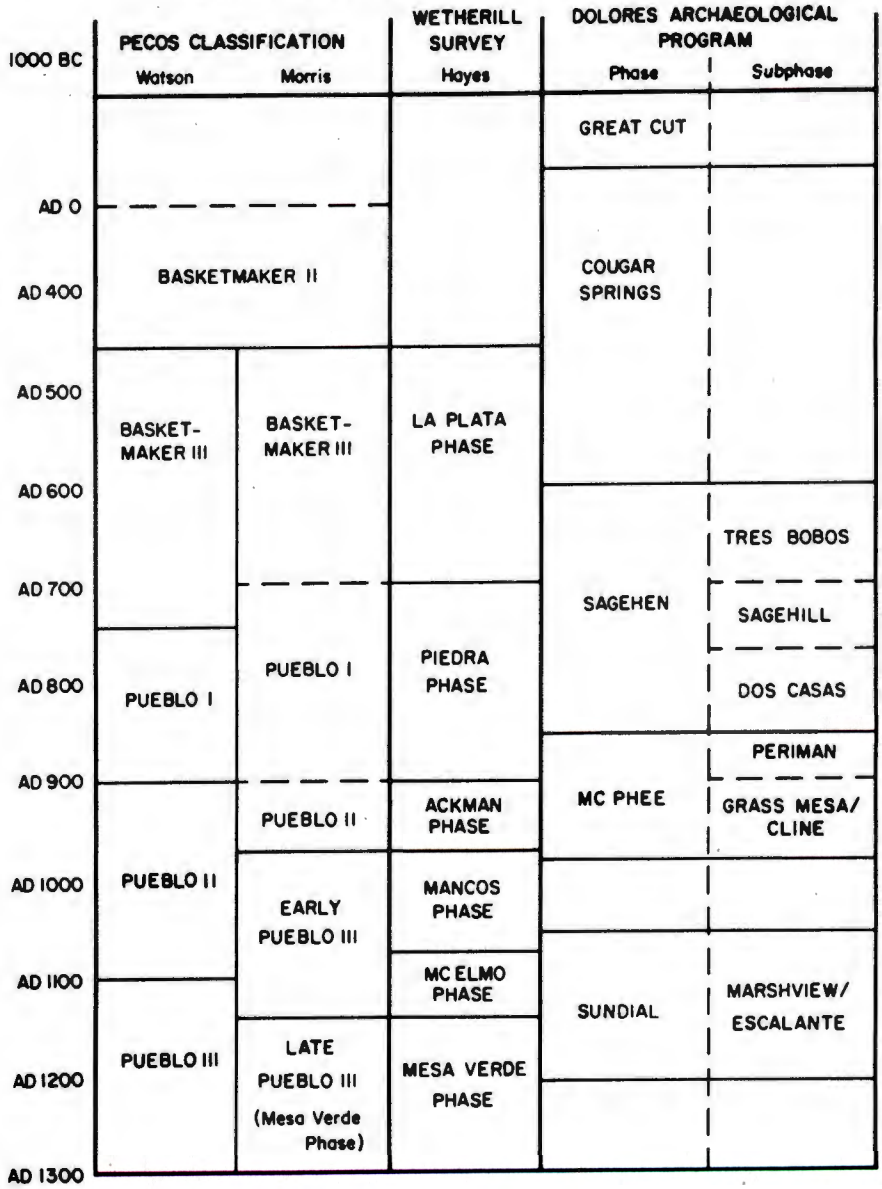
On a more positive note, this study did test the assumptions of the site abandonment mode. Although it is acknowledged that the sample size was small, the return in data supports the abandonment mode concept and the conservative estimate of potential information retrieval from Case 2 abandonment structures. The increased risk of contamination by noncultural, intrusive botanical remains indicates the necessity of sampling the more secure areas of a structure, like features. In contrast, data from Pitstructure 1, Site 5MT4644 (data on file, DAP), has illustrated the substantial increase in information retrieval from a catastrophically abandoned structure. A major assumption of the Case 4 abandonment mode is that of active occupation of a structure at the time of destruction, thereby permitting recovery of in situ activity sets. The optimal preservation situation presented by Case 4 abandonment structure enhances the probability of deriving correlates concerning prehistoric behavioral patterns from the activity sets. Intensive analysis of catastrophically abandoned structures also provides a more complete data set pertaining to resource exploitation and utilization by the prehistoric occupants.

A secondary function of this report has been to illustrate the interpretational complexity surrounding archaeobotanical remains. The remains can directly represent a refined level of behavioral residue. They can also support inferential statements about human-environmental interaction systems which concurrently lead to models of human behavior patterns. It is hoped that the previous discussion has indicated the problems inherent in using botanical remains as a data set in prehistoric behavioral studies. Adequate understanding of the intricate network within a human-environmental system requires a conservative approach to interpretations until enough data has been amassed to study multiple, alternative behavioral pathways.

Finally, results from this study will aid research concerned with the DAP Research Design Problem Domain 1: Economy and Adaptation (Kane, Lipe et al. 1981). The botanical remains recovered will supplement or further substantiate information concerning potential subsistence resources of the Escalante Sector Anasazi. As previously discussed, the occurrence of economic disturbance plant remains in cultural contexts allows hypotheses to be formulated about human-environment interaction systems. Understanding the variables inherent in these interactive systems will allow models to be developed explicating the cultural adaptation and procurement systems of the Escalante Sector Anasazi.

D.A.P. FORMAL SERIES

RELATIONSHIPS TO OTHER ANASAZI CHRONOLOGIES



Chapter 6

SUMMARY AND CONCLUSIONS

Chapter 6

SUMMARY AND CONCLUSIONS

by Christine K. Robinson and Allen E. Kane

The DAP (Dolores Archaeological Program) is a large-scale cultural resources mitigation effort that has been in existence since June 1978. The Program, under the direction of the Bureau of the Reclamation, calls for the completion of field work in FY 1983 and for the production of a final report in FY 1985.

As it has developed, the DAP is responsible for three major functions: design, planning, and performance. The articulation between these functions and fieldwork, analysis, and reporting can be conceptualized in a three-function-by-three-function matrix (table 41). Bureau approval prior to implementation of design, planning, and performance functions is required.

The overall conceptual design umbrella under which DAP operates is the Dolores Project Cultural Resources Mitigation Design (Knudson et al. n.d.; also chapter 2, this report). The Mitigation Design is composed of (1) a statement of the concepts which guide DAP work efforts, (2) the Research Design, and (3) the Implementation Design.

The structure of DAP scientific inquiry is guided by the Research Design. It ensures that data recovery and analysis is consistent across five Problem Domains: Economy and Adaptation, Paleodemography, Social Organization, Extra-regional Relationships, and Cultural Process. The structure of inquiry provided in the Research Design does not assume that answers to all of the questions stated therein are necessary or desirable. It is, however, a "set of logical rules . . . designed to lead each researcher through an identical process of theoretical development, library research, hypothetical formulation and testing, progressive inference (extrapolation, interpolation, or patterning) and summarization" (Knudson et al. n.d.:9).

The Implementation Design is the DAP mechanism for assessing the scientific adequacy of data recovery. It is an attempt to establish the sample sizes required to answer basic questions with varying degrees of confidence.

Beyond the Dolores Project Cultural Resources Mitigation Design, additional DAP design and planning functions are supported by a series of secondary documents. These take the form of yearly work plans (for fieldwork and analysis) and a series of midlevel research designs which articulate individual data sets with the Research Design. In addition

Table 41. Articulation of DAP design, planning, and performance functions with fieldwork, analysis, and reporting

Function	Design	Planning	Performance
Fieldwork	Mitigation Design (Research and Implementation Designs) Site-specific research designs	Annual work plan Fieldwork plan for remainder of DAP (FY83)	Completion of data recovery
Analysis	Mitigation Design (Research and Implementation Designs) Midlevel analytical Research Designs Preliminary, intensive and synthetic analyses	Annual Study Management Plan Master Plan for the remainder of DAP (FY85)	Completion of analysis
Reporting	Report formats Style Guide	Report scheduling	Completion of reporting

to explanatory models of Dolores cultural history and process, individual analytic and synthetic studies are also critical to DAP design and planning functions.

DAP performance is measured in the areas of fieldwork, analysis, and reporting.

As reported in chapter 3, Dolores prehistoric cultural resources are part of a vast population of prehistoric resources in the Yellowjacket and Western Districts of the Mesa Verde Region (Gillespie 1976; Kane 1981a; Kidder 1962; Nickens 1977). Although a substantial number of archaeological investigations have been conducted in the two districts, quantitative knowledge about the overall data base is lacking. The DAP investigations will provide for the first time a primary reference base with a regional perspective of the prehistoric cultural resources in these two archaeological districts.

The DAP has chosen to formulate program-specific temporal, spatial, and site-type units which are designed to reflect the local variability in Dolores prehistoric cultural resources. This is in accordance with the stance taken by the DAP staff and others (refer to Cordell and Plog [1979]) regarding normative constructs, such as the Pecos Classification, that have been used previously in the American Southwest. The DAP is in firm agreement with the following statement from Cordell and Plog (1979:407):

> The types of normative statements to which we object are those that seek to identify some typical or average pattern that is said to characterize the northern Southwest or to draw broad spatial or temporal contrasts. If such characterizations of any point in time are incorrect, descriptions or explanations of processes based on them will be equally incorrect. Such statements almost invariably ignore some of the available evidence by assuming it to be atypical and ignore the possibility that what characterized economic, cultural, and organization patterns in the area was in fact the articulation of diversity.

With the above orientation, the prehistoric archaeology of the Dolores Project has been presented. Within this presentation some of the diversity in the Dolores data is illustrated.

A cultural reconstruction of Dolores historic resources is presented in the Historic Studies section. The section is not a true reflection of DAP progress and knowledge in this area. The unexpected termination (18 May 1981) of the DAP Historic Studies program precluded comprehensive treatment of Dolores historic resources. However, the discussion is useful for overview purposes.

Progress to date with respect to prehistoric resources and the DAP Research Design is documented in chapters 2, 3, 5, and appendixes A through F. As stated in chapter 3, substantial progress has been made in gathering base-level data to answer the initial questions in each of the five problem domains. Progress has also been made in the problem domains beyond these base-level questions. However, substantial work remains to be done. Additional skeletal material is required to assess more fully the meaning of characteristics (such as age, sex, and health) of Dolores populations in order to address Problem Domain 2. Social Organization (Problem Domain 3) is a complex topic in relation to archaeological data. A more adequate excavation sample is needed to verify current DAP social units and to assess the social significance of residence units. Other data inadequacies are also summarized in chapter 3. Immediate work necessary in Problem Domain 5 is related to Question 3; the model thus specified will direct future work in Problem Domains 1 through 4. This modeling effort is discussed in chapters 2 and 3 and a pilot approximation is included as appendix F.

The DAP is currently in a unique position to begin to contribute to cultural resources management archaeology and to the larger archaeological community. The present preliminary data base is broadly focused and is approaching statistical adequacy in many areas. Most of the present DAP data base is computerized, and inputting, verification, and outputting procedures have been streamlined. With basic descriptive work nearing completion, the DAP is now in a position to turn the corner to synthetic studies.

The DAP will, as it has in the past, pursue explanations of Dolores patterns and processes and will adopt the approach recommended by Plog (1974:15).

> Explanation in substantive terms means decomposing and accounting for variability in some phenomenon under investigation. Anthropologists deal with variations in behavior and cultural processes at different spatial loci at a single point in time, variations in culture and behavior at different points in time at a single spatial locus, and variations in culture and behavior at different points (usually parallel) at multiple spatial loci. In dealing with spatial phenomena, it is argued that the phenomenon under study has some patterned spatial distribution. In dealing with temporal phenomena, the variable forms a trace, or trajectory, over time. Explaining variability means developing the ability to predict or retrodict the spatial patterns or the shape of the trace, whichever is relevant.

We believe that the preliminary data base is adequate for most statistical purposes, but is deficient in some categories

needed to reconstruct the complete range of Dolores spatial, temporal, and functional variability. The DAP modeling effort is directed toward:

> goals that limit the number of variables studied in a given piece of research; that require explication and explanation; that strengthen the ties between archaeology and other social sciences, rather than weaken them, and that emphasize the unique aspects of archaeological data rather than those aspects shared with all social data (Plog 1974:5).

To this end, the DAP plans to complete the modeling procedure during the summer of 1981 and, based on that procedure, to generate fieldwork and master plans for the remainder of the project.

APPENDIXES

Appendix A

PALEODEMOGRAPHY AND SETTLEMENT PATTERNS

by Janet D. Orcutt

INTRODUCTION

A total of 60 habitation and 38 limited activity and seasonal sites were extracted from the DAP (Dolores Archaeological Program) temporal-functional matrix for use in a study of paleodemography and settlement patterns. These sites are located in the pool, borrow areas, and Great Cut Dike; therefore, this is a limited study applicable primarily to the Dolores River valley (an area of 20.79 km^2 or 8.32 mi^2). Extrapolations to areas beyond the river valley are not feasible because of the "local" nature of these data; i.e., conclusions resulting from this analysis are restricted to the river valley.

The habitation sites were chosen from a larger group of sites and were employed because they fulfilled certain requirements for inclusion in this analysis. The major requirement was that the sites had to have some measurement of habitation area available (rubble mound, rubble scatter, pitstructure area), either measured in the field or estimated from the site sketch maps. The criteria for a measure of habitation area probably produced a biased sample because pitstructures, indicative of habitation in earlier sites, are not identified as easily from surface remains as aboveground masonry rooms. In addition, only sites assigned to a DAP temporal phase (Sagehen, McPhee, Sundial) were included in the analysis.

Finally, the 38 limited activity and seasonal sites were examined in terms of the amount of site area per phase and by elevation within phases. The limited activity and seasonal sites are analyzed as a group because of the small sample size.

METHODS

Measuring prehistoric population size is a difficult task. A number of measures can be used including, in descending order of preference, floor area, number of rooms, rubble area and/or pithouse area, and total area of site surface scatter (site size). Site size is the least desirable variable because it is a function of too many other variables in addition to population size (Orcutt 1974). Attempts to control for the effects of other variables on the amount of surface artifacts generally have been disappointing (Kohler and Schlanger 1980). In the Dolores area, room counts and floor area data from roomblock and/or room measurements are rare. Therefore, the population estimator used in this analysis is rubble area and/or pithouse area. A similar approach was used by Plog (1974); however, he carried it a step further by developing a regression equation to predict floor area. Here, only the rubble and pitstructure measurements can be used; therefore, the result must be considered tentative but useful in describing general trends.

Dickson's (1975, 1979:25) site weight index was employed to compensate for the differing lengths of the phases. The procedures for calculating site weight were as follows: first, a gross site weight was calculated for each site for each phase of occupation using the following equation:

$$\frac{\text{Total rubble and/or pithouse area} + 1}{\text{Total number of phases occupied}}$$

Second, the gross site weight in each phase was adjusted according to the length of the phase. This adjustment was accomplished by determinimg the length of the shortest phase (common denominator) and then dividing the common denominator into the length of all the phases. The quotients of these divisions were divided into the site weight for each site to obtain corrected site weights. The corrected site weights were summed to produce a total site weight for each phase.

The site weights were converted to numbers of people using a conversion factor of 6 m^2 per person (Casselberry 1974). Population was calculated for each phase and by 100-ft elevation categories within the phases.

Finally, the distribution of limited activity sites was examined in the settlement pattern analysis. The site weight index was applied to these sites to obtain corrected site area figures.

RESULTS

Population Size

The population trajectory (fig. 108) shows that population in the river valley was largest during the McPhee Phase. The McPhee Phase population was 42 percent higher than the Sagehen Phase population. Population was the lowest during the Sundial Phase and probably represents a major demographic change — the population was 87 percent lower than it was during the McPhee Phase.

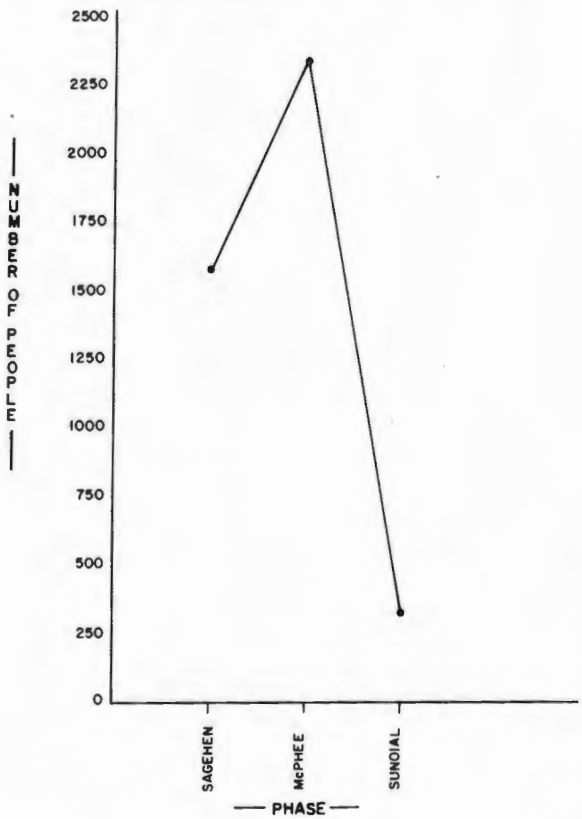


Figure 108. Population by phase.

Settlement Pattern — Habitation Sites

Figure 109 shows the distribution of population in several elevation categories. The elevations used are (in feet): 6650 to 6749, 6750 to 6849, 6850 to 6949, 6950 to 7049, 7050 to 7149, and 7150 to 7249.

During the Saghen Phase, all the elevation zones were occupied; however, only 0.3 percent of the population was in the lowest zone. The 6850- to 6949-ft zone had the highest population (56 percent of the Sagehen population).

The McPhee Phase population had a more restricted distribution, with the 6950- to 7049-ft zones exhibiting no

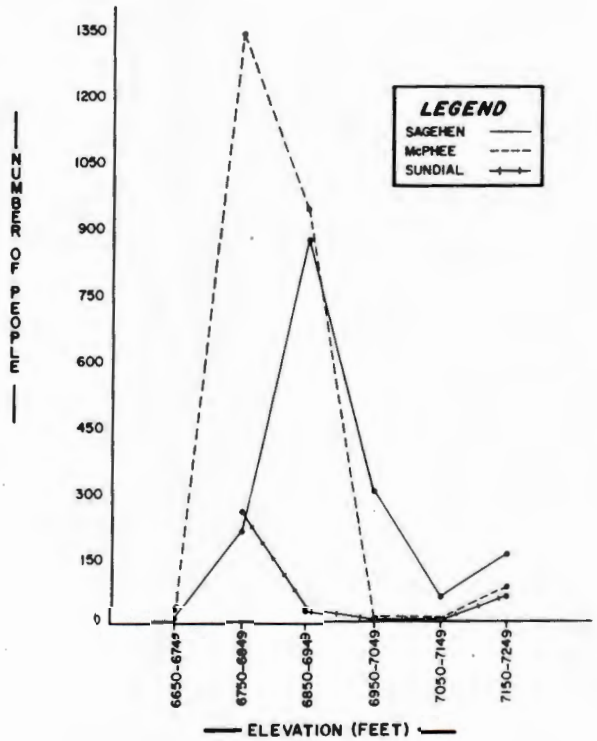


Figure 109. Population by phase and elevation.

evidence of occupation. The heaviest occupation occurred in the 6750- to 6849-ft (57 percent) and the 6850- to 6949-ft (40 percent) zones. As illustrated by the graphs and percentages, the population in the 6750- to 6849-ft zone increased from 13 percent during the Sagehen Phase to 57 percent during the McPhee Phase. In the 6850- to 6949-ft zone, population decreased from 56 percent during the Sagehen Phase to 40 percent during the McPhee Phase. An examination of table 42, however, shows that the number of people in both zones increased during the McPhee Phase. That is, both the 6750- to 6849- and 6850- to 6949-ft zones were supporting more people during the McPhee Phase than during the Sagehen Phase.

Table 42. Population by zone

Elevation zone (ft)	Sagehen	McPhee	Sundial
6650-6749	5	19	
6750-6849	206	1343	250
6850-6949	874	943	19
6950-7049	312		
7050-7149	46		
7150-7249	110	49	41
Total phase population	1553	2354	310

The small Sundial Phase population was concentrated in the 6750- to 6849-ft zone (81 percent of the Sundial population). Only two other zones were occupied during this phase: 6850 to 6949 ft (6 percent of the population) and 7150 to 7249 ft (13 percent of the population).

Perhaps more important in terms of understanding changes in settlement location is population density. Population density is often viewed as an independent variable capable of causing changes in other variables, especially in resource availability, local group size, and competition. Changes in population density also have an indirect effect on many other variables. If population density was increasing in the river valley, we might expect to see increased aggregation and intensification of agriculture, among other things. The presence of these possible changes must be investigated in the future and their occurrence tied into regional events.

The density analysis indicates that population density was highest during the McPhee Phase (table 43). The McPhee Phase population density was 51 percent higher than the Sagehen density. The Sundial density was the lowest of all phases and represents an 87-percent decrease from the McPhee Phase.

Table 43. Population density (km²)

Elevation zone (ft)	Sagehen	McPhee	Sundial
6650-6749	2	8	
6750-6849	29	188	35
6850-6949	90	97	2
6950-7049	446		
7050-7149	67		
7150-7249	733	327	273
Total phase density	75	113	15

The population density by elevation indicates that the 7150- to 7249-ft zone was the most densely populated in all phases; however, the density declined steadily through time. The population density increased in the 6750- to 6849- and 6850- to 6949-ft zones during the McPhee Phase, thus confirming the trend toward occupation of the lower elevations. The density figures, however, indicate that the higher elevations did not lose as much of the population, in relative terms, as the population count suggests. The relationship between these population trends and population dynamics in the remainder of the region are critical to understanding why these changes occurred in the river valley.

There appears to be a locational trend toward lower elevations and fewer zones, although the density data are slightly ambiguous on the former point. This kind of distribution could indicate an increasing specialization in the subsistence economy, and thus the need for more restricted site locations. In order to test whether there was a significant change in the number of elevational zones occupied, a diversity analysis was performed.

The Shannon-Wiener Diversity Index (H) was calculated for each phase in order to quantify the changes in elevational occupation (Wilson and Bossert 1971). A larger H indicates more diversity in zones occupied. The indices for the phases are as follows: Sagehen = 1.2, McPhee = 0.81, and Sundial = 0.61. A t-test adapted by Hutcheson (1970) can be used to test whether there were significant differences in the diversity of elevational zones occupied.

The t-test shows no difference at the .05 level of significance between the Sagehen and McPhee Phases (t = 1.86, df[1] = 2176); however, this is significant at the .10 level. There is no significant difference at the .05 level between the McPhee and Sundial diversity indices (t = -1.04, df = 468). Finally, there is a significant difference at the .05 level between the Sagehen and Sundial indices (t = 2.31, df = 1146). In conclusion, it appears that there were significant changes in elevational diversity of habitation site locations between the Sagehen and Sundial Phases. The change was not as dramatic between the Sagehen and McPhee Phases; however, at the .10 level of significance this can be interpreted as indicating a trend toward less diversity in the elevation of habitation sites.

Finally, it is useful to examine average habitation site size to determine whether population aggregates increased in size as a response to growing population. During the Sagehen Phase, the average site weight was 266 m², which converts to 44 people. The average McPhee Phase site weight increased 66 percent to 441 m² (74 people). The Sundial average was smaller than that for McPhee but larger than Sagehen — 372 m² (62 people). Kane (1981b) describes Sagehen Phase sites as being occupied by one to three households, which would yield an average population per site much smaller than the 41 calculated here. The discrepancy could be the result of multioccupancy of Sagehen sites, with the Sagehen occupation actually being the smaller one. The averages for the McPhee and Sundial Phases are more in line with Kane's (1981b) figures.

The significance of these apparent changes in aggregation can be assessed statistically. Because the distribution of site weights does not approximate a normal distribution, the nonparametric Mann-Whitney U-test (Siegel 1956:116-127) was chosen to test whether there was a significant difference between Sagehen and McPhee site sizes, and McPhee and Sundial site sizes.

The U-test is a one-tailed test implying directionality in the alternative hypothesis (H_1). The null hypothesis (H_0) is that site sizes have the same distribution in all the phases. The

[1]degrees of freedom

alternative hypotheses are that (1) McPhee Phase site sizes were larger than Sagehen Phase site sizes, and that (2) McPhee Phase site sizes were larger than Sundial Phase site sizes. With a sample size of $n = 20$, the normal approximation to the sampling distribution of U is used (Z).

First, the null hypothesis that McPhee sites were no larger than Sagehen sites was tested. With alpha = .05, the null hypothesis was rejected with $Z = -1.96$ ($p < .0250$). The McPhee Phase site size appears to be significantly larger.

Second, the null hypothesis that McPhee sites were no larger than Sundial sites could not be rejected with alpha = .05 ($Z = .13$, $p < .4483$).

Settlement Pattern—Limited Activity Sites

The amount of site area (corrected for length of phase) in limited activity sites was very high during the Sundial Phase (fig. 110). The McPhee Phase has the least amount of limited activity site area, but there was only 4 percent more limited activity site area in the Sagehen Phase than during the McPhee Phase. The amount of area in Sundial limited activity sites was 91 percent higher than during the McPhee Phase and 84 percent higher than during the Sagehen Phase.

The elevational distribution of limited activity sites was similar during both the Sagehen and McPhee Phases. The shape of the Sundial curve follows the same trajectory as the Sagehen and McPhee Phases; however, the magnitude of the curve is very different (fig. 111).

During all phases the largest amount of limited activity area was in the 6850- to 6949-ft zone. In this zone the amount of area was 39 percent higher in the McPhee Phase than during the Sagehen Phase. The Sundial data show a 107-percent increase in site area over the McPhee Phase in the 6850- to 6949-ft zone.

The density of limited activity site area in the elevational zones can be used to describe changes in the importance of the elevational zones as resource procurement areas (table 44). These data provide a different picture of limited activity locational patterns from the site area data discussed above. The most important change probably was the steady increase in density in the 6850- to 6949-ft zone through time — the Sundial density was 188 percent higher than the Sagehen density. The most densely utilized zone during the Sagehen Phase was 7050 to 7149 ft, which contradicts the site area data. The limited activity area density was highest in the 6850- to 6949-ft zone during both the McPhee and Sundial Phases, confirming the site area data.

A diversity analysis was performed on the limited activity sites to determine whether there were changes in the diversity of elevational zones occupied. The diversity indices for

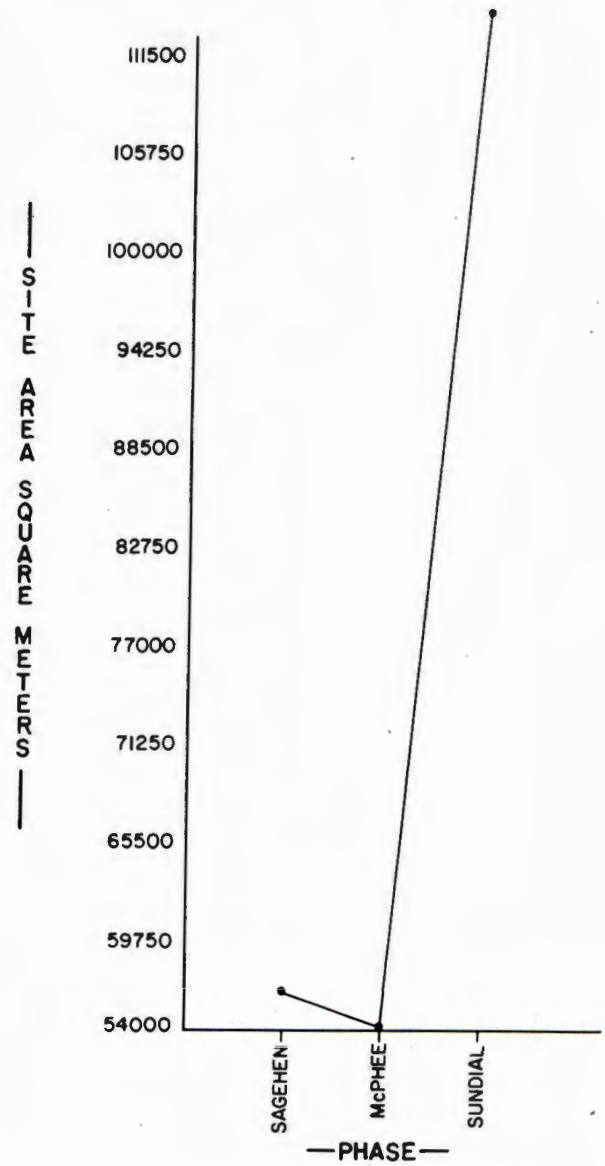


Figure 110. Total limited activity site area.

Table 44. Limited activity site area density (m^2)

Elevation zone (ft)	Sagehen	McPhee	Sundial
6650-6749			98
6750-6849	459	691	
6850-6949	3 745	5215	10 797
6950-7049	8 684		183
7050-7149	17 778	1958	1 632
7150-7249			
Total phase density	2 798	2686	5 140

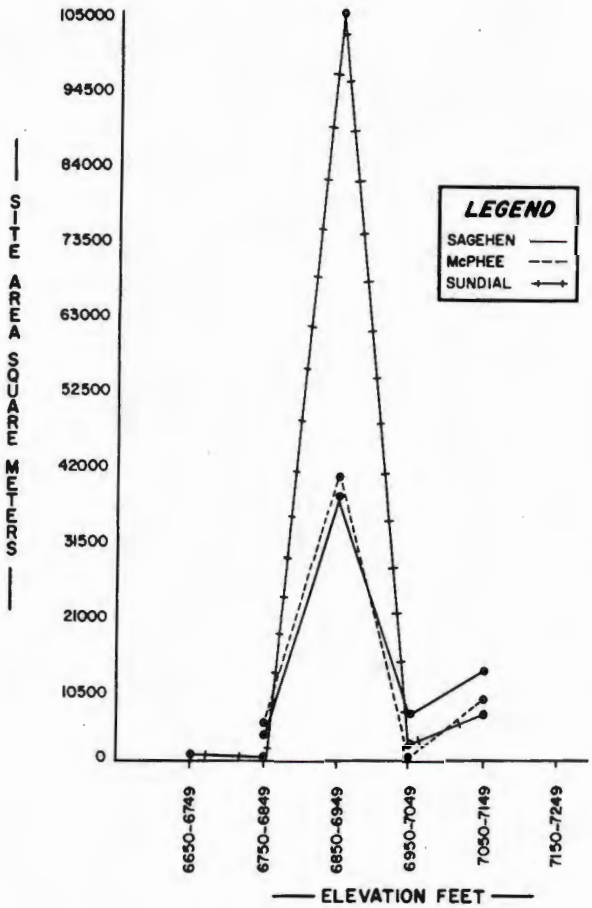


Figure 111. Limited activity site area by phase and elevation.

the phases are the following: Sagehen = 1.02, McPhee = 0.39, and Sundial = 0.08. The *t*-test, with all degrees of freedom large, shows significant differences at the .05 level for Sagehen and McPhee (t = 2.86), Sagehen and Sundial (t = 28.5), and McPhee and Sundial (t = 8.9). On the basis of these changes in elevational diversity, it can be proposed that there were changes in resource procurement and/or land use patterns. The trend from more to less diversity suggests a restriction in resource use, possibly indicating some kind of specialization. Such propositions, of course, need to be stated formally in the future and test implications should be devised to verify the propositions. In addition, alternative hypotheses or propositions should be devised for future testing.

The limited activity site area data indicate a major change in utilization of the river valley during the Sundial Phase. This is illustrated by figures 110 and 111 and by ratios of limited activity area to habitation area. During the Sagehen Phase, there were 6 m^2 of limited activity site area per 1 m^2 of habitation area. During the McPhee Phase, the ratio dropped to 4:1. The ratio during the Sundial Phase jumped to 59:1. Thus, it appears that the river valley was emphasized more as a seasonal use area during the Sundial Phase than in the previous phases and was not a favorable habitation area.

One must assume that this shift in the relationship between limited activity site area and habitation area reflects a change in resource use and, further, one must ask why this change occurred. Possible propositions which might explain a change in resource use are changes in climate, organization, or technology. One of the next steps in DAP locational studies should be to expand the analysis to a regional scale, a move which would allow the definition of both regional and local changes in resource use. From the river valley, data questions and hypotheses can be formulated regarding the regional pattern, but it is not possible to test the hypotheses without the regional data.

Paleodemography and Settlement Patterns—Comparison of Dolores and Mesa Verde

Some comparisons of Dolores and Mesa Verde demography and settlement patterns can be made on a gross level. These comparisons are of necessity general because the Mesa Verde data are not available in the same form as the Dolores data, the latter allowing much more detailed analyses.

Demographic patterns were different at Mesa Verde. While it is not possible to compare population density or absolute numbers of people, Hayes' (1964) cultural reconstruction for Wetherill Mesa allows a comparison of population curves. The Mesa Verde sequence indicates an occupation at least 100 years longer than the Dolores occupation. In addition, there was no hiatus in occupation at Mesa Verde as there was in the Dolores area. The peak population on Wetherill Mesa was probably achieved in the Piedra Phase (A.D. 700-900) or possibly the Ackmen Phase (A.D. 900-975).[2] The Dolores peak (McPhee Phase) probably occurred slightly earlier than the Mesa Verde maximum.

The nature of the Mesa Verde data does not allow an elevational diversity analysis comparable to that reported here for the Dolores data. Hayes' (1964:110) data on the percent of sites by phase and landform were used to approximate the Dolores elevational analysis. The Shannon-Wiener diversity index was calculated for the Wetherill Mesa data in an attempt to compare settlement patterns. In using this approach on the Mesa Verde data, it is assumed that the landform categories (mesa, talus and canyon, and cliffs) roughly reflect different elevation zones. The greatest locational diversity occurs during the McElmo Phase (H = 0.48), the same phase as the population minimum and the beginning of population aggregation. This is in contrast to

[2]Jack E. Smith, National Park Service, personal communication.

the Dolores River valley, where the greatest locational diversity (Sagehen Phase) occurred almost 200 years earlier than at Mesa Verde. In Dolores, this period of diversity occurred during a phase in which hunting and gathering presumably were of greater importance than in later phases. The Mesa Verde data, however, indicate that the greatest diversity occurred when agriculture probably was becoming more important and hunting and gathering were declining in importance. These data, therefore, indicate a major contrast in the developmental sequence between the two areas.

We must be cautious in assuming that the Dolores area was the same as Mesa Verde merely because of proximity. This brief comparison indicates some major differences between the two areas which cannot be ignored. In fact, one must wonder why an area with a permanent water source like the Dolores River valley was not occupied longer than Mesa Verde, where the only permanent water supply within the Mesa Verde boundaries was springs and seeps (Erdman et al. 1969). What environmental and cultural constraints were operating in the Dolores area that resulted in an earlier abandonment than Mesa Verde? Questions such as this and many others, must be answered in the future using a more regional approach to prehistoric adaptation and change than has been presented in this report.

SUMMARY AND CONCLUSIONS

Rubble and/or pithouse area were used in conjunction with a site weight index (Dickson 1975, 1979) to estimate prehistoric population size for the pool, borrow areas, and Great Cut Dike. The site weight index also was applied to limited activity and seasonal sites to apportion site area to the phases.

Population was highest, in both numbers and density, in the McPhee Phase and lowest during the Sundial Phase. The population was concentrated in the 6850- to 6949-ft elevation zone during the Sagehen Phase and the 6750- to 6849-ft zone during the McPhee and Sundial Phases. The distribution of population among the elevation zones showed a decrease in diversity over time.

The average site size (site weight) was significantly larger during McPhee than Sagehen, suggesting that population aggregation occurred.

The amount of area in limited activity sites was highest during the Sundial Phase and very low during both the Sagehen and McPhee Phases. During all three phases, the largest amount of limited activity area was in the 6850- to 6949-ft zone. There was a strong trend through time for fewer elevation zones to have limited activity sites.

Population aggregation appears to coincide with population growth and shift in location. The McPhee Phase was the time of both the highest population and the most aggregation. There was a locational shift to lower elevations during the McPhee Phase and a restriction in distribution to fewer elevation zones.

The locational shifts during the McPhee Phase suggest a change in resource use. The limited activity site area data also suggest these changes for the McPhee Phase — the total amount of limited activity site area was the lowest during this phase. It is proposed that the shift in habitation locations, aggregation, and decrease in limited activity site area reflect an increased dependence on agriculture during the McPhee Phase.

This analysis has raised more questions than it has answered. There is concern with the fact that this analysis is limited spatially. Because of this restricted coverage, caution must be exercised in drawing conclusions regarding population and settlement pattern in the entire project area. At best, questions and hypotheses regarding a larger area can be formulated for future testing. Eventually, this analysis must be extended beyond the confines of this study to gain a regional perspective on population and settlement dynamics.

Appendix B

BIOTIC REMAINS

by Bruce F. Benz

BOTANICAL ARCHAEOLOGICAL REMAINS

INTRODUCTION

Recovery, processing, and analysis of biotic remains from archaeological contexts provide a backdrop for understanding the economy and adaptation of the prehistoric occupants in the DAP area. It seems evident that the interaction between culture and environment is reciprocal; that is, as man affects the environment, the environment affects man. An understanding of ecosystem dynamics is a necessity for elucidating the processes of human intervention affecting ecosystem development. As such, Odum's (1969) description of the various components of an ecosystem directs the DAP investigation of data recovered from prehistoric contexts. Cultural systems act to maintain themselves by obtaining required materials and energy in the form of productivity; these materials, when present in archaeological contexts, can be used as a basis for understanding the reciprocal interaction of man and environment. Further, ecosystem productivity can be increased through human modification of ecosystem components (e.g., agriculture) and through altering the importance of certain types of productivity. Such modifications are evident in the remains associated with subsistence routines of various occupation periods in the DAP area.

The objective of collecting botanical remains is to address directly the questions in Problem Domain 1 of the DAP Research Design. Specifically, what natural plant resources might have been available to the prehistoric occupants, and which of these resources were exploited? To address these questions, a variety of collection modes have been implemented to collect plant materials that are unambiguously associated with cultural deposits. Assumptions and subsequent inferences enable one to describe which plant resources were used, where and how they were processed, and later, how these plants contributed to the prehistoric subsistence routine. In addition, it can be determined which components of the prehistoric plant communities were not exploited. From this it should be possible to elaborate on the seasonality and scheduling of the prehistoric occupants' subsistence regime.

METHODS AND MATERIALS

Biotic remains are recovered from DAP archaeological sites in various forms and by various methods. Three collection modes are employed to recover botanical materials of two types. Macroremains include wood fragments, seeds and fruits of various domesticated and nondomesticated plants, and composite artifacts (e.g., basketry or matting). Small seeds and other plant residue recovered through water separation are included in this class. Microremains include pollen and biogenic opal (phytoliths or plant silica), although only pollen has been collected and analyzed to date.

Samples for pollen are collected using nearly sterile techniques. These samples are processed using an accepted technique commonly employed in the Southwest (Scott 1980; Woosely 1978). The sample is mounted and the first 200 grains are counted and identified using comparative material.

Macroremains collected during excavation are submitted for analysis without further processing. Analysis of this material type (i.e., vegetal material) is contingent upon the condition of the material. Identification is accomplished with the aid of comparative specimens collected in the project area.

Bulk soil samples are collected from excavated features and cultural surfaces for the recovery of plant parts which may not be visible in the field. These samples are processed by water separation. The inherent bouyancy from air trapped within the cellular structure of organic materials allows these materials to be removed from the soil/sediment and cultural debris matrix. The organic materials (vegetal macroremains) which float (Struever 1968b) are poured off, dried, and presented for analysis. Identification and subsequent analysis of seeds and other plant parts is accomplished with the aid of a comparative collection of plants gathered in the project area.

A sampling strategy designed for bulk soil and pollen samples has been implemented by DAP personnel (Litzinger

1979). The rationale for this strategy is that by restricting sampling to those contexts which are replicated in time and space and are predictable, time and money expenditures related to the processing and analysis of the samples will be reduced. Further, contextual ambiguity will be reduced by specifying which sort of sampling contexts are interpretable and which are not. Samples are taken to confidently separate those plant residues which are direct or indirect evidence of cultural behavior from those which are noncultural (i.e., intrusive).

The sampling design implemented by the DAP is being evaluated through examination of some 350+ bulk soil and 125+ pollen samples recovered from Pitstructure 1 at Site 5MT4644. This intensive sampling was initiated during the 1979 field season when it was realized that this pitstructure offered an excellent preservational environment, having been abandoned because of catastrophic burning. The complexity of the sampling design resulted in the recovery of a range of botanical materials that are quite anomalous in contrast to other sites where botanical investigations have not been so intense. As a result, Site 5MT4644 will be cited as the sole representative for evidence of numerous botanical remains.

RESULTS

The botanical data presented here are preliminary. Identification of certain plant parts can be very tenuous (Ford 1979:302, 303). Other problems of analysis which are commonly encountered pertain to the condition of the botanical evidence. Determining whether a seed was carbonized pyrogenically or biologically is difficult. Often the seed or other plant fragment must be broken in order to confidently determine if a seed is indeed pyrogenically carbonized. Much discussion in the American archaeo-ethnobotanical literature has revolved around the problem of specimen condition and cultural association (Adams 1980b; Bohrer 1980; Ford 1979; Minnis 1981). The general consensus of those concerned is that beyond a reasonable doubt, pyrogenically carbonized (charred) plant remains are the result of human activity when recovered from an undisputed cultural context. A greater problem is which of the noncharred plant parts can be attributed to cultural activity and which are a result of animal activities or natural seed dispersal.

For the discussion here, only charred plant parts are presented. One exception to this is the remains of domesticated plants (e.g., maize, beans, squash). Since the coat of squash seeds and the pistillate inflorescence of maize are extremely resistant to decay, their presence, even noncharred, in a prehistoric cultural context may be assumed to result from prehistoric human activities; therefore, their presentation here seems warranted.

Interpretation of pollen evidence suffers from similar problems. When pollen is recovered from the floor of a pithouse, what lines of evidence support the interpretation that the occupants actually used the plant in question? Supportive evidence can be derived from macroremains. The macroremains might also provide a more sound basis for understanding the season of use, the plant part used, and the range of uses for the plant represented by pollen. The presence of certain anemophilous pollen types can also be disconcerting. Morman tea (*Ephedra viridis, E. nevadensis* type or *E. torreyana* type) is commonly represented in the DAP pollen record. Presently, no macrobotanical evidence has been recovered to support the inference that *Ephedra* sp. was actually used by the prehistoric occupants. In addition, species of *Ephedra* are known to produce anemophilous pollen which can be carried great distances (Adams 1980b:38). Although currently the plant has not been located in the project area, it would be illogical to exclude it entirely as an ambient pollen type, particularly since its stems make a healthful tea. With these sorts of vagaries in mind, the botanical evidence will be presented in the following groups: (1) domesticated plants, (2) ruderal plants, and (3) wild and/or naturally occurring species.

Domesticates

Evidence for domesticated plants is obtained by all three collection modes (i.e., vegetal material, bulk soil samples, and pollen samples). Cultivated plant remains are found in both charred and noncharred conditions. Only LeMoc Shelter, however, has provided remains of all three cultigens (squash, maize, and beans) in a noncharred condition.

Cucurbits (seeds, pericarp fragments, and peduncles) are present in deposits representing the two earliest phases of Anasazi occupation (i.e., Sagehen and McPhee). Remains of squash are never very common in comparison to other cultivated plant remains. Although no intensive analysis of all cucurbit materials has been undertaken, at least one species of squash, *C. pepo,* is definitely present in DAP sites. At this time no definite evidence for *Lagenaria siceraria* exists in the Escalante Sector. However, it is suspected that further analysis will substantiate its presence, since *Lagenaria siceraria* has been recovered from many sites of Anasazi age in the San Juan Area (Bye 1978; Cutler 1966). Pollen evidence for cucurbits is present at only one site, Site 5MT4644. However, cucurbits are insect-pollinated and the likelihood of picking up pollen evidence of these plants in the archaeological record is low.

Maize is represented by macroremains and microremains for every cultural phase of Dolores area Anasazi occupation. The preponderance of this cultigen supports the inference that corn was a major staple. Though the pistillate inflorescence (cob) of maize is extremely resistant to decay, its frequent archaeological occurrence in nearly every possible cultural context (e.g., on surfaces, in firepits, in midden deposits, in roof fall) and in all site types (large and

small habitations, seasonal and limited activity sites) substantiates its role as a major staple. Remains of the maize plant occur as cob fragments, partial ears, pollen, and vegetative plant parts (stalks). No specific program studies have addressed the racial nature of this cultigen (Cutler and Meyer 1965; Cutler 1966), or the nature of its cultivation (i.e., phenotypic variation [Ford 1979]), although certain elaborations are possible. The introduction of "Maiz de Ocho" (eight-rowed corn) into the southwestern United States has a long history of inquiry. When and where this probable flour corn entered the Southwest and where it spread from there has been questioned by numerous authors (Carter and Anderson 1945; Galinat and Gunnerson 1963; Galinat and Campbell 1967; Galinat et al. 1970). This race of maize is postulated as a primary source of greater corn productivity through hybridization with the early indigenous race, Chapalote. The result of this mixture, the race Pima-Papago, was purportedly a greater producer and more adaptable to the variable growing conditions of the northern Southwest (Cutler 1966; Galinat and Campbell 1967). Consequently, documenting the racial stock cultivated during the Anasazi occupation of the Dolores area is a necessity. Sufficient material exists for documenting the presence of eight-rowed maize during the earliest Anasazi occupations in the DAP area (e.g., Site 5MT4545). Much more elaborate studies are necessary to document the occurrence and ecological adaptability of this eight-rowed corn and its succeeding hybrid. It should be possible to document ecotypic variation of maize and to elaborate on the farming practices (e.g., field location) with more intensive analyses. Pollen evidence for corn cultivation is present in 60 percent of analyzed DAP site collections. The varying amounts of maize pollen are difficult to interpret. Maize produces pollen that is wind disseminated. Consequently, it is not possible to determine whether the occurrence of pollen indicates cultivation at or near the site or whether the frequency of pollen on occupational surfaces is due to processing activities (Scott 1980; Adams 1980b).

Cultivated beans (*Phaseolus* sp.) are represented only as seeds and seed fragments. These remains occur in every phase of Anasazi occupation except the most recent Sundial Phase. Whether the lack of *Phaseolus* sp. during the latest phase of occupation is due to environmental conditions, or lack of preserved evidence, is complicated by the small sample of Sundial Phase sites. No specific analysis of domestic beans has yet been undertaken. This fact, coupled with the charred nature of the recovered *Phaseolus* sp. remains, does not allow for specific identification of this cultivar. *Phaseolus vulgaris* was probably the major species cultivated, judging from the studies of related archaeological assemblages of this cultivar (Bye 1978; Cutler 1966; Kaplan 1956).

Ruderal Plant Remains

The seeds and fruits of ruderal (weedy/camp follower) plants are commonly recovered from archaeological sites in the DAP area. The presence of these plant remains may be used to make inferences about the state of the ecosystem and how it was affected by human disturbance. Because agricultural practices disrupt the natural sequence of ecosystem development, niches that might have been occupied in more natural systems are now open to colonization by weedy annual plants which readily establish themselves. Without continued disturbance these colonizers may give way to perennials which can be better competitors by hoarding certain resources through internal biogeochemical cycling. Man can capitalize on the disturbance he creates in two ways: (1) maintaining the ecosystem at an early stage of succession through continued cultivation of domesticated plants, and (2) allowing the open habitats to be colonized by ruderals and harvesting this productivity in addition to the primary resource (i.e., domesticated plants) (see Bye 1981b; Ford 1977; Odum 1969; Papendick et al. 1976). It should be possible to describe the intensity of reciprocal plant/man interaction by following the developmental processes of an ecosystem through examination of the frequency of ruderal plant remains through time.

Plants which might be categorized as ruderal are commonly recovered in bulk soil samples. In the DAP area, the plant families Amaranthaceae, Chenopodiaceae, Cruciferae, Solanaceae, and Portulacaceae contain genera which might be characterized as ruderal because of their colonizing nature. Remains representing these families are common in the DAP archaeological record. However, because of analysis priorities the occurrence of these remains is not yet documented for many sites, time periods, or geographic locations in the Dolores area.

Amaranthaceae. Seeds of pigweed (*Amaranthus* sp.) have been recovered in bulk soil samples representing the Sagehen and McPhee Phases of occupation. These seeds are commonly associated with living areas and refuse deposits and may indicate a consumable resource. Plants of this family are characterized by shifting phenology, which implies that they were available in various stages of maturation throughout the growing season. This suggests that various plant parts (greens and/or seeds) were available for exploitation throughout the growing season. Ethnographic and archaeological analogy support the inference that these plants were exploited (Adams 1980b; Castetter and Bell 1942; Minnis and Ford 1977; Stevenson 1915; Swank 1932). The high frequency of pigweed seeds from Site 5MT4644 seems to substantiate the use of this plant. Until analysis is completed, however, cultural (inferred) use cannot be totally accepted. The seeds may have been carried into the pitstructure on the occupants' clothing and their charred nature may be a result of catastrophic burning.

Chenopodiaceae. This family is represented by goosefoot (*Chenopodium* sp.) fruits in the two major phases of the

Anasazi Tradition (i.e., Sagehen and McPhee). Again, bulk soil samples from only a select group of sites have undergone analysis. Therefore, those from many of the later, larger habitations have not yet passed through preliminary analysis. Consequently, the apparent underrepresentation of *Chenopodium* sp. in the later phases may be skewed. Annual plants of this family are characterized by shifting seasonality, much like the Amaranth family. In the same fashion as the amaranths, various plant parts (e.g., greens, fruits) may have been available for consumption during the frost-free season. In support of this inference, various ethnographic and archaeological analogs can be cited (Adams 1980b; Bohrer 1980; Dobyns 1974; Stevenson 1915; Whiting 1939).

The pollen of these two families is virtually indistinguishable; consequently, the category "Cheno-Am" is used in table 45. The ubiquitous occurrence of pollen in this category may reflect the continued cultural disturbance and colonization of agricultural lands or the immediate site environment by plants of this group. Since the pollen of these families is wind disseminated, it may be deposited upon prehistoric occupation surfaces from anthropogenic communities; i.e., agricultural fields, site microenvironment, or both. If occupational intensity can be associated with continued environmental perturbation and more extensive anthropogenic plant communities, the Cheno-Am pollen should be expected to reflect this trend. Considering this association, exploitation of ruderal plants (*Chenopodium* sp. and *Amaranthus* sp.) might increase because they would be more readily available. However, it must be assumed that these plants were perceived as exploitable by the Puebloan peoples, as seems to be indicated by the analysis of coprolites on Mesa Verde (Stiger 1977). This proposition must await further analysis to complement the existing data.

Cruciferae. The mustard family contains numerous genera that are characterized by their weedy nature (Bye 1978). *Descurania* and *Lepidium* are two genera which are common today in human-disturbed habitats. Their occurrence (seeds and pollen) in Sagehen and McPhee Phase deposits may suggest that they were exploited prehistorically. Unfortunately, evidence is lacking for many sites for the same reason explained with reference to the pigweed and goosefoot families (i.e., ambiguous association). Ethnographic and archaeological documentation of the role of these genera can be found in the aforementioned references.

Solanaceae. The nightshade family comprises a number of New World domesticates and weedy camp followers. Tobacco (*Nicotiana* sp.), ground cherry (*Physalis* sp.), and wolfberry (*Lycium palladium*) are species which commonly occur in southwestern Colorado today. Macro- and microremains of these plants have been recovered from archaeological deposits in the Dolores area. Although these three species may not be true colonizers, botanical reconnaissance in the DAP area has recorded tobacco and ground cherry in old-field situations. Wolfberry is commonly associated with prehistoric ruins (Yarnell 1965 and Litzinger[1]). Both ground cherry and wolfberry have occurred infrequently in bulk soil samples analyzed thus far. Additional work is necessary to fully understand the occurrence of these genera. Tobacco (*Nicotiana* sp.) is represented more frequently than the other genera of this family. Unfortunately, it has not yet been determined whether this is the domesticated species (*N. rustica*) or the present-day colonizing species (*N. trigonophylla* or *N. attenuata*). Based upon recovery of charred and noncharred remains of tobacco, it is speculated that the specimens recorded in table 46 are seeds of one of the colonizing species which had been gathered from surrounding anthropogenic communities. Distributional analysis of these remains on the floor of a pitstructure at Site 5MT4644 should confirm or refute this speculation.

Portulacaceae. Purslane (*Portulaca* sp.) seeds have been recovered from five sites representing two phases of the Anasazi Tradition (Sagehen and McPhee). Like *Amaranthus* sp. and *Chenopodium* sp., purslane commonly flowers and fruits throughout the growing season, although greens are more readily available in midsummer, and seeds, in the fall. Adams (1980b:53) refers to purslane seeds as being both an edible resource and of ceremonial significance. Archaeological representation of the plant's vegetative remains would not be expected. Thus the seeds provide the only evidence of postulated utilization of this plant. Ethnographic and archaeological analogy support the economic inference for this plant (Doebley 1976; Elmore 1944; Minnis and Ford 1977; Swank 1932; Whiting 1939). Evidence for the archaeological occurrence of this plant is also present in the pollen record.

Wild or Natural Resources

Plants covered in this category are classified as resources gathered and utilized for tools, shelter, and fuel. This category of resources is distinctive because the plants and the communitites in which they are found do not respond to human manipulation in the same manner as do domesticates or weeds. That is, these plants (and the resources they provide) are usually not annually renewable, nor are they productive in the same way as those plants subjected to human manipulation. When these plants and their associated communities are harvested, the community does not quickly regenerate.

Fiber and Weaving Materials. At least three plants have provided material that was used to construct mats and basketry and to aid in construction. Remains of Spanish

[1]William J. Litzinger, University of Colorado, Boulder, personal communication.

Table 45. Pollen (microremains)
(Percent of total pollen by site)

	Site number										
	4545	2858	2198	4614	4644	2194	2192	23	2320	2191	2203
Alnus	<1.0										
Opuntia			<1.0				<1.0				
Cleome	2.8	<1.0	3.0	3.6	3.8	1.4	3.2	5.0	<1.0	1.3	<1.0
Sarcobatus			<1.0		<1.0		<1.0			<1.0	<1.0
Compositae	7.8	8.5	7.8	6.5	9.9	12.4	12.6	9.7	8.6	13.3	14.3
Compositae-liguliflorae				<1.0	<1.0				<1.0	<1.0	
Achillea	4.4	12.5	3.8	10.1	7.5	10.7	5.9	26.4	6.6	5.6	4.4
Artemisia	37.6	43.0	44.8	30.1	35.1	47.8	31.1	6.6	29.9	30.8	38.4
Cruciferae					<1.0		<1.0				
Lepidium		1.0					<1.0			<1.0	
Cucurbita					<1.0		<1.0				
Juniperus	4.1	8.0	5.3	7.5	2.6	4.3	5.6	2.6	2.5	6.3	4.2
Shepherdia					<1.0						
Quercus	1.1	1.0	1.0	1.5	<1.0	<1.0	2.0	1.3	1.0	<1.0	1.1
Gramineae	1.1	1.0	1.0	2.4	1.8	1.0	<1.0	<1.0	4.0	<1.0	<1.0
Zea mays	2.4		<1.0		2.0		<1.0	<1.0		<1.0	
Liliaceae				<1.0			<1.0				
Sphaeralcea	<1.0				<1.0		<1.0		<1.0	<1.0	
Onagraceae					<1.0						
Circaea					<1.0						
Picea					<1.0		<1.0			<1.0	
Pinus	14.8	2.5	15.9	4.6	5.2	2.5	15.4	13.7	22.3	8.3	10.4
Eriogonum	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0		1.0	1.0	<1.0
Polygonum					<1.0		<1.0	<1.0			<1.0
Polygonum sawatchensis-type	<1.0			<1.0	<1.0	<1.0	<1.0			<1.0	<1.0
Portulaca						<1.0			1.2		
Ranuncul aceae				<1.0							
Rosaceae	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0		<1.0		
Salix					<1.0		<1.0				
Lycium					<1.0	<1.0					
Nicotiana					1.3						
Typha					<1.0		<1.0				
Celtis					<1.0						
Umbelliferae			<1.0	<1.0	2.8				<1.0		
Ephedra				<1.0	<1.0						
Ephedra nevadensis-type	1.0	<0.5	1.1	<1.0	1.7		1.4		1.0	<1.0	1.3
Ephedra torreyana-type			<1.0		<1.0	<1.0	<1.0			<1.0	<1.0
Cheno-am	14.8	10.0	7.5	11.0	11.3	6.2		29.9	6.6	11.4	15.6
Indeterminate	6.1	11.5	6.3	16.2	10.1	10.5	7.2	2.8	13.2	13.3	7.0

Pollen frequency is determined by summing the total pollen record of each site and dividing it into the total frequency for each pollen type. Problems occurred at Site 5MT23 and Site 5MT2151 because pollen samples from different time periods were combined, thus inflating the occurrence of certain taxa (e.g., *Artemisia*).

bayonet (*Yucca* sp.) have been recovered from archaeological contexts. The sites represented belong to the two earliest phases of Anasazi occupation, Sagehen and McPhee. *Yucca* sp. fiber is present in basketry from the earliest phase and as cordage during the second phase of occupation. It appears that there is no specific processed vegetative part that is unique to a particular use. In some instances entire leaves (cuticle, fiber, and ground tissue) are present in basketry or cordage, while in other instances only the leaf fiber is present. There is no apparent difference in the type of yucca fiber used during different temporal phases.

Leaves of what may be cattail (*Typha* sp.) have been recovered from the floor of a single pithouse (Site 5MT4644).

Table 46. Macrobotanical remains

	Archaic			Sagehen Phase													McPhee Phase														Sundial Phase	
	Limited activity			Habitations											Seasonal/ activity††		Habitations								LGM†	Seasonal/activity††				Habitations	
				Early			Mid			Late							Early Cluster				Late	Early GM†									
	2199	2242	4789	4545	4684	2854	2193	2198	4614	4644	4671	2151	4640	2181	4651	4763	4475	4479	4480	4725	4475	23	2161	4650	23	2205	2191	2203	2151	2215	2235
Amaranthaceae																															
Amaranthus sp.				1		2				37											1										
Agavaceae																															
Yucca sp.			2	++/2						+												++					4		+		
Betulaceae							+																								
Chenopodiaceae																															
Chenopodium sp.				3		1	1		1	29						3													+		
Compositae																															
Artemisia sp.		++		+++	+	++	+++	+	+++	+++	+		+			++		+			+						+++				+++
Helianthus sp.																															
Cruciferae								2		1							3				3						1				
Descurainia sp.										1																					
Cucurbitaceae																															
Cucurbita sp.					•					•												•					•		•••		
Cupressaceae																															
Juniperus sp.				+		+	+++	+		++		+					+			+	+	++	+	+	++		1			+	+
Fagaceae																															
Quercus sp.				+	+	+	+			++	+							+				+	+	+	+						+
Gramineae	1	1		1		1	2			2																					
Phragmites sp.				+			++	+		+							+				+				+				++		
Zea mays				•••	•••	•••	•••	•••	•••	•••	•		••	•••	•	•	•	••	•		••	•••	•	•	••	••	•••		•••		••
Grossulariaceae																															
Ribes sp.																	1														
Leguminosae										2																					
Phaseolus sp.				•	••	••	•														•	•					•		•		
Malvaceae																															
Sphaeralcea sp.										3																					
Pinaceae		++		++	+	+++	+++			+++	+++		+		+		+	+++			+/1	+++		+	++						
Pinus edulis	+		+		5												1	++				+/1	+/1		++						
Pinus ponderosa	+		+															++	++			+	+		++				+		
Polygonaceae										3																					
Portulacaceae																															
Portulaca sp.									2	131							4				2						11				
Rosaceae				1																											
Cercocarpus sp.													+									+	+								
Salicaceae					+++	++	+++			+++	++							+					+								
Populus sp.	+					5				47						+						++	+	+	+++						
Solanaceae																											1				
Nicotiana sp.																															
Physalis sp.																2															
Typhaceae																															
Typha sp.							+																								

Domesticates: • - present
•• - common
••• - frequent

Nonreproductive parts: + - present in limited amount
++ - commonly occurring
+++ - frequent; may comprise a major part of the vegetal assemblage
† - Grass Mesa (L = Late)
†† - Limited activity site

Reproductive parts (seed, fruit) - number recovered

The frequency of occurrence is most beneficially examined within a site. The comparison between sites is hampered by different sample size and by lack of bulk soil and pollen data for many sites. The relative frequencies were calculated by determining how many times a particular plant was represented by each site over the total number of sampled units examined.

The restricted occurrence of this plant on the occupation surface may argue for its utilization as matting.

Juniper (*Juniperus* sp.) or sagebrush (*Artemisia* sp.) bast has been preserved on the floors of domiciles and in the roof fall of burned structures. The occurrence of bast in either context is not associated with any particular time period. Use of this material is archaeologically documented at Kiet Siel in Tsegi Canyon, Arizona (author's personal observation).

Undoubtedly, other plant and animal products functioned as weaving/cordage materials. Much of the material recovered during DAP excavations requires further intensive analysis in order to understand the range of materials and processing stages associated with the use of these resources.

Contruction Materials. One of the primary construction materials employed during the Anasazi occupation was wood. A variety of coniferous and deciduous trees provided main support posts, stringer poles, and matting for roofing of habitations. A wood resource depletion model (chapter 5, section 4, this report) based on data from the Grass Mesa site (Site 5MT23) indicates that the wood remains from the early occupation at Grass Mesa prior to about A.D. 850 are dominated by juniper and various members of the pine family. After that time, cottonwood, oak, and various dicotyledonous trees and bushes increased in relative importance on the site, a large village. Further work is necessary to interpret these findings through the monitoring of contemporary forest and examination of the archaeological occurrence of these genera. There probably were other species used in construction (e.g., *Pseudotsuga menziesii, Populus tremuloides,* and *P. angustifolia*); unfortunately the identification of these genera, and the species within the various genera, is problematic.

The frequent occurrence of cottonwood in DAP sites suggests that the riverine environments greatly contributed to the resource base of the Anasazi occupants. In contrast, the use of tree species for construction purposes in Mesa Verde sites (Hayes and Lancaster 1975) reflects the limitations in wood resources of the prehistoric Mesa Verde vegetation communities. Although somewhat later in time than the Dolores Anasazi occupations, the woods used in construction of Badger House reflect the absence of the riparian community on Mesa Verde. Hayes and Lancaster suggest that Douglas-fir (*Pseudotsuga menziesii*) was preferred for its straightness and ease of trimming, although they present evidence for juniper being the most commonly used species. Kohler et al. (chapter 5, section 4, this report) show that juniper was used throughout the occupation of Grass Mesa, Site 5MT23. Exploitation of Douglas-fir also increased after A.D. 900 at the Grass Mesa site.

One additional plant that was frequently utilized in roof and wall construction is an aquatic grass, *Phragmites* sp. Use of this plant in jacal walls and in roofs is documented by impressions in jacal and by burned roof matting.

Fuel. Many trees and shrubs were used as fuel. Ponderosa pine (*Pinus ponderosa*), pinyon pine (*Pinus edulis*), cottonwood or aspen (*Populus* sp.), juniper (*Juniperus* sp.), oak (*Quercus gambelii*), rosaceous shrubs (*Cercocarpus* sp.), and sagebrush (*Artemisia* sp.) are commonly recovered from hearths and middens. From the Archaic period sites (table 46), pine (*Pinus* sp.), cottonwood (*Populus* sp.), and sagebrush (*Artemisia* sp.) are the only types of wood found. However, the small sample of sites and features from these sites may not accurately indicate the selection of fuel resources. Pinyon, juniper, and sagebrush are the predominant fuel sources represented in DAP sites for all phases of occupation. The preponderance of sagebrush in sites located in the Sagehen Flats Locality (e.g., Sites 5MT4545, 5MT4684, 5MT2193, 5MT4614, 5MT4644), and the paucity of sagebrush from sites in the Grass Mesa Locality (Sites 5MT2151, 5MT2161, 5MT23) suggest that sagebrush was either more readily available in the Sagehen basin or that pine, juniper, and oak were not as easily collected by people occupying the Sagehen locale. The pollen record also substantiates a general paucity of sagebrush about the Grass Mesa site.

Wild Foods. Very few wild plant foods have been found in archaeological deposits examined by DAP personnel. Remains representing the grass family (Gramineae), yucca, and gooseberry (*Ribes* sp.) are present in the archaeological record. At the present time, the grasses have not been intensively examined and their generic identity remains unknown. Analysis has shown that grasses were used primarily during the Archaic Tradition and the Sagehen Phase. The possibility that these grasses were intrusive or used to start fires precludes associating their occurrence with only subsistence activities. Although this is a conservative position, considering the recent literature describing cool-season grasses in southwestern prehistory (Adams 1980b; Bohrer 1975), the data base at present is not sufficient to support more specific interpretations.

Gooseberry is represented by a single seed from the early occupation of McPhee Pueblo (Site 5MT4475). This plant commonly occurs in moist areas such as riverbanks. Because of the proximity of McPhee Pueblo to the river valley flood plain, no elaborate discussion of the presence of gooseberry at the site is necessary. The tasty fruit was probably consumed and the seed discarded.

Pinyon nuts were gathered by occupants of two sites (table 46). The infrequent occurrence of pinyon nuts limits discussion of their contribution to subsistence. The paucity of remains of pinyon nuts or cones suggest very limited use, although the higher frequency of occurrence during the earliest phase of Anasazi occupation may suggest a greater contribution during the initial occupation. Analysis of bulk

soil samples should allow greater latitude in discussing this plant as a resource.

DISCUSSION

Inferred Temporal Patterns

The Archaic Tradition (3000 B.C.-A.D. 500) is represented by botanical remains from only three excavated sites (Site 5MT2199, Site 5MT2242, Site 5MT4789). From these three sites, only a small number of features produced botanical remains. Those features were heavily contaminated by modern noncharred plant remains. The charred remains indicate that pine, cottonwood, and sagebrush were used as fuel. Present in these features in a charred condition were two grass caryopses, a single *Chenopodium* sp. fruit, and two *Yucca* sp. seeds. The presence of these charred remains in these features suggests that these resources were gathered.

The early Anasazi occupation (Sagehen Phase) is represented in the paleoethnobotanical record by all three cultigens, a number of ruderal plants, and the continued occurrence of grass fruits. Sagehen Phase peoples exploited accessible forests and/or shrublands for firewood and construction materials. Interaction with the environment seems to have been intense, since the botanical remains indicate frequent occurrence of ruderal species.

The paleoethnobotanical record of the later Anasazi occupation (McPhee Phase) does not seem to deviate greatly from that of the earlier phase of occupation. There is little change in the frequency of domesticates, although spatial distribution of cucurbit and bean cultivation may have changed. The frequency of ruderal plant species seems to have decreased during this period, although sampling may have skewed the representation of ruderal plants in the record. Use of coniferous and deciduous trees continued for construction purposes and for fuel. Site location may have influenced the type of wood exploited by the occupants, therefore influencing the differential occurrence of wood types shown in table 46.

Gathering wild plant products continued during the McPhee Phase. Pinyon nuts are present in deposits dating to this time period; however, they decreased in frequency from the earlier phase. Sampling may pose a problem when dealing with small-scale remains such as pinyon nuts and other small seeds. Until more bulk soil data can be evaluated, much of what has been reported must remain preliminary.

The most recent Anasazi occupation (Sundial Phase) is represented by very little data. One site (Site 5MT2215) seems to have been occupied for a very short period of time. A second site (Site 5MT2235) had very few archaeobotanical specimens recovered. Little can be said from this limited body of data. The occupants of both sites used juniper for fuel and possibly for construction. The occupants of Site 5MT2235 possibly used sagebrush and oak for construction and/or fuel. This group also consumed the produce of at least one domesticate, corn.

Inferred Spatial Patterns

Both pollen and macroremains seem to indicate widely different exploitative environments for sites located at different distances from the river valley and for sites located in the Dolores River canyon or in the Sagehen basin. Sagebrush (*Artemisia* sp.) is commonly recovered from firepits in sites located close to or within the Sagehen basin. It is all but absent from sites located downstream in the canyon. The pollen record substantiates the macrobotanical evidence for the frequent occurrence of *Artemisia* sp. in sites located in the Sagehen basin, although pollen from only two sites in the canyon environment (Site 5MT23 and Site 5MT2151) has been analyzed. Analysis of additional pollen samples from sites located within the canyon should shed light on the occurrence and distribution of *Artemisia* sp. The frequent occurrence of cottonwood (*Populus* sp.) has been noted with reference to the proximity of sites to the riparian community. The use of this tree may be related to previous depletion of other species, but the factor of site location must be controlled for in order to see the true picture. The use of a riparian community characterized by annual, natural disturbance would undoubtedly provide a more stable resource base for timber selection. The regeneration time of tree species from a riparian community would probably be shorter than that for other communities receiving major perturbation. As a result, increased selection of timber from the riparian community would be suspected in times of depletion in other woodland communities.

SUMMARY

Botanical data which span most of the prehistoric occupation of the DAP area are presented using Odum's (1969) ecosystem development model as an organizing principle. During most of the prehistoric occupation, agriculture provided the greater part of the botanical subsistence regime. Along with agricultural practices, one would expect (following Odum) that ruderal plants (colonizing species) would augment the domesticates (corn, beans, and squash) as a subsistence resource. Further, as the intensity of agricultural practices increased, the frequency of ruderal species would also increase and potentially contribute more to the subsistence system. Although all data are not yet available, this pattern of co-linearity does not present itself. The frequency of agricultural produce seems to be fairly steady after initial occupation. The frequency of ruderal plant remains increases to sometime during the late Sagehen Phase and then nearly disappears. No alternative model is proposed. Until additional data are compiled, the results of this analysis remain preliminary.

Botanical resources which are not dependent on the action of man for survival include various plants that provide food, fiber, and construction materials. Plants from the riparian plant community include *Phragmites* sp. and *Populus* sp. and/or *Salix* sp. The use of *Phragmites* sp. and *Populus* sp. for constructing the superstructure of domiciles has been documented. Cottonwood (*Populus* sp.) seems to be a more frequent element in construction during the later part of the McPhee Phase. This may indicate an overuse of timber from other plant communities. Use of other trees (Douglas-fir, ponderosa and pinyon pine, and juniper) for fuel and construction suggest that a variety of plant communities were exploited. Sagebrush (*Artemisia* sp.) occurs most frequently in sites that are located in the Sagehen Flats Locality; this suggests that exploitation of this wood for fuel may have been expeditious.

The collection and analysis of bulk soil, vegetal material, and pollen samples taken by DAP is unique. No other archaeological investigation in the northern San Juan region has undertaken the examination of such an extensive range of botanical materials representing this temporal period. Therefore, few comparisons can be made. The systematic collection of bulk soil and pollen samples is rivaled only by the Salmon Ruin Archaeological Project (Irwin-Williams and Shelley 1980). With Mesa Verde being the closest comparable source of archaeobotanical investigation, justification for DAP investigations concerning botanical resources can be understood by realizing that at Mesa Verde, only dendrochronological specimens, pollen, and cultivated plant remains have received more than cursory attention (Cattanach 1980; Cutler and Meyer 1965; Fritts et al. 1965; Martin and Byers 1965).

FAUNAL RESOURCES

INTRODUCTION

Information derived from the analysis of faunal remains is useful for addressing aspects of the lifeways of the DAP area prehistoric occupants. Unfortunately, certain areas of lifeway research employing faunal data cannot be thoroughly explored because the data file containing all faunal information is undergoing editing and verification. Until this is complete, information concerning animal/man interaction and interrelationships must remain cursory. Consequently, the discussion which follows will consider only two of the five Problem Domains of the DAP Research Design: Economy and Adaptation, and Cultural Process. In order to accomplish this, a topical presentation will serve to arrange the discussion; "Analytical Methods" will be first, followed by a brief discussion of three alternative models which serve as a theoretical framework for the interpretation of DAP faunal remains. A select group of exploited fauna and their native habitats will then be examined in light of these three models; and finally, a short discussion which may establish some testable propositions will be presented.

ANALYTICAL METHODS

Animal remains are encountered in midden deposits, and as primary and de facto refuse (Schiffer 1976:30). When encountered, the provenience is noted and the remains are sent to the laboratory to be washed, separated, and packaged. All faunal material is then sent to the Faunal Task Specialist (Steven D. Emslie, Center for Western Studies) for analysis. Here the bones are first sorted into gross taxonomic groups (order, family) by provenience. This is followed by preliminary analysis, which describes and quantifies individual species (when possible), element and side, number of items, type of breakage, and presence of butchering marks. On complete elements, morphometrics are recorded (Emslie 1978). The MNI (minimum number of individuals) is currently calculated by field provenience unit. This technique may give rise to interpretation problems since variably sized excavation units can under- and/or overrepresent the MNI, depending on the size (volume) of the aggregation unit (Grayson 1979:208ff). Thus, although the MNI is recorded, presentation of these data is limited by the size of the sampling unit; they are not included in this presentation. Consequently, the data are presented in ordinal units in table 47 as absent ( ), present (+), or present in large numbers (++). In the latter case, if a taxon is represented by more than 50 occurrences, it is considered present as in large numbers.

THEORETICAL FRAMEWORK

The archaeofaunal data recovered from DAP sites are approached using one or more of three models:

1. Garden hunting (Linares 1976). This model suggests that human manipulation of anthropogenic communities provides a fairly reliable subsistence regime for agriculturalists. The primary source of harvestable productivity is found in the form of domesticated plants, although agricultural fields also produce weedy plant species. Man is one of the primary herbivores in this trophic structure; however, other primary herbivores such as animal pests are also frequently associated with agricultural fields. Man, acting as a predator, may have harvested these other primary herbivores as a form of secondary productivity while at the same time reducing stress on, and overcoming competition for, these crops.

2. High-altitude exploitation. Exploitation of this kind may be attributed to one or both of two factors. One factor is climatic fluctuation during the Holocene. These fluctuations may have contributed to the altitudinal lowering of boreal habitats (Emslie 1981; Hargrave and Emslie 1980:260), some types of which are found to the northeast of the Dolores area today. If more mesic conditions existed

Table 47. Selected faunal species

	Archaic		Sagehen Phase				McPhee Phase						Sundial Phase	
	Camp	Limited activity	Habitation			Seasonal/ activity[2]	Habitation					Seasonal/ activity[2]	H[3]	Seasonal/ activity[2]
			Early	Middle	Late		Early	Late	Early GM[1]	Late GM[1]	House Creek			
Leporidae														
Lepus sp.		+	+	++ (388)	++ (133)		++ (108)	++ (93)	+	+	+	+	++	+
Sylvilagus sp.	+	+	+	++ (836)	++ (171)	+	++ (66)	++ (148)	+	+	+	++	++	++
Sciuridae														
Cynomys gunnisoni		+	++	++	+	+	+	++			+	+	++	+
Castoridae														
Castor canadensis			+	+	+		+	+	+	+		+	+	+
Erethizontidae														
Erethizon dorsatum			+	+	+		+	+	+	+		+	+	
Canidae														
Canis familiaris			+	++	+		+	+	+	+		+		
Cervidae														
Cervus canadensis				+	+		+	+	+		+	++		
Odocoileus hemionus			+	++	++	+	+	++	++	+	+	+	+	+
Antilocapridae														
Antilocapra americana			+	+	+		+	+	+	+				
Bovidae														
Ovis canadensis				+	+		+	+	+	+		+	+	
Meleagrididae														
Meleagris gallopavo			+	+	+			+	+		+	+	+	
Gruidae														
Grus canadensis				+	+				+		+		+	

[1]Grass Mesa
[2]Limited Activity
[3]Habitation
+present
++present in large numbers

at any time during the DAP Anasazi occupation, an increased occurrence of otherwise boreal fauna may be expected. The second factor is a possible response to a greater availability of animals at higher elevations, areas which were removed from dense settlement.

3. Expedient use of easily accessible species. This model refers to man's fortuitous exploitation of some animal species. The occurrence of these animals was probably neither encouraged nor discouraged by man's manipulation of the environment, and the presence of a species was the main factor in determining whether or not it became part of the procurement system.

RESULTS

The Garden Hunting Model

This model provides a framework for understanding the interactions and interrelationships of the human occupants of the Dolores area and the contemporaneous faunal communitites, both domesticated and commensal.

Domesticated animals. It is possible that domesticated animals, in preying on pests associated with agricultural fields, may have been a part of a pest-control system; evidence exists which suggests that these domesticates were in turn used as a food source by the Anasazi. Remains of two species of domesticated animals — the domesticated dog and the domesticated turkey — have been recovered from both Sagehen and McPhee Phase site deposits in the DAP area.

Domestic dog (*Canis familiaris*) is the more common of the two domesticated species. Butchering marks observed on the bones of these animals indicate that they played a role in the subsistence strategy of the Anasazi occupants. Articulated interments are also present, possibly indicating some other relationship between man and canine apart from a consumable resource. Suspected ceremonial interments have been located at Site 5MT2854, Site 5MT4475, and possibly at Site 5MT2151 (fig. 112). These animals were found in an articulated fashion on or immediately above structure surfaces. Similar occurrences have been documented for Anasazi kivas in Mancos Canyon. Gillespie (1976:67) and Emslie (1977:167) suggest that these canids were killed and placed on the floors of the structure as "deconsecration" rituals prior to abandonment. Certain vertebral anomalies have been associated with canids to indicate their use as beasts of burden (Emslie 1978). The inferred association should be testable using information from the DAP.

Domesticated turkey (*Meleagris gallopavo*) is also represented in Anasazi Tradition occupations. This animal is most frequently recovered from deposits dating to the Sundial Phase. Remains of this species are not extremely common and they occur in lower frequency than domestic dog. The remains of turkey reflect human consumption as they are often burned and/or butchered, and frequently are of immature individuals. The presence of this domesticated bird may reflect the cultural perpetuation of a predator-prey system, in which the turkey maintained low levels of insect pests in agricultural fields. This interaction within a man-maintained ecosystem also illustrates one of many possibly exploited sources of secondary productivity (e.g., turkeys).

Commensal animals. Many types of commensal animals are represented in the faunal remains recovered from DAP sites; these include artiodactyls, lagomorphs, rodents, and birds.

The most common artiodactyl encountered in DAP sites is deer (*Odocoileus hemionus*), whose bone occurs most frequently in middle to late Sagehen Phase sites (Sagehill and Dos Casas Subphases). These mammals were also frequently procured during the McPhee Phase. Bones of large mammals (which probably include deer) occur in all Anasazi deposits in the DAP area. Unfortunately, the minimum number of individuals, the relative frequency between sites, and their contribution to prehistoric diet have not been ascertained. Until a suitable-sized unit (i.e., total site, structural units, feature types, or any combination thereof) for describing the faunal assemblage can be determined, gross temporal groupings must be considered as the basis for comparison. Since different spatial/volumetric units can be used to address different Research Design questions (which pertain to intrahousehold activities or different community subsistence practices), research goals should be prioritized accordingly. Once it has been determined which comparisons are the most appropriate and necessary, a method for calculating minimum number of individuals can be selected and the associated dietary contribution can be made using already established formulas (Grayson 1979; White 1953). It has been noted by the Faunal Task Specialist that immature individuals comprise a sizable portion of the total for this species, particularly those from McPhee Village.[2] The lack of deer remains from Archaic Tradition deposits may be an "artifact" of preservation or of cultural processing activities, since large unidentifiable mammal bone fragments (which may be in part deer) are frequently encountered in DAP Archaic deposits.

Two lagomorphs, cottontail rabbits (*Sylvilagus* sp.) and jackrabbits (*Lepus* sp.) are very common from all prehistoric deposits in the project area. These two genera apparently are the most consistently and frequently occurring animals in prehistoric deposits in the DAP area. At this time, the cottontail rabbit is the only definitely identified mammal that is represented at Archaic Tradition sites. The

[2]Steven D. Emslie, Center for Western Studies, Flagstaff, Arizona, personal communication.

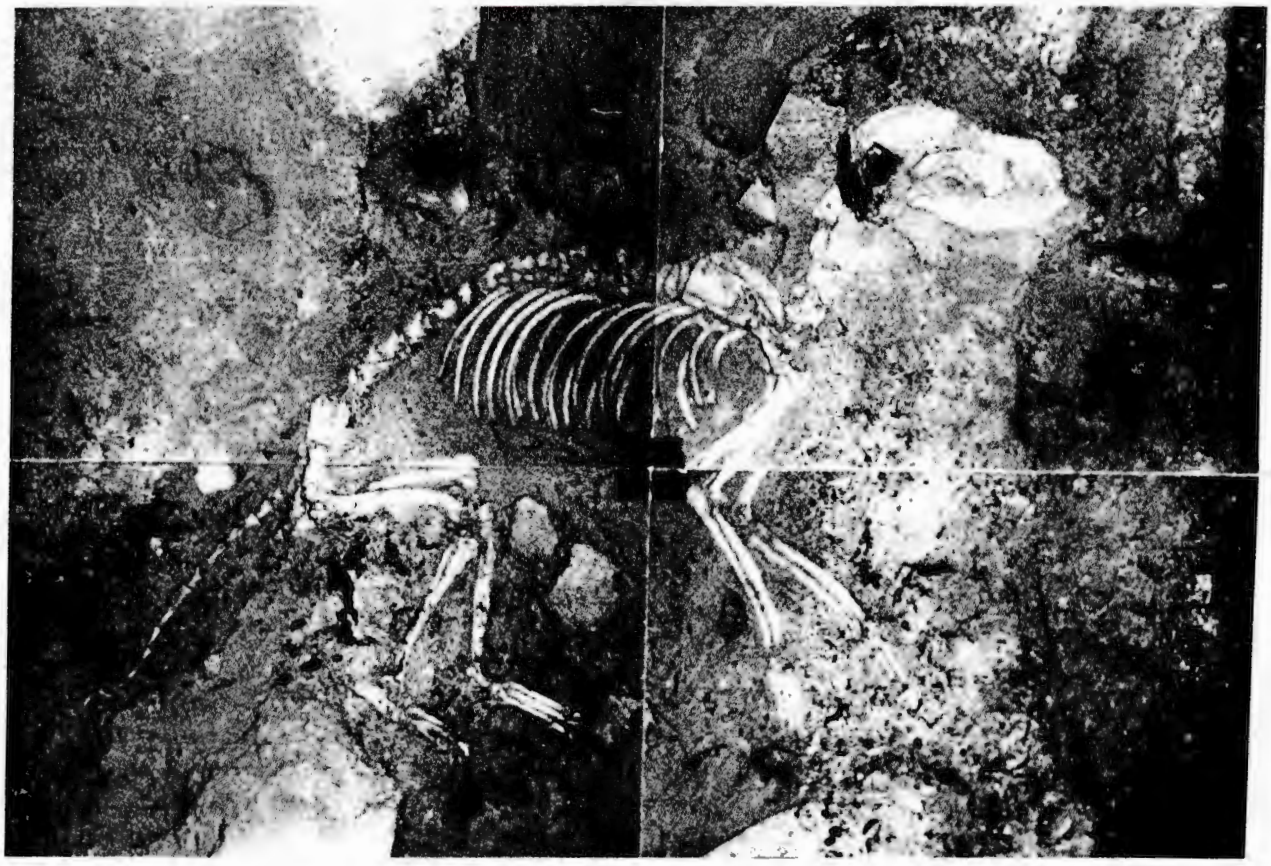


Figure 112. Photograph of dog burial in Pitstructure 1, Site 5MT2854 (DAP 077833).

frequent occurrence of all elements of these genera suggest their important contribution to the subsistence base of prehistoric occupants of the DAP area. The potential of the DAP archaeofauna for addressing questions of social organization and the redistributive interaction of households has been noted by the Task Specialist (S. Emslie). It seems that certain elements frequently occur in a patterned fashion within certain village sites, e.g., Site 5MT4475. This information suggests a never-before realized means of understanding prehistoric human behavior. Further investigation of these patterns should receive a high priority.

Although many kinds of rodents are represented in the archaeological record, the presence of a single rodent species in Anasazi deposits is noteworthy. Gunnison's prairie dog (*Cynomys gunnisoni*) is represented in most sites of Anasazi age. Though this animal may in part reflect post-occupational bioturbation, one element reveals some indication of prehistoric cultural practices, e.g., burning or cut marks (Site 5MT2854). Remains of this rodent are most frequently encountered during the initial phase of Anasazi occupation, i.e., the Sagehen Phase. The presence of elements representing this rodent suggest that this animal contributed at least minimally to the subsistence regime of the Anasazi occupants.

Another animal that is probably affected by the response of the ecosystem to agricultural land clearing is the sandhill crane (*Grus canadensis*). According to S. Emslie,[2] "cranes are rare in the area today, but were apparently quite common during Anasazi occupation; this species is highly attracted to agricultural areas and is currently extending its range into southern Arizona as a result of agricultural practices." This relationship between agricultural fields and sandhill cranes may find further support in the DAP archaeological record. That is, during the Archaic Tradition, no domesticated plants were being cultivated in the DAP area and sandhill crane elements are absent from deposits of this age. During the Anasazi period, however, domesticated plants were being cultivated and sandhill crane elements are frequently encountered in sites dating to this time. The proximity of sites to a source of water has also been offered to explain the presence of sandhill crane

[2]Steven D. Emslie, Center for Western Studies, Flagstaff, Arizona, personal communication.

remains in archaeological deposits (Hargrave and Emslie 1979:296), although this proposition cannot explain their absence in Archaic deposits.

In summary, assuming that the species discussed thus far reflect the use of a range of exploitative strategies, it should be expected that an understanding of the habitats favored by these species can shed further light on the Anasazi subsistence regime. That is, a variety of procurement strategies would be expected in capturing large game, small mammals, and birds. An understanding of the habitats which were occupied by these animals can be brought to bear on the problems of interpreting differing procurement strategies. The habitat requirements of rabbits, prairie dogs, deer, and to some extent, sandhill cranes include a diversity of vegetative forage. The mule deer prefer forest-edge or brushy habitats, since their dietary preference is for young browse (Armstrong 1972:304ff). Although these forest-edge or ecotonal situations undoubtedly existed prehistorically without the intervention of man, these situations could have been enhanced by human-environmental manipulation. Land-clearing activities for agriculture commonly give rise to these ecotonal situations. Consequently, the agricultural practices of the Anasazi could have favored the development of habitats suited to deer.

In a similar vein, rabbits (both *Sylvilagus* sp. and *Lepus* sp.) prefer brushy or woodland edge situations (Armstrong 1972:82-85, 92-93). Although the rabbits can survive in a variety of habitats in various lifezones, their preference for edges would seem to support the hypothesis that Anasazi agricultural activities would bring humans and those particular animals into close association (Emslie 1977:65ff).

The prairie dog remains pose a different kind of interpretive problem. The remains of these small mammals occur very frequently in Anasazi deposits but relatively few of the bones representing this animal show evidence of cultural use (e.g., cut marks, burning). The possibility that many of these occurrences represent intrusions cannot be ruled out. However, the presence of prairie dogs as agricultural pests today in addition to the high frequency of prairie dog remains found in Anasazi deposits tends to suggest human exploitation (Armstrong 1972:139; Bailey 1971:125-130; Emslie 1977:67-69).

The occurrence of sandhill cranes in archaeological contexts has been discussed with respect to Anasazi agriculture. As with deer and rabbits, disturbance of land by agricultural practices increases the possibility that these areas would be suitable habitats for sandhill cranes. Until it is possible to ascertain the location of frequent occurrences of sandhill crane (and certain other fowl) and determine the areas which might have been farmed prehistorically, the resource (water or farm field) which would have attracted these birds remains speculative.

The High-Altitude Exploitation Model

Certain animals which occur in the Dolores area archaeological record provide data which may indicate environmental change and/or changing subsistence practices. Three small mammals and one bird are represented in various Anasazi deposits, the presence of which suggests cooler summers and milder winters during Anasazi occupation than today.[2] The remains of snowshoe hare (*Lepus americanus*) occur during the Sagehen Phase. Elements from the snowshoe hare and pine marten (*Martes americana*) and pygmy owl (*Glaucidum gnoma*) occur infrequently during the McPhee Phase. Pine martens are also boreal mammals; their range is restricted to spruce-fir and lodgepole pine forests above 2740 m (9000 ft), according to contemporary records (Armstrong 1972:274). The pygmy owl is an inhabitant of mountainous woodlands. A single element representing pika (*Ochotona princeps*) has been recovered from Site 5MT2235, a Sundial Phase site. Pika usually occur at or above timberline, although habitat (talus slopes with available grasses and forbs) is as important as altitude in determining distribution. Contemporary collections of this species have been at or above 2590 m (8500 ft) (Armstrong 1972:87). This assemblage of boreal species possibly indicates a climate quite different than that of today. The suggestion that the presence of these animals is indicative of cooler summer conditions has not found support in at least one climatic reconstruction based on pollen recovered from two lakes in the La Plata Mountains (Petersen 1981b). An alternative hypothesis which addresses the exploitation of higher altitude fauna regards the procurement of these animals as a response to intensification of human occupation in the Dolores area during the McPhee Phase and a need to expand the range of faunal resource acquisition. Additional data, perhaps resulting from library research, to acquire a regional perspective would be necessary to adequately address these hypotheses.

The remains of certain birds seem to reflect the exploitation of habitats that are unique to the DAP area. For example, the relative abundance of sage grouse and other grouse (family Tetraonidae) when compared to domestic turkey is much higher in the DAP area than in Mesa Verde sites.[2] The relative paucity of domestic turkey from DAP Anasazi deposits may reflect the habitat differences that are seen today between these two areas. The Sagehen Flats Locality was possibly dominated by big sagebrush (*Artemisia tridentata*) in the past (if the remains of wood from Archaic and Anasazi firepits are any indication; refer to botanical section, this appendix) and would have provided a suitable habitat for sage grouse. Moreover, the farming practices of the Anasazi occupants would have further enhanced the preponderance of sagebrush in this area, as this plant is also a colonizing species on disturbed lands. The occurrence of

[2]Steven D. Emslie, Center for Western Studies, Flagstaff, Arizona, personal communication.

sage grouse should be investigated with respect to the garden hunting model presented earlier. The possible occurrence of blue grouse in an archaeological context might provide further understanding of the climatic differences/high-altitude exploitation strategy discussed above.

Numerous other species of mammals and birds have been recovered from DAP excavations. The uniform occurrence of fish bone, although infrequent, from all DAP Anasazi occupations is quite different from that of any faunal assemblage on Mesa Verde, although this difference may be related to sampling (Cattanach 1980; Hayes and Lancaster 1975). Similarly, although certain boreal animals (e.g., pygmy owl) have been recovered from Anasazi sites in Utah and New Mexico,[2] they are absent from Mesa Verde sites. This may reflect the relative distances between Mesa Verde and these other areas to accessible higher elevations. The low frequency of remains of various other species in DAP sites, however, restricts their usefulness for interpretation. Consequently, further discussion of the presence of species will be brief and will be in the context of how their occurrence might be interpreted.

Expedient-Use Model

Numerous other animals in addition to those mentioned above were exploited by the Dolores area Anasazi. Some of these mammals were undoubtedly hunted, since they were available in accessible plant communities (pinyon-juniper, ponderosa-oak). The archaeological presence of beaver (*Castor canadensis*) and porcupine (*Erethizon dorsatum*) probably reflects Anasazi exploitation of these plant communities.

Elements of beaver have been recovered from all temporal periods of Anasazi occupation. Beavers are commonly found inhabiting streams with low grades and where phreatophytic (water-loving) vegetation is abundant (Armstrong 1972:183). The flood plain and oxbows of the Dolores River valley would be expected to provide this sort of habitat. The exploitation of these habitats by the Anasazi probably reflects their familiarity with the riparian community.

Porcupines are also represented in all phases of Anasazi occupation (i.e., Sagehen, McPhee, and Sundial). Armstrong (1972:252) states that porcupines' "most conspicuous food item is the inner bark of trees, particularly conifers . . . notably pinyon and ponderosa." It is assumed that during Anasazi times, the project area was in part covered by pinyon-juniper and possibly ponderosa pine associations (Bye 1981a), habitats suited to porcupines. The frequency with which the remains of this animal are encountered in an archaeological context in the Dolores area probably illustrates fortuitous hunting by the Anasazi peoples.

In addition to deer, remains of other artiodactyls are common from Anasazi Tradition sites. Some of these (elk, bighorn sheep, and pronghorn) occur in relatively low frequencies when compared to deer. Elk and bighorn sheep are seasonal migrants that may have frequented lower elevations such as those of the Dolores area. Procurement of these animals would have been less frequent than that of deer which were probably residents frequenting the disturbed plant communities surrounding human habitations. Pronghorn commonly occupy areas of short grass prairie, open shrublands, and mountain parklands (Armstrong 1972:307). Suitable habitats possibly occurred in the Sagehen Flats Locality and to the south in the Montezuma Valley. The historic distribution of this animal in New Mexico indicates that it was most common in the northeast corner of that state (Bailey 1971:22), although Armstrong (1972:306-307) describes its distribution as statewide in Colorado. Remains of pronghorn appear during the Sagehen and McPhee Phases.

Other animals that could have been a part of the expedient procurement system are those which are part of a natural predator-prey system. This system might be brought into closer association with human settlement if the prey species have a preference for humanly disturbed habitats. The predator-prey system of canids such as coyote and fox with rodents and lagomorphs seems to indicate this situation. Canids occur most frequently in deposits dating to the Sagehen and McPhee Phases. Commonly preying on rabbits and small rodents, coyote and fox would be expected to occur in conjunction with population peaks of these prey species. In keeping with the hypothesis about increased frequency of rabbits during periods of intensive land use by humans (e.g., Sagehen and McPhee Phases), a contemporaneous high frequency of predator species such as these canids would be expected. The coincidence of fox, coyote, and rabbit is supported by the occurrence of these canids and lagomorphs at Badger House and in Mancos Canyon (Hayes and Lancaster 1975; Emslie 1977).

DISCUSSION

The faunal assemblages recovered from Anasazi sites in the DAP area reflect patterns that were somewhat different from other Anasazi occupied areas. For example, remains of beaver and, to some degree, fish are relatively common in the DAP area but are rare or absent from Mesa Verde sites. Remains of beaver are also infrequent from Mesa Verde sites (Hayes and Lancaster 1975; Emslie 1977). It is likely that the infrequent occurrence of beaver and fish bones from Mesa Verde sites hinges on the distance of these sites from permanent water sources. Nearly all sites in the DAP area lie within easy access to the resources of the Dolores River, which would have allowed regular exploitation of such riparian resources as fish and beaver. These animals were probably consumed if ethnographic and

archaeological analogs provide any clues (Henderson and Harrington 1914; Olsen and Wheeler 1978). Specific investigations of the fish species present will provide a means by which man's use of the waterways and his impact on the riverine environment can be investigated.

A wide variety of avifauna occur in the DAP area Anasazi deposits. Many of these species would have been seasonal occupants of the area and might be used to construct models for yearly cycles of faunal exploitation. Problems with models of this sort should be anticipated since sedentary peoples leave midden deposits which are frequently mixed; this precludes sorting out a particular depostitional episode that may represent part of a year. It may be possible, however, to describe the seasonal use of architectural units within a site if faunal remains can be associated with isolated features.

Artiodactyls (elk, bighorn sheep, deer, and pronghorn) contributed much to the subsistence base of the Anasazi in the DAP area. Although their relative proportions have not yet been the subject of intense examination as has been the case on Mesa Verde (compare Stiger 1977; Emslie 1977), some difference should be expected. That is, habitats commonly occupied by certain of these large mammals were probably more accessible to DAP area residents. The more frequent occurrence of elk remains in Anasazi sites of the DAP area when compared to the Mesa Verde area suggest that the Dolores River valley provided easier access to habitats preferred by this species. Further inquiries will address the similarities and differences in frequency of pronghorn and bighorn sheep in the DAP area, Mesa Verde, and other Anasazi occupations in the northern San Juan Area.

The pattern that emerges when examining assemblages of species which are commonly found in ecotones seems to indicate that garden hunting was a common practice. This assemblage, which is dominated by deer and rabbits, is common from Anasazi sites on Mesa Verde and in southeastern Utah (Emslie 1977; Hayes and Lancaster 1975). When examined in light of the inferred land-use practices of the Anasazi Tradition occupants, the exploitation of these animals can be easily explained. Although the concept of garden hunting has been in the literature for years (Henderson and Harrington 1914; Bennett and Zingg 1976), few archaeological studies have used it as a basis for describing the prehistoric reliance on animals such as deer, rabbits, prairie dogs, other small rodents, and some birds (however, refer to Emslie [1977]). Linares (1976) suggests that agricultural activities (i.e., agricultural crops and ruderal plants) tend to attract various animals and that these animals might be exploited easily and efficiently. The use of highly productive habitats (plant communities such as agricultural lands which are in the early stages of succession or ecotonal situations) by herbivores such as deer and rabbits is documented in the ecological literature (cf. Armstrong 1972) and archaeological literature (e.g., King and Graham 1981). It can be assumed that deer and rabbits were residents of disturbed lands and ecotonal situations that resulted from agricultural activities of the Anasazi occupation. It can be inferred that the Anasazi peoples capitalized on the presence of these animals and were involved in an expedient faunal exploitation strategy. The stability of this strategy remains open to question. If the McPhee Phase of Anasazi occupation also exhibited intensified agricultural practices, then an increase in the exploitation of faunal species characteristic of these lands might be expected. Rabbits do not seem to follow this pattern. The frequency of rabbits (both *Sylvilagus* sp. and *Lepus* sp.) decreases during the McPhee Phase. Deer, however, do increase in frequency during the McPhee Phase. This may reflect a greater extent of agricultural land use during the McPhee Phase over that of the Sagehen Phase. If deer frequented agricultural lands which were distant from the large villages, and rabbits frequented closer fields, then one possible inference is that the Anasazi were expanding their agricultural system into peripheral areas.

Two domestic species (dog and turkey) are frequently encountered in Anasazi occupation sites in the DAP area. The consumption of these animals is inferred from the occurrence of these animals' bones from immature individuals. Snap fractures on many of the elements representing these animals support this contention. The lower overall frequency of turkey in the DAP area when compared to Mesa Verde and southeastern Utah is not yet understood. One plausible explanation revolves around the greater frequency of the remains of grouse in DAP Anasazi deposits. This substitution of grouse for turkey is plausible with regard to the consumption of fowl, but fails miserably when considering the domestic turkey as a link in the predator-prey system proposed for agricultural lands. Additional hypotheses for examining and explaining this phenomenon are needed.

SUMMARY

The exploitation of fauna during the Archaic Tradition (Great Cut Phase) seems very restricted. Elements of three small mammals have been definitely identified. Other remains from large mammals (possibly deer, elk, pronghorn) have not been complete enough for more specific identification. Obviously lacking from Archaic deposits are domesticated animals, a variety of avifauna, and a wide range of rodents. Eight archaeological sites or parts thereof represent this tradition (Sites 5MT2173, 5MT2199, 5MT-2202, 5MT2235, 5MT2242, 5MT4682, 5MT4789, and 5MT4790). The preservational biases noted for these sites may skew the species representation.

The DAP Anasazi Tradition faunal assemblages reflect a great diversity of exploited habitats. The Anasazi peoples

profited by hunting rodents, rabbits, carnivores, artiodactyls, a variety of birds, and aquatic vertebrates. The frequent occurrence of rodents, rabbits, and deer is offered as evidence in support of a garden hunting model. The presence of one bird (sandhill crane) suggests an extension of its range in order to take advantage of the agricultural lands tilled by the Puebloan group. High altitude species (pika, marten, pygmy owl) are recovered from Anasazi Tradition sites; this suggests either climatic change or a different exploitative strategy. It seems that rabbits and deer made the largest contribution to the Anasazi diet. Bison bone (*Bison bison*) which was fairly common from some Mesa Verde sites is notably absent from the DAP area.

Elements of domesticated animal species support the contention that no continuum from Archaic Tradition to Anaszi Tradition has been identified. Further investigations will provide evidence to support or refute this contention.

Appendix C

THE CERAMIC DATA BASE

by William A. Lucius

INTRODUCTION

The ceramic data base consists primarily of data derived from inventory analysis of excavated ceramic assemblages from the 1978-80 field seasons. These data are composed of attribute and typological variable values in a computerized format. Refiring analysis and material source data have also been utilized for the following discussion. The definition of extraregional ceramic types has been facilitated through the use of a type collection library and by correspondence with ceramic specialists in adjacent regions. The ability to define the temporal placement of ceramic artifacts is inherent in the ceramic typology being used for data reduction and that characteristic has been instrumental in the evaluation of the various subjects being raised for discussion.

One purpose of this manuscript is to relate the ceramic data base to the temporal/functional systematics of the DAP. The exercise allows for illustration of the amount and type of data in the data base and provides examples of how the data can be structured in order to address archaeological questions. The temporal/functional matrix of the DAP represents an ordering of the project cultural features in terms of phase/subphase affiliation and site type. A discussion of the project systematics is available in Kane (1981a) and placement of sites or portions of sites into the temporal/functional matrix was accomplished by Kane.[1] Computer manipulation of the inventory level data by the matrix categories has provided the majority of the data cited in the study of the DAP systematics.

A second topic involves a discussion of the characteristics of the DAP ceramics and comparison with ceramics from other areas of the Mesa Verde region. The correlation of technological variables of ceramics (such as paste type and temper type) with resource availability and utilization has allowed for the characterization of ceramic variability within the Mesa Verde region.

Thus, two major topics are being addressed in this document. First, the discussion assesses the project systematics through the correlation of temporally diagnostic types, ceramic attributes, and foreign ceramics with the site types and the phase/subphase divisions. Second, a comparison of DAP ceramics with other ceramics of the Mesa Verde region is presented as a discussion of the progress made in relation to Problem Domain 1 of the Research Design (Kane, Lipe et al. 1981).

DISCUSSION OF SITE TYPES

Analysis Based on Ceramic Types

Six site-type groupings were selected for the organization of ceramic data for this discussion. Nonhabitation site types include seasonal loci (Anasazi), limited activity loci (Anasazi), and limited activity loci (Archaic/Anasazi mixed). Habitation site types include hamlets, large hamlets, and villages. Archaeological investigations have shown that hamlets predate large hamlets, which in turn predate villages. A change from simple to complex habitations apparently occurred between A.D. 600 and 900, with continuation of village occupation at a few sites well into the 10th century A.D.

In order to evaluate the association of ceramic types with the site types, a series of ceramic profiles was constructed for the six site types in the study (figs. 113-119). Since the three types of habitation sites generally are associated with different time periods, it was expected that the relative contribution of each dated ceramic type to the overall site type profile would be unique for each site type. A certain amount of "noise" was expected, because multicomponent sites selected for the analyses contain ceramic types unassociated with the particular site type being investigated. All calculations were based on sherd weights.

Figures 113, 114, and 115 illustrate the ceramic profile for each of the three habitation site types in the analysis. Each profile demonstrates the relative percentage of contribution each diagnostic type makes to the ware (each ware

[1]Allen E. Kane, Dolores, Colorado, personal communication.

represents 100 percent of its included types). The contribution each ware makes to the total of diagnostic ceramics in the site type is listed in parentheses as a percentage figure. The date ranges of the ceramic types are based on Breternitz et al. (1974), with additional refinements made possible by correlation of DAP ceramics with absolute dating results. The profile represents a seriational type of approach for the illustration of the relationships between diagnostic types at each site type. The ceramic profile for each site type is unique, as the relationships between ceramic types change through time. Therefore, derivation of a profile for each habitation site type allows for discussion of the criteria for distinguishing these site types by use of the ceramic data base. Also, it allows for determination of the approximate temporal range and occupation indicated for each site type.

The ceramic profile for small hamlets (fig. 113) is interpreted as supportive of the assertion that the site type is generally early in the Anasazi occupation (A.D. 600-750). The presence of Abajo Red-on-orange (A.D. 750-800) and Bluff Black-on-red in the site type may indicate that the present dating of those types is incorrect or that the site type continued to be used as late as A.D. 800. The occurrence of minor amounts of the later types of gray and white wares is interpreted as "noise."

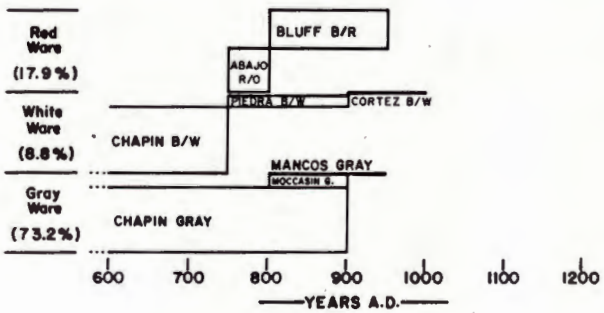


Figure 113. Diagnostic ceramic type occurrences for hamlets.

Large hamlets exhibit similar red ware occurrences (fig. 114), but Chapin Gray and Chapin Black-on-white types have been largely replaced by the distinctive Moccasin Gray and Piedra Black-on-white types. The dating of those types indicates that large hamlets generally appear at about A.D. 800 and last at least until approximately A.D. 850.

The ceramic definition of village sites (fig. 115) reflects a reduction in the amount of Abajo Red-on-orange and a subsequent increase in Bluff Black-on-red along with a decrease in Piedra Black-on-white in favor of Cortez Black-on-white. Moccasin Gray remains the predominant gray ware type associated with villages. The date range for villages can therefore be interpreted as beginning at about A.D. 850 and extending to A.D. 950 or 1000.

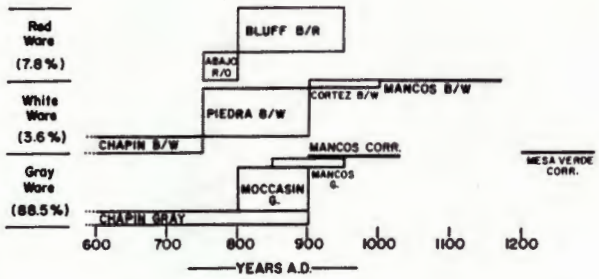


Figure 114. Diagnostic ceramic type occurrences for large hamlets.

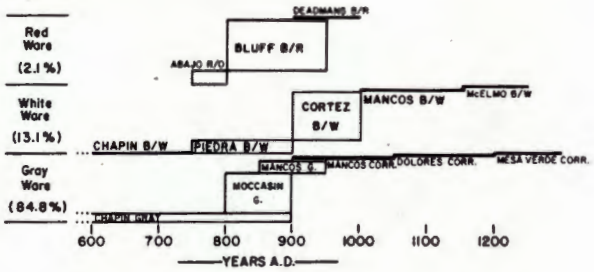


Figure 115. Diagnostic ceramic type occurrences for village sites.

The preponderance of Cortez Black-on-white in the village sites requires comment. At approximately A.D. 900, all village habitations in the river valley were apparently abandoned; an occupational hiatus has been documented at Site 5MT4475 and Site 5MT4477. Post-A.D. 900 occupation of the McPhee Community (Sites 5MT4475, 5MT4477, 5MT4479, and 5MT4480) and Grass Mesa (Site 5MT23) accounts for all of the Cortez Black-on-white, Deadmans Black-on-red, and Mancos Corrugated ceramics in the village profile. Interpretation of the data suggests that two separate occupations may be defined. A typical Pueblo I village type appears to occur between approximately A.D. 850 and 900, with reoccupation at only some of these locations after A.D. 900. Unfortunately, no reliable dating of the second occupation is available; it apparently ended by A.D. 1000. It should be noted that withdrawals of Cortez Black-on-white from the Pueblo I village profile would make profile separation of large hamlets and villages difficult (figs. 114 and 115).

The seasonal loci (Anasazi) site type was also included in the analyses, and the ceramic profile for this site type is interpreted as an indication that such sites were in use during the entire period from A.D. 600 to 1150 (fig. 116). Most of the seasonal loci have been interpreted as representing economic activities, primarily agricultural camps or field houses associated with habitation site types.

Figures 117 and 118 present the ceramic profiles for limited activity loci assigned to an Anasazi or Archaic/Anasazi

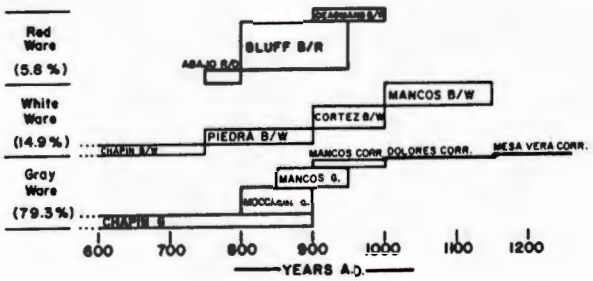


Figure 116. Diagnostic ceramic type occurrences for seasonal loci (Anasazi).

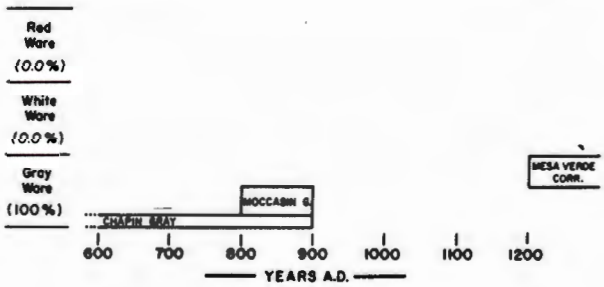


Figure 117. Diagnostic ceramic type occurrences for limited activity loci (Anasasi).

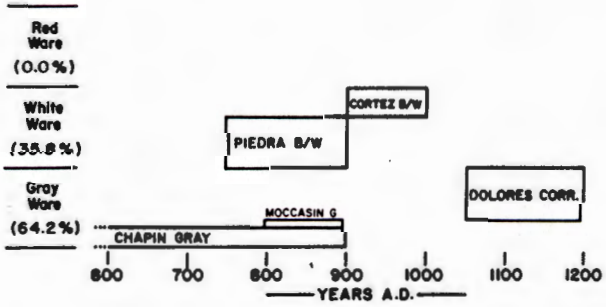


Figure 118. Diagnostic ceramic type occurrences for limited activity loci (Archaic/Anasazi).

affiliation. These sites have been interpreted as being primarily economic in purpose,[2] and generally exhibit small amounts of ceramic debris. The ceramic profiles of these site types are interpreted as indicating sporadic use by the Anasazi over a long period of time (A.D. 600-1200).

The ceramic profile derived for the data base which groups all site types (fig. 119) is interpreted as reflecting the range of Anasazi occupation in the project area. Primary occupation begins at approximately A.D. 600 and ceases by A.D. 1000, with subsequent occasional use indicated by the occurrence of later Pueblo II and Pueblo III ceramics in the collections.

[2]See footnote 1.

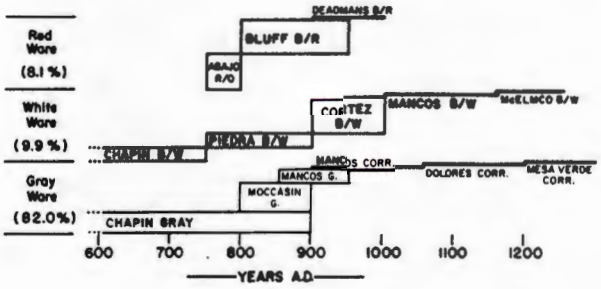


Figure 119. Diagnostic ceramic type occurrences for all site types.

Analysis Based on Temper Type

The characterization of site types by ceramic attributes was attempted through the examination of the number of distinct temper types at each site of a site type. The total number of temper types per site was plotted in a histogram format in order to evaluate the temper type variability for each site type (fig. 120). Site types are inferred to reflect structural complexity (Kane 1981a); ceramic diversity as reflected by temper type occurrence was also expected to vary directly with site type complexity. Specific temper types are indicators of resource utilization, and a general locale of manufacture can be derived for each distinct temper type (Lucius 1981a). Many of the manufacturing centers are located in the general Mesa Verde region. The occurrence of regional temper types as well as those indicating extraregional contacts in the various site types can be used to evaluate the approximate level of nonlocal interaction. The level of nonlocal interaction should reflect, to a degree, economic diversity in that greater levels of interaction provide greater opportunities for exchange of economic items.

Limited activity loci, in addition to exhibiting a limited range of ceramic types, consistently lack temper types foreign to the Mesa Verde region. Also, the number of temper types diagnostic of manufacturing centers adjacent to the Dolores area is minimal.

Seasonal loci generally include a broader range of temper types than the limited activity loci. Two sites (Site 5MT2203 and Site 5MT2241) exhibit ceramics diagnostic of the Chuska and Cibola regions. The occurrence of extraregional ceramics in those seasonal loci has been interpreted as an indication that such site types will reflect the ceramics available in the "parent" habitation site. Correlation of limited activity loci with parent sites for investigation of their possible relationships has not been attempted.

By far the largest number of excavated sites in the ceramic file represent habitations. Small hamlets show a considerable range of variability in the number of temper types present (fig. 120). Although temper type variability can be

partially explained as resulting from increasing exchange contacts with adjacent groups through time, not all of the variability can be explained in terms of differences in temporal affiliation, since some of the early Pueblo I small habitations exhibit a great amount of temper type variability (Site 5MT2193 and Site 5MT4644). It is suggested that the temper type variability in the small hamlet site type may be related to the number of households as well as the duration of site occupation. The mean value of temper type diversity in the small hamlet site type allows for distinction between the site type and any other type in the project site typology.

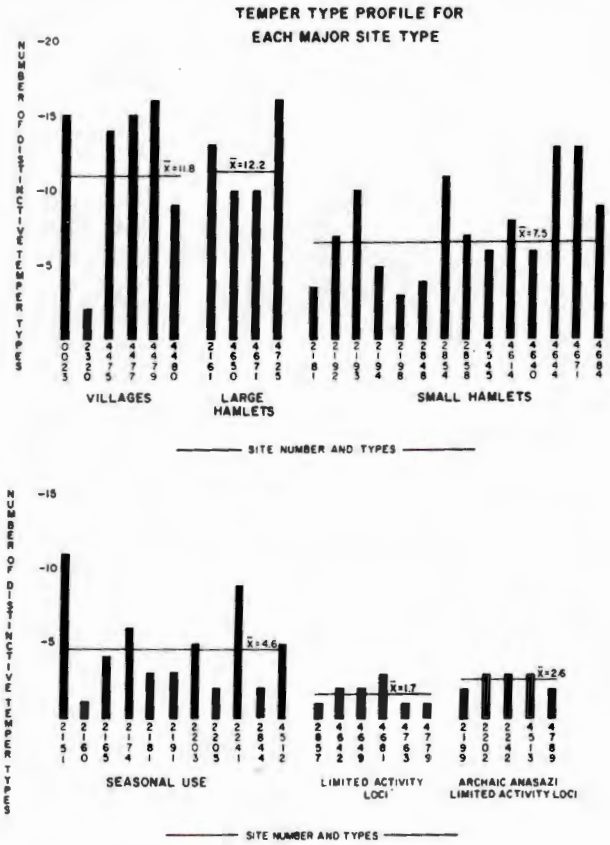


Figure 120. Temper type profile for each major site type.

Mean temper type diversity does not distinguish large hamlets from village sites. The similarity in temper type diversity between the two site types is in part due to the low value for Site 5MT2320; removal of this anomalous site from the village group increases the mean to 13.8. Further similarity in the temper types associated with both types of sites can be suggested to be possibly related to the similar time frame for the majority of the sites. In this case the temporal affiliation may be as important as the site type, since ceramic diversity increases after A.D. 850.

The Mann-Whitney *U*-test was applied to the ceramic temper type data ordered by site type in order to evaluate the ceramic variability of the site types (Siegel 1956:116-127). The exercise resulted in verification of the null hypothesis — there is a 91-percent probability that the village and large hamlet data were drawn from the same population. The slight differences between the two site types can be explained by noise in the data base. There appears to be little ceramic difference between village and large hamlet site types in terms of temper type variability. Evaluation of the remaining site types suggests that they are distinguishable by ceramic temper attributes.

The proposal that site type would correlate positively with the temper type diversity in the site (both classifications represent measurements of social complexity) seems to be borne out by the exercise. However, the data also can be interpreted to suggest that temporal affiliation, household size, and duration of occupation are involved in the temporal type diversity in the site types of the DAP. It should also be noted that the range of temper variability in the site types, especially for small hamlets, precludes assignment of specific sites to a site type only by the number of temper types present.

Analysis Based on Nonlocal Ceramics

As was previously discussed, the diversity of temper types in a site reflects the amount of nonlocal interaction during that occupation. Since limited activity and seasonal loci site types rarely contain foreign ceramics, they have not been included in this discussion of site types and their associated nonlocal ceramics.

Hamlets can be characterized as indicative of a dispersed settlement pattern. This segment of the Anasazi occupation dates roughly from A.D. 600 to 750 or 800; analysis of ceramics recovered from that site type consistently reveals a paucity of nonlocal ceramics. Those sherds of nonlocal ceramics can be consistently interpreted as having been manufactured in areas west of the project area, extending as far as the Kayenta region. Immigration and reciprocal exchange among kinsmen are thought to have been responsible for the movement of these ceramics from their point of origin (Lucius 1981a).

Ceramics interpreted as evidence of long distance exchange does not seem to occur until the appearance of large hamlets, about A.D. 750 (Lucius 1981a). A continued southwestern orientation is indicated by the presence of San Juan Red Ware which appears to have been manufactured in the southeastern Utah area (Lucius and Wilson 1980). Accompanying the red ware is an increased range of Mesa Verde temper types and a small amount of Mogollon Brown Ware.

Beginning at about A.D. 850, large hamlets and villages reveal the presence of ceramics derived from the Cibola and

Chuska areas to the south. White wares of the Cibola area and white, gray, and red wares fom the Chuska region have also been documented in these site types. Mesa Verde region ceramics from the San Juan River and Durango areas also become evident in those site types. After an occupation hiatus, which occurred at approximately A.D. 900, the McPhee Community ceramics exhibit an increased range of ceramics derived from the areas south of the project area. Red ware exchange with southeastern Utah was apparently continued, spanning the period from A.D. 750 through 1000.

Summary

The major Anasazi occupation of the Dolores Project area spans the use of three habitation site types. A shift from isolated hamlets to nucleated settlements is evident in the ceramic profiles. The reoccupation of several village sites by a population using Pueblo II ceramics (primarily Cortez Black-on-white and Mancos Corrugated) is not obvious when data are grouped by site type.

Limited activity loci and seasonal loci exhibit very identifiable ceramic profiles. Ceramic diversity also correlates well with site complexity. A correspondence between site type and the type and amount of foreign interaction can be proposed, but finer control of proveniences smaller than the site are required for evaluation of the proposition. Separation of large hamlets from villages on the basis of ceramics cannot be justified.

INVESTIGATION OF PHASES AND SUBPHASES

Analysis Based on Ceramic Types

For the purposes of discussion, the ceramic data base was subdivided to reflect the temporal systematics of the DAP (Kane 1981a). The Sagehen Phase (A.D. 600-850), when subdivided into early, middle, and late segments, reflects a continuum of development when plotted against temporally diagnostic ceramics (fig. 121).

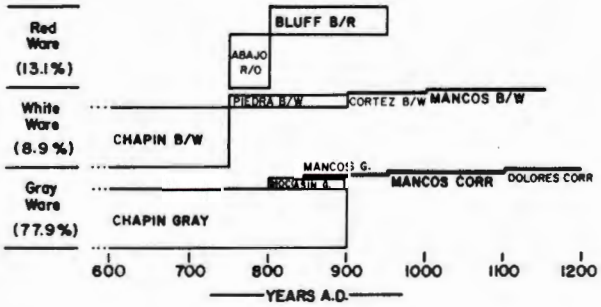


Figure 121. Diagnostic ceramic type occurrences for Sagehen Phase habitations.

Early Sagehen Phase sites (fig. 122) exhibit a ceramic profile typical of Anasazi occupation dating from A.D. 600 to 750. The date range coincides with the Basketmaker III period and, in part, with the La Plata Phase as proposed by Hayes (1964:88). Kane has suggested a date range from A.D. 600 to 700 for the subphase. As indicated in figure 113, small hamlets are the predominant habitation site type throughout the entire Sagehen Phase (Kane 1981a:68).

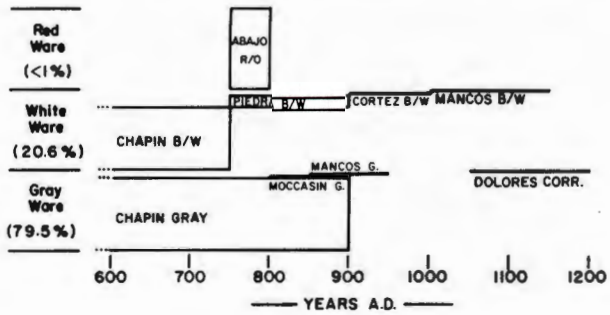


Figure 122. Diagnostic ceramic type occurrences for early Sagehen Phase (Tres Bobos Subphase) habitations.

The ceramic profile for the middle Sagehen Phase is interpreted as indicating a date range from approximately A.D. 750 to 800 (fig. 123). The virtual absence of Moccasin Gray ceramics, a type which has been dated as occurring only after A.D. 800 in the project area, suggests that sites of that subphase were occupied prior to the beginning of the ninth century A.D. Kane assigns a date range of 80 years to the middle Sagehen Phase (A.D. 700-780).

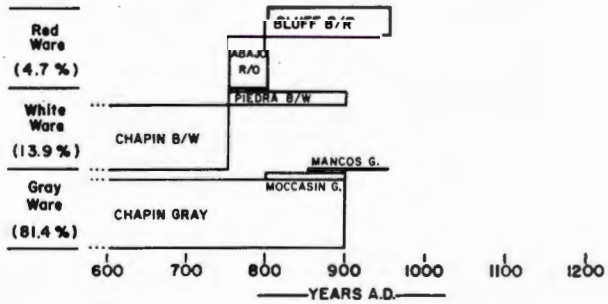


Figure 123. Diagnostic ceramic type occurrences for middle Sagehen Phase (Sagehill Subphase) habitations.

The end of the late Sagehen Phase has been estimated at A.D. 850 based on the lack of temporally diagnostic Mancos Gray in the ceramic profile (fig. 124). Both the middle and late portions of the Sagehen Phase fall within the Pueblo I period (A.D. 750-900).

The ceramic profile for the McPhee Phase (fig. 125) habitation sites in the McPhee Village supports an A.D. 850 date ascription for the beginning of the phase. (fig. 124). The

majority of DAP sites exhibit occupation during the McPhee Phase, A.D. 850-975 (Kane 1981a:68). The majority of the field houses excavated in the Dolores River area fall within this phase as do a number of limited activity loci (figs. 126 and 127).

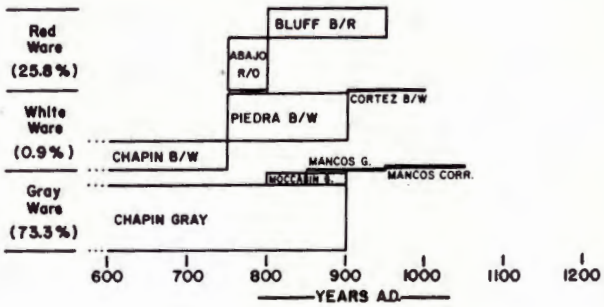


Figure 124. Diagnostic ceramic type occurrences for late Sagehen Phase (Dos Casas Subphase) habitations.

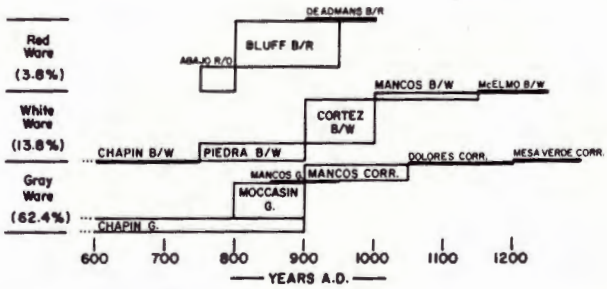


Figure 125. Diagnostic ceramic type occurrences for McPhee Village (McPhee Phase) habitations.

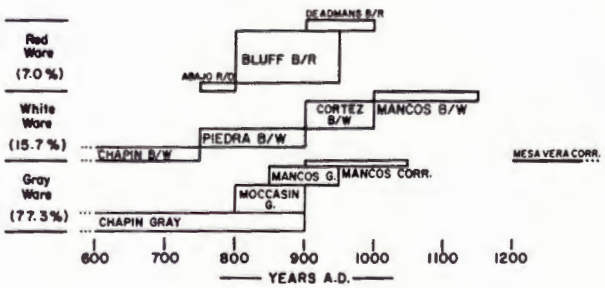


Figure 126. Diagnostic ceramic type occurrences for McPhee Phase seasonal loci.

Large hamlets and nucleated village site types were being occupied during the early McPhee Phase, dated from A.D. 850 to 900 based on the ceramic profile (fig. 128). Cortez Black-on-white, consistently dated as occurring between A.D. 900 and 1000 (Breternitz 1966), is minimal in the early McPhee Phase sites located in the McPhee Community (fig. 128). The indicated time period falls within the late Pueblo I period as well as the late Piedra Phase (Hayes 1964).

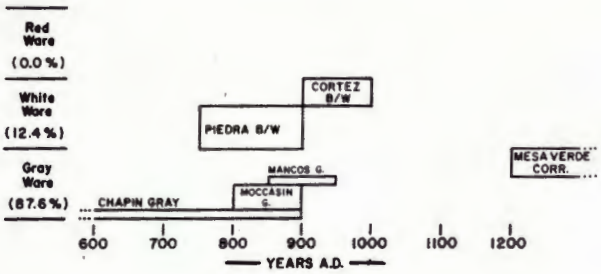


Figure 127. Diagnostic ceramic type occurrences for McPhee Phase limited activity loci.

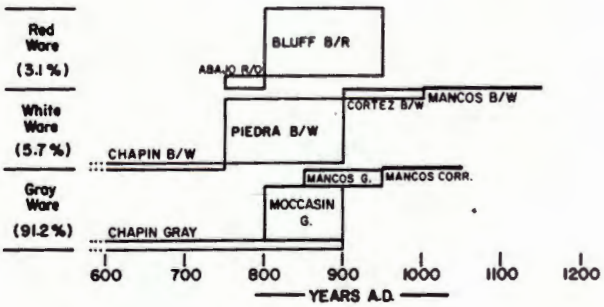


Figure 128. Diagnostic ceramic type occurrences for McPhee Village, early McPhee Phase (Periman Subphase) habitations.

The late McPhee Phase ceramic profile is based on collections from portions of two sites of the McPhee Community (Site 5MT4475 and Site 5MT4477); the subphase apparently documents the reoccupation of these sites after an occupational hiatus which occurred at approximately A.D. 900 (fig. 129). Mancos Corrugated and Cortez Black-on-white ceramic types are considered the hallmarks of the early Pueblo II period (Hayes 1964:92). Ceramic profiles from the Grass Mesa Village show a similar early/late dichotomy in the McPhee subphases (figs. 130 and 131).

The terminal date for the McPhee Phase has been estimated at A.D. 975 by Kane (1981a:66). Hayes (1964:88) dates the early Mesa Verde Pueblo II occupation as

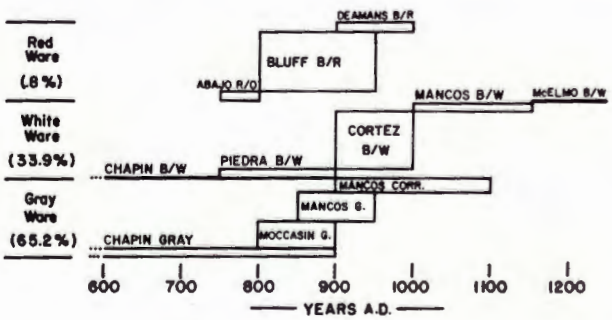


Figure 129. Diagnostic ceramic type occurrences for McPhee Village, late McPhee Phase (Cline Subphase) habitations.

occurring between A.D. 900 and 950. A lack of absolute dates for the cessation of the Pueblo II occupation of the McPhee and Grass Mesa Villages prevents the assignment of a more precise date range to the project area occupation. The lack of significant amounts of Mancos Black-on-white ceramics in these sites suggests that the project area was abandoned again prior to A.D. 1000.

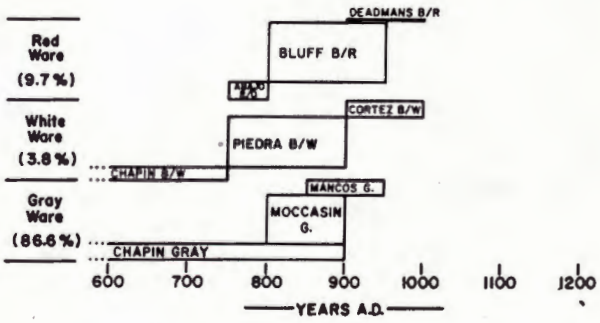


Figure 130. Diagnostic ceramic type occurrences for Grass Mesa Village early habitations (Periman Subphase).

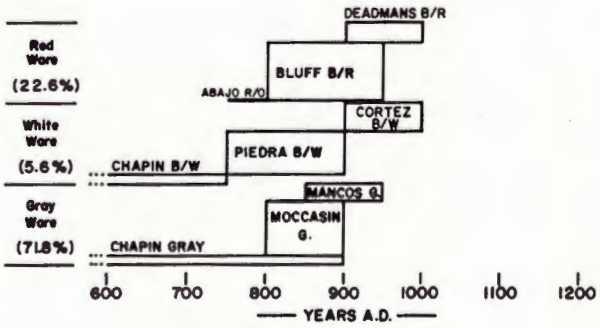


Figure 131. Diagnostic ceramic type occurrences for Grass Mesa Village late habitations (Grass Mesa Subphase).

The Sundial Phase has been tentatively dated as occurring between A.D. 1050 and 1200 (Kane 1980). Subphase designations have been formulated but, due to the small sample size, they were not considered in this analysis. Hamlets are again recorded as the primary habitation site types of this phase. Review of the ceramic profile for hamlets of this phase (fig. 132) supports this general dating framework. However, the McElmo Black-on-white ceramics recovered from DAP sites suggest cessation of occupation at the primary site of this period (Site 5MT2235) by A.D. 1150, or during the early part of the phase. Seasonal and limited activity loci site types of the Sundial Phase (figs. 133 and 134) support a Late Pueblo II to Early Pueblo III assignment to this occupation (Hayes 1964:88).

Summary

In summary, subdivision of the ceramic data base by the DAP temporal systematic scheme allows for review of the

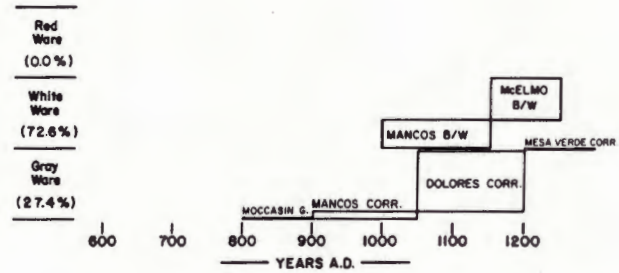


Figure 132. Diagnostic ceramic type occurrences for Sundial Phase small habitations.

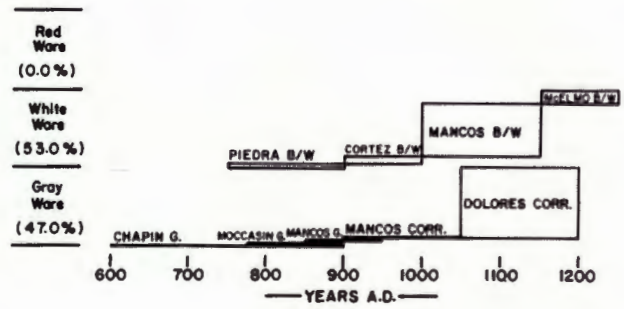


Figure 133. Diagnostic ceramic type occurrences for Sundial Phase seasonal loci.

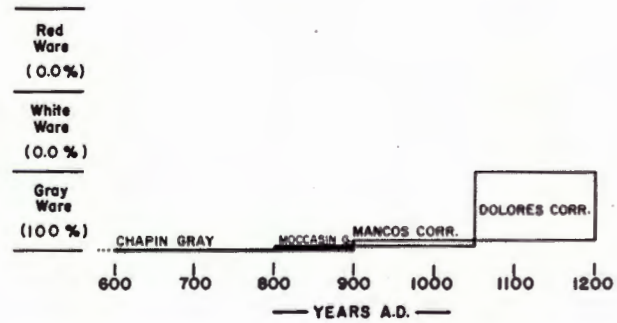


Figure 134. Diagnostic type occurrences for Sundial Phase limited activity loci.

phases and subphases of the DAP. Settlement pattern and architectural criteria were primarily used in the definition of phases and subphases (Kane 1981a). Therefore, evaluation of the temporal systematics has been accomplished through the use of an independent data base. In general, the major phases and their subphases can be illustrated through the use of ceramic profiles.

Attempts were made to evaluate the project systematics from two additional viewpoints. Comparison of the frequency of vessel forms (bowl, jar, other) with site types revealed no significant or interpretable differences. When compared with phases, the vessel form data do indicate a shift in the Sundial Phase to a lesser percentage of jars and a

concurrent increase in bowl sherds. Much of the difference may be attributable to sampling error; very few Sundial Phase ceramics have been recovered in comparison with ceramics from the preceding Sagehen and McPhee Phases. Also, the recovery of funerary offerings at Site 5MT2235 may have skewed the vessel form frequencies, as bowl forms were predominant in that collection.

If the observed patterning in vessel form frequencies does hold true for the Sundial Phase, the characterization of the temporal affiliation of a site based on the relative frequencies of the three primary vessel forms may become a useful tool.

Correlation of site types and the phase/subphase divisions with the frequency of gray, white, and red ware occurrences revealed no interpretable differences. Without finer temporal division of the proveniences, no differentiation of the project area cultural features by the associated wares is possible.

Location Of Manufacture Of DAP Ceramics

The Resource Proposition

Definition of ceramic manufacturing locales smaller than the region is an integral part of the DAP ceramic analysis program (Lucius 1981a). A basic tenet allowing for the definition of manufacturing areas is the resource proposition. The proposition recognizes that there are differences in the availability of ceramic resources and that the use of different combinations of resources (clays and tempers) in a suite of ceramics is an indicator of the location of manufacture of the ceramics. Problem Domain 1 of the Research Design has directed research into resource availability and utilization in the project area and has allowed for the characterization of DAP ceramics. The following discussion proposes answers to several questions in the Research Design (as they apply to ceramics). The ability to relate specific ceramics to particular areas within the Mesa Verde region allows for the distinction of intraregional ceramics. The characterization of those ceramics is based on the combinations of clay and temper types that can be associated with particular areas of resource availability and use.

Analysis of the ceramics of the Mesa Verde region prior to the DAP investigations, although recognizing temper variability in ceramic types, treated the types as regional in scope (Breternitz et al. 1974; Hayes 1964; Rohn 1977). No attempt was made to define manufacturing locales smaller than the region, although the variability in temper types was recognized as a distinguishing characteristic for the separation of San Juan and Mesa Verde White Wares (Abel 1955).

The analysis of ceramics from several areas of the Mesa Verde region has allowed for the definition of several distinct manufacturing tracts within the area (Lucius 1981a). The Dolores Tract is defined as an area of ceramic manufacture which consistently exhibits the production of ceramics with a limited range of clay types in association with a specific temper type. A distinctive crushed rock type derived from river cobbles was used for locally manufactured ceramics. Those ceramics consistently represent the majority of ceramics in the DAP sites; the definition of locally produced ceramics requires that they exhibit the use of locally available resources and constitute the majority of ceramics in local sites. The Dolores Tract extends along the Dolores River valley to Dove Creek, Colorado (fig. 135).

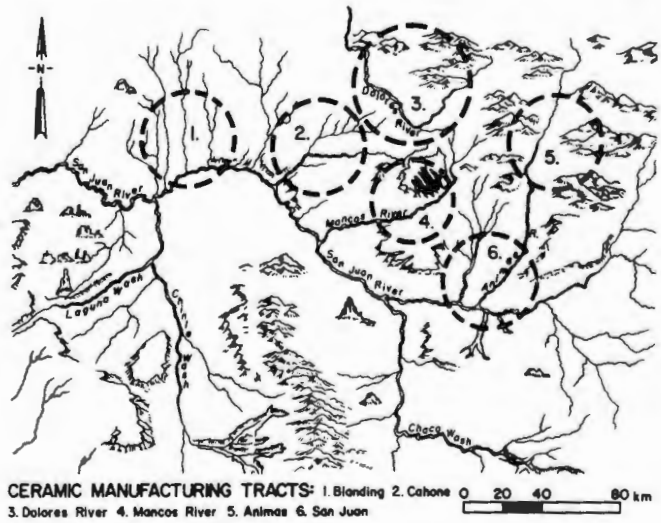


Figure 135. Ceramic manufacturing tracts.

In the Durango area, the Animas Tract produced distinctive white ware ceramics with glaze paint during the Pueblo I period of Anasazi occupation (Ellwood 1980; Lucius 1981b; Shepard 1939). Gray ware ceramics of the area consist of red-burning clays in association with a crushed quartzite temper. Red ware manufacture was apparently practiced in the southeastern Utah area (the Blanding Tract) of the region (Lucius and Wilson 1980). Recent analysis of the ceramics from the MAPCO Pipeline Project (Lucius 1981b) has suggested that distinctive ceramics with a sand temper were also being produced in the Cahone Tract of southwest Colorado.

Ceramics of Mesa Verde National Park and surrounding areas have been intensively reported (Hayes 1964; Hayes and Lancaster 1975; Rohn 1971) and summarized (Breternitz et al. 1974). However, the lack of a similar resource orientation in those studies makes comparison of the Mesa Verde ceramics with those of the DAP difficult. Analysis of the ceramics derived from the Palmer Mesa Survey (Lucius 1981c), located adjacent to the Mancos River, suggests that ceramics of the Mesa Verde National Park area are similar to those of the DAP. A crushed river cobble temper which is difficult to distinguish from the type of rock used in the

DAP ceramics is used in the Mancos Tract. Refiring analysis would need to be undertaken to distinguish effectively between ceramics of the Mancos Tract and the Dolores Tract. However, the different clay resources of the two areas should have led to the selection of differing clays for manufacture. No such analysis has yet been undertaken.

Ceramics from the San Juan River area of the Mesa Verde region (the San Juan Tract) have been recovered in DAP sites. They contain a distinctive clay type in association with a crushed river cobble temper distinguishable from that of the Dolores and Mancos Tracts. It is believed that analysis of ceramics from other areas of the Mesa Verde region will define additional ceramic tracts which produced ceramics different from those of the Dolores River area. The location of one such tract, which is definable by the use of a crushed sandstone temper, has not yet been defined.

Summary

The ceramics of the Dolores area can be distinguished from those made in other tracts of the Mesa Verde region. The value of those distinctions lies in the ability to model cultural interaction based on the occurrence of nonlocal (intraregional) ceramics in sites of a specific area. Preliminary assessment of several such models has led to the proposition that the distribution of ceramics between the various manufacturing tracts of the Mesa Verde region was common for all wares. The transfer of those ceramics may be approached in terms of models of immigration, exchange, or expeditionary forces (Lucius 1981a).

DISCUSSION AND SUMMARY

The analysis, data, and interpretations presented in the preceding sections address several questions of the Research Design (Kane, Lipe et al. 1981). In addition to evaluation of the site type and phase/subphase systematics of the temporal/functional matrix (chapter 3, this report) the discussion directly approaches two of the five problem domains of the Research Design.

Problem Domain 1, which is concerned with resource availability and use, is reflected in the resource proposition data used in the characterization of the DAP ceramics. Resource assessment and refiring analyses are ongoing at the DAP. However, the regional scope of the inquiry will require similar analyses outside of the DAP.

The ability to characterize the location of manufacture for ceramics has allowed for the definition of locally produced ceramics. Recognition of nonlocal ceramics in DAP sites has additionally allowed for the development of a general model of ceramic exchange and movement (Problem Domain IV), and has been used to evaluate the DAP site types.

The investigation of resource availability and utilization and foreign interaction also has ramifications for the study of Problem Domain 3 (Social Organization). Future analyses are being designed in order to use the ceramic data base in association with other computerized data in an attempt to define social groupings such as task or kinship groups.

The difficulty in making concrete statements concerning many of the issues raised by this discussion relates directly to the interim nature of many of the investigations being undertaken by the additive task group specifically and by the DAP in general. A major portion of the preceding 3 years has been involved in the design and implementation of the procedures for the documentation, storage, and retrieval of the ceramic data base. Recently, a greater amount of time and effort has been spent on the necessary tasks of reviewing the utility of the data and its application to specific problems of the Research Design. The amount of effort required for this facet of the analysis routine is expected to increase throughout the remaining life of the DAP investigations.

Appendix D

LITHICS

by Carl J. Phagan

LITHIC DATA SUMMARY

This data summary includes most of the DAP survey and excavated materials. A few of the 1980 excavated materials have yet to be edited and approved for file use, but these should not seriously affect the totals or percentages that appear in this summary. Variables which have been selected for inclusion and preliminary interpretation are as follows:

Flaked Lithic Tools (FLT)
- Two raw material variables
- Traditional "morpho-use" category
- Item condition
- Four production technology variables
- Core specialization
- Item weight

Nonflaked Lithic Tools (NFLT)
- Traditional "morpho-use" category
- Item condition
- Technological production stage
- Item weight

Flaked lithic debitage data have not been included, but very preliminary indications are that they will confirm and expand upon the interpretations given here.

The data will be organized according to groupings which reflect the program's temporal and spatial systematics and site typology. Descriptions and interpretations will be brief and for the most part restricted to unique elements or characteristics for the particular data group(s). Most of the data have been converted to percentages within each site grouping, and total sample size (N) is given for each group.

Systems of lithic tool production and, to a lesser extent, tool use are among the most stable of behavioral subsystems within cultures. It is anticipated, therefore, that lithic variability within the DAP sequence will be much more closely associated with, and useful in interpreting, site function rather than with the time of the site's occupation. Only in very broad terms should lithic assemblage variability serve as a temporal indicator.

Archaic Tradition (FLT: N = 553; NFLT: N = 315)

DAP archaeological materials that represent the Archaic Tradition are few and poorly identified. They invariably (?) occur as mixed Archaic and Anasazi deposits, and their definition and interpretation are therefore difficult. It is impossible to determine how much of the material is actually Archaic, though all possible "apparently Anasazi" material has been removed. The sample size from Archaic camps is too small for adequate interpretation (FLT: N = 32; NFLT: N = 11), and all Archaic material will therefore be interpreted as a single group of "Archaic-plus-some-Anasazi" material. Generalized comparisons are with combined DAP Anasazi material. (Note: A percentage profile of combined DAP Anasazi lithic material will be found in chapter 5, section 6, this report. In addition, the use of "lithic profiles" is considered in detail.)

The FLT assemblage (N = 553) has the following characteristics:

A low proportion of utilized flakes (20.7 percent)

Low proportions of used and unused cores (3.5 and 4.9 percent)

A slightly high proportion of specialized items (4.6 percent)

A slightly high proportion of thick bifaces (11.5 percent)

A significantly higher proportion of thin bifaces (16.7 percent)

A significantly higher proportion of projectile points (15.4 percent)

Low proportions of cortex on both dorsal and ventral faces (19.2 and 5.0 percent)

A high proportion of items with well-worked faces (30.3 percent)

A high proportion of items with bidirectionally produced edges (43.8 percent)

A high proportion of items with produced edges around entire tool (28.1 percent)

A low proportion of complete items (57.7 percent)

A low mean weight (38.3 grams; standard deviation = 101.6)

This profile strongly suggests a pattern of lithic tool production which involves considerable input per item, as clearly seen in the relatively high proportions of specialized items, bifaces, and projectile points, with little cortex remaining on tool surfaces. Tool edges are frequently formed completely by bidirectional flaking, rather than by either unidirectional flaking or simply the selection of appropriate flake edges. Archaic flaked lithic tools are considerably smaller than Anasazi tools, though at least part of this difference is due to the lower proportion of complete items in the Archaic assemblage.

The Archaic NFLT assemblage (N = 315) is characterized by the following:

Considerably fewer hammerstones (2.5 percent)

More one-hand manos (23.8 percent)

Fewer two-hand manos (4.8 percent)

Fewer hafted items (0.3 percent)

Considerably fewer items used with little (8.3 percent) or no (27.9 percent) production modification

Considerably smaller items (mean weight = 487 grams), very few of which (15.6 percent) are complete

Both FLT and NFLT characteristics of the Archaic assemblages are consistent with general expectations for the supposed lifeways of highly mobile hunters and gatherers. A very "curated" approach to flaked lithic technology is apparent, in which effort is focused, probably at resource procurement locations, on the production of well-worked, high-input items which are relatively small (for easy transport) and which are maintained and repaired until they are either broken or lost. Most direct evidence in the assemblage is concentrated on the later and final stages of lithic reduction. Nonflaked tools suggest a very different, more "expedient" approach to tool production.

Sagehen Phase (FLT: N = 4,065; NFLT: N = 2,196)

DAP Sagehen Phase materials occur primarily within archaeological situations termed "unit hamlets," or small permanent habitation sites of Anasazi households. The FLT profile (N = 4,065) for these sites has the following characteristics:

35.4 percent utilized flakes

35.7 percent used and unused cores

All major tool classes range only between 2 and 9 percent, including

9.1 percent thick unifaces

7.6 percent thin unifaces

2.7 percent specialized items

7.1 percent thick bifaces

6.8 percent thin bifaces

5.4 percent projectile points

84.3 percent of items are complete

31.1 percent of items retain cortex on one or both faces

8.2 percent of items have well-worked faces

22.0 percent of items have bidirectionally produced edges

9.0 percent of items have produced edges around the entire margin

Mean weight of FLT items is 119.3 grams, with a reasonably small standard deviation (229.4), which indicates a rather "standardized" approach to tool production

The NFLT profile (N = 2196) is characterized by the following:

16.7 percent hammerstones

18.7 percent one-hand manos

10.4 percent two-hand manos

8.2 percent metates

3.5 percent hafted items

57.3 percent complete items

78.9 percent of items used with little or no prior production modification

Mean weight of NFLT items is 2057 grams (standard deviation = 5069)

These lithic tool profiles, when compared with those for the Archaic Tradition assemblage, demonstrate a considerably more "expedient" approach to flaked tool manufacture. There are noticeably fewer high-input items; more FLT items retaining cortex, and fewer with well-worked faces; more NFLT items used with little or no production modification; fewer FLT items with produced edges around all or most of the tool margins; many more unretouched flakes and their parent cores; significantly larger FLT and NFLT items, with many more complete items in the assemblage. These profiles, too, appear to fit well with general expectations for the more sedentary, horticultural Anasazi household groups.

It is apparent in the DAP archaeological record that, while these Sagehen Phase unit hamlet sites are quite similar in many respects, they should also reflect in some way(s) the Anasazi cultural development which led to the population increase and agglomeration evident in the large village sites of the succeeding McPhee Phase. In order to examine this Sagehen Phase cultural development in more detail, habitation sites were separated on a preliminary basis into early (Tres Bobos Subphase), middle (Sagehill Subphase), and late (Dos Casas Subphase) temporal groupings. In addition, the small group of seasonal occupation and limited activity sites has been considered separately. It should be stressed that the DAP lithic analysis systems are primarily designed to monitor technological and, indirectly, functional variability in archaeological assemblages. It is anticipated, therefore, that lithic variability among the rather brief time periods represented by an early-middle-late Sagehen grouping will be quite minimal. The basic Anasazi pattern of producing and using stone tools should change very little during any temporal phase, even though other organizational or individual aspects of the culture, including its population, may have been altered significantly.

Of the 32 FLT attribute states evaluated for this data synthesis, 5 demonstrate a possible trend through time in their values. The proportion of utilized flakes increases from 31.7 percent (early, total N = 728) to 33.6 percent (middle, total N = 1344) to 39.6 percent (late, total N = 1779); used cores decrease from 19.8 to 18.1 to 9.7 percent; projectile points decrease from 7.0 to 4.1 to 3.8 percent; items with well-worked dorsal faces decrease from 9.0 to 6.5 to 3.2 percent; and items with well-worked ventral faces decrease from 9.0 to 5.2 to 2.8 percent. Among 16 NFLT attribute states, 2 reveal such trends: the proportion of hafted items increases from 2.2 percent (early, total N = 448) to 2.5 percent (middle, total N = 908) to 5.5 percent (late, total N = 761), and the proportion of complete items increases from 52.2 to 56.9 to 62.3 percent.

In addition to these trending attribute state values, early Sagehen sites demonstrate slightly more FLT items retaining cortex, and a slightly coarser grain size for FLT items. Middle Sagehen sites show a lower proportion of recognizably local FLT raw materials, a slightly higher proportion of complete FLT items, the lowest proportion of FLT items retaining cortex, slightly lower proportions of FLT items with well-worked faces, and slightly larger FLT but smaller NFLT items. Middle Sagehen NFLT assemblages are also characterized by greater proportions of hammerstones and one-hand manos, but fewer two-hand manos than early or late Sagehen sites. In addition, middle Sagehen NFLT items show less production modification, more are broken, and at least partly as a consequence, weigh less.

The late Sagehen site grouping shows increased proportions of noncrystalline FLT raw materials, as well as more local cherts and local quartzites, which may indicate an unusual pattern of selecting primarily the higher quality local materials. This interpretation is somewhat contradicted by the fact that very few dorsal and ventral tool faces are well worked. Among NFLT variables, the late Sagehen Phase grouping shows a slightly low proportion of one-hand manos, a rather high proportion of hafted items, and a slightly high proportion of complete items.

While this early-middle-late division of Sagehen habitation sites does not demonstrate strong or consistent temporal trends in the lithic materials, neither do the results argue against such trends. The lithic data simply indicate minor technological or functional distinctions among the three groups of small Anasazi habitation sites.

However, as expected, the small group of Sagehen Phase seasonal occupation and limited activity sites, because it is functionally rather than temporally defined, demonstrates striking variation from the overall Sagehen Phase profile. Lithic raw material characteristics are typical Sagehen, but every FLT (N = 266) type and technological variable shows unusual values, as follows:

Low proportions of utilized flakes (28.6 percent), used and unused cores (4.1 and 4.5 percent), and thin bifaces (6.8 percent)

High proportions of thick unifaces (13.2 percent), specialized forms (7.9 percent), and projectile points (17.7 percent)

Very low proportions of both dorsal and ventral faces which retain cortex (20.7 and 2.7 percent)

Extremely high proportions of both dorsal and ventral faces which are technologically well worked (47.8 and 38.4 percent)

A very high proportion of items with bidirectionally produced edges (38.0 percent) located around the entire circumference

A very low mean weight (39.4 grams), with a slightly high standard deviation (135.4)

For the NFLT (N = 84) variables, Sagehen seasonal and limited activity sites demonstrate the following:

A somewhat low proportion of hammerstones (9.5 percent)

An extremely high proportion of one-hand manos (52.4 percent)

An absence of trough metates (could be an early analysis definition problem)

A low proportion of complete items (35.7 percent)

A low proportion of well-shaped items (3.6 percent)

A very low mean weight of 690 grams (standard deviation = 1575)

These lithic profiles strongly support a functional distinction for the sites in the group. The precise nature of this distinction will be defined and quantified in intensive and synthetic studies, but a few tentative generalizations are appropriate. Activities at these sites are probably focused on procurement and processing of wild plant and animal resources. The FLT tool kit emphasizes small, specialized, high-production-input items, with the exception of thick unifacial choppers. This, along with the very high proportion of projectile points, suggests hunting activity for at least some of the sites, and confirmation of this interpretation may be available from the faunal data. The NFLT assemblage, on the other hand, consists predominantly of low-input items, with a very heavy emphasis on small one-hand manos. This strongly suggests the processing of wild plant foods rather than the specialized processing of corn.

McPhee Phase (FLT: N = 4091; NFLT: N = 3172)

Unlike the earlier Sagehen Phase, the majority of McPhee Phase archaeological material occurs in large, pueblo-type village contexts. Several general models, as well as preliminary indications from the DAP archaeological assemblage, suggest some form of Anasazi cultural development which involves the following interacting elements: increasing population, movement of population to fewer and larger habitation sites, increased complexity of social organization, and increased dependency on corn.

On the basis of these few broad assumptions, one might expect the McPhee Phase lithic assemblage to be affected in several ways. The basic technology of production should remain fairly stable for both FLT and NFLT. If dependence on corn increases, both the total proportion of NFLT's and of specialized tool forms for its production and processing should increase: At the same time, specialized FLT forms associated with animal procurement should continue, but could decrease slightly in frequency. As village populations increase, procurement of food will be located further from these habitations, and these specialized procurement locations should increase in number and variety. In addition, they should be readily distinguishable as such from habitations on the basis of their lithic artifact content, since they occur as special function sites.

The total FLT assemblage for the McPhee Phase differs very little from the Sagehen assemblage. Slightly more McPhee Phase raw material consists of very fine grained local quartzites, and the proportion of nonlocal raw material is reduced. Among technological variables, McPhee differs from Sagehen only in having a slightly higher proportion of both dorsal and ventral tool faces which are well worked (12.4 and 11.1 percent). The only tool type differences are that McPhee has slightly more thick unifaces and bifaces (11.3 and 8.5 percent) and fewer thin unifaces and bifaces (5.6 and 4.7 percent).

In the NFLT assemblage, McPhee has a significantly increased percentage of well-shaped items (22.4 percent), and the relative proportions of one-hand and two-hand manos are reversed: Sagehen has more one-hand manos (18.7 percent one-hand, 10.4 percent two-hand), while McPhee has more two-hand manos (11.3 percent one-hand, 18.6 percent two-hand). These total assemblage variations, while not exactly overpowering, are consistent with expected patterns. None, except perhaps the NFLT differences, could be used confidently to distinguish McPhee Phase sites from Sagehen Phase sites.

McPhee Phase habitation sites were subdivided into six groups on the basis of time and/or space, and two additional groups on the basis of site type or function. Comparisons are with the total McPhee Phase habitation assemblage.

1. <u>McPhee Village, early (FLT: N = 646; NFLT: N = 622)</u>
This group displays a very low proportion (11.1 percent) of FLT lithic raw material which was not identifiable and a low proportion of nongranular raw material (13.2 percent). There is a low proportion of utilized flakes (24.8 percent), a high proportion of both used cores (21.4 percent) and unspecialized cores (29.9 percent), and a slightly low proportion of well-worked ventral tool faces (3.8 percent). The NFLT assemblage shows an unusually low proportion of one-hand manos (2.6 percent), a slightly high proportion of trough metates (12.4 percent), and a slightly higher mean NFLT weight (2757 grams, standard deviation = 6777).

2. McPhee Village, late (FLT: N = 846; NFLT: N = 724)
The only attribute values which vary significantly from the McPhee Phase means are a slightly high proportion of FLT dorsal and ventral faces which are well worked (20.7 and 17.2 percent), and a slightly low FLT mean weight (100 grams, standard deviation = 173).

3. Grass Mesa Village, early (FLT: N = 420; NFLT: N = 185)
This site grouping demonstrates an unusually high FLT proportion of local quartzite raw material use (44.3 percent), a slightly low proportion of thick bifaces (3.8 percent), and a slightly reduced proportion of bidirectionally produced tool edges (16.2 percent). The NFLT assemblage shows increased proportions of trough metates (16.8 percent), hafted items (6.5 percent), and ornaments (3.2 percent). In addition, the NFLT items are noticeably larger (mean weight = 2879 grams, standard deviation = 6441).

4. Grass Mesa Village, late (FLT: N = 322; NFLT: N = 279)
The only FLT variables which demonstrate marked differences from the mean of all McPhee Phase habitations are a low proportion of utilized flakes (26.7 percent), a slightly high percentage of used cores (20.2 percent), and a high proportion of projectile points (10.9 percent). Among NFLT variables, this site group demonstrates only a slightly high proportion of ornaments (3.2 percent).

5. House Creek Village (FLT: N = 90; NFLT: N = 130)
This small group, which consists of a single site, shows high proportions of noncrystalline FLT raw material which is not identifiable (27.8 percent), and somewhat low proportions of both local cherts (5.6 percent) and local quartzites (11.1 percent). FLT technological variables show slightly high proportions of well-worked dorsal and ventral tool faces (15.6 and 14.4 percent), low proportions of thick unifaces (4.4 percent), and high proportions of thin unifaces (14.4 percent) and thin bifaces (8.9 percent). NFLT variables show rather low proportions of hammerstones (8.5 percent), trough metates (1.5 percent), and hafted items (0.8 percent). In addition, the proportion of FLT's to total tools (FLT and NFLT) is quite small.

6. Rio Vista Village (FLT: N = 704; NFLT: N = 364)
For this data grouping there is a high proportion of recognized local FLT raw materials, particularly local cherts (27.4 percent). Several FLT technological variables suggest an unusually low level of production input: slightly low proportions of thin bifaces (3.4 percent) and projectile points (2.6 percent), and very low proportions of well-worked dorsal and ventral tool faces (0.9 and 0.9 percent). There is also a rather low proportion of bidirectionally produced edges (17.3 percent), and they are infrequently placed around the entire tool margins (3.7 percent). NFLT characteristics are very low proportions of both one-hand manos (2.5 percent) and two-hand manos (10.7 percent), and a low proportion of well-shaped items (13.7 percent).

There are no obvious trends in either FLT or NFLT characteristics which could be temporally defined. The percentage of flaked lithic tools in the total assemblage varies from 40.9 percent at the House Creek Village to 69.4 percent in the early Grass Mesa site cluster. A definite pattern for all groups seems to be the use of the most locally available lithic materials for producing flaked lithic items. The high proportions of ornaments in the Grass Mesa Locality groups may indicate a status differential at that locale.

7. McPhee seasonal occupation sites (FLT: N=690; NFLT: N= 528)
This group consists primarily of "field houses," or small sites with minimal architecture located away from the main McPhee Phase villages. These are tentatively defined as locations of corn production and processing, with perhaps some incidental animal resource procurement, or "garden hunting." With reference to FLT raw material, this site group shows a low proportion of nongranular materials (12.9 percent), very few of which are recognized as either local cherts (2.3 percent) or quartzites (12.5 percent). The flaked lithic assemblage contains fewer utilized flakes (28.6 percent), fewer used cores (10.3 percent), more specialized items (5.4 percent), more thick unifaces (17.0 percent), and more specialized cores (7.0 percent). There are fewer items retaining cortex on dorsal faces (25.7 percent) and on ventral faces (1.9 percent).

Among the NFLT variables, there are fewer hafted items (1.1 percent), more one-hand manos (20.5 percent), fewer two-hand manos (7.4 percent), and fewer trough metates (4.4 percent). Fewer items are complete (35.4 percent), and there is a low proportion of well-shaped items (5.5 percent).

The suggestions here are for some type of specialized FLT activity which is not focused on high-input bifacial tools — perhaps the production, maintenance, or use of bone or wood tools such as digging sticks, bows and arrows, or snares and traps. The high proportion of one-hand manos, as well as relatively few two-hand manos and trough metates may indicate the somewhat lesser importance of processing the corn produced at the sites and greater importance of collecting and processing wild plant foods and/or seeds.

8. McPhee Phase limited activity sites (FLT: N = 204; NFLT: N = 97)
This site group demonstrates extremely different lithic profiles for both FLT and NFLT assemblages. These are summarized as follows:

FLT (N = 204)

A very high proportion of nongranular raw material (43.6 percent)

A very low proportion of utilized flakes (18.6 percent)

A very low proportion of used cores (5.4 percent)

A very low proportion of unused cores (6.4 percent)

A high proportion of specialized items (5.9 percent)

A very high proportion of thin bifaces (10.3 percent)

A very high proportion of projectile points (17.2 percent)

A low proportion of complete items (66.7 percent)

A low proportion of items retaining dorsal cortex (23.6 percent)

A very high proportion of well-worked dorsal faces (51.4 percent)

A very high proportion of well-worked ventral faces (44.6 percent)

A very high proportion of bidirectionally produced edges (44.2 percent)

A very low mean weight (42 grams; standard deviation = 115)

NFLT (N = 97)

A low proportion of hammerstones (6.2 percent)

A very high proportion of one-hand manos (52.6 percent)

A very low proportion of two-hand manos (4.1 percent)

An absence of trough metates

A low proportion of hafted items (1.0 percent)

A low proportion of complete items (35.4 percent)

A low proportion of well-shaped items (5.5 percent)

These differences, of course, are substantial and reflect the functional definition of the site grouping. There are obvious similarities with the Archaic Tradition profiles, and site activity is probably quite similar: the acquisition and processing of wild resources, both plant and animal, at temporary hunting camps and collecting locations. The FLT pattern is one of small, high-production-input items, specialized tool forms, and high curation and maintenance of these items. The NFLT pattern is one of casual production and use of low-input items — a very expedient approach.

Sundial Phase (FLT: N = 880; NFLT: N = 629)

There are several indications that the Sundial Phase Anasazi cultural patterns may be sufficiently different from Sagehen and McPhee Phase patterns to be reflected in the lithic profiles. Among these differences are a reduced population, smaller sites, and a generally altered subsistence base and/or procurement system. This should produce sites which are functionally distinct from earlier sites, and therefore visibly distinct in lithic profile. Sundial Phase sites have been subdivided into groupings of small habitations, seasonal occupation sites, and limited activity locations. These groupings, too, should demonstrate some variation in lithic patterns. Interpretations of any variability will be highly tentative, since Sundial Phase Anasazi culture in the sector is very poorly understood.

When compared to Archaic, Sagehen, and McPhee Phase totals, the Sundial Phase materials do demonstrate distinct profiles. Some variables are similar to the Archaic profile, some to Sagehen or McPhee, and others have completely unique values. Some of the more obvious characteristics of the total Sundial lithic assemblage are listed below. Comparison is with combined Sagehen and McPhee Phases.

FLT (N = 880)

A high proportion of nonlocal raw material (76.4 percent)

A high proportion of utilized flakes (40.1 percent)

Low proportions of used cores and unspecialized cores (7.3 and 5.9 percent)

A high proportion of specialized forms (5.6 percent)

A slightly high proportion of thin bifaces (9.5 percent)

A low proportion of complete items (74.2 percent)

A slightly higher proportion of well-worked dorsal tool faces (16.7 percent)

A very low mean weight (59 grams; standard deviation =150)

NFLT (N = 629)

A low proportion of hammerstones (6.4 percent)

A slightly low proportion of two-hand manos (7.2 percent)

A very low proportion of trough metates (1.0 percent)

A high proportion of slab metates (5.7 percent)

A very low proportion of complete items (17.5 percent)

A low proportion of items used without production modification (24.8 percent)

A very low mean weight (848 grams; standard deviation =2312)

1. Sundial Phase Small Habitations (FLT: N = 582; NFLT: N = 358)

This assemblage is characterized by very low proportions of local raw material and generally low production input. Only slightly higher proportions of specialized items (7.2 percent) and of well-worked dorsal tool faces (20.1 percent) indicate careful attention to tool production. The NFLT profile also indicates an unspecialized assemblage, except for a very high proportion of slab metates (8.4 percent). If analytic definition and consistency are adequate (and there may be some question concerning this), this may indicate a major technological shift in the processing of corn. Trough metates are nearly absent (1.1 percent), and manos are equally divided between one-hand and two-hand types (9.8 percent). There are few well-shaped NFLT items (6.1 percent), and they are small (mean weight = 802 grams, standard deviation = 2202), at least partly because there are very few complete items (22.1 percent).

2. Sundial Phase Seasonal Occupations (FLT: N = 120; NFLT: N = 51)

This small assemblage appears technologically a bit unusual for Sundial, in that it has a high proportion of FLT non-granular raw materials (36.7 percent), high proportions of both local cherts (31.7 percent) and local quartzites (30.0 percent), a slightly higher percentage of thin bifaces (11.7 percent), and a slightly lower proportion of complete items (62.5 percent). In addition, there is a technological emphasis on the bidirectional production of item edges (33.4 percent) and their placement around the entire margin (17.5 percent). This emphasis is apparently at the expense of producing item faces, since the proportion of well-made surfaces on both dorsal and ventral faces is very low (3.3 and 1.7 percent). FLT items are also larger than other Sundial groups (mean weight = 98 grams, standard deviation = 210).

The small size of the NFLT assemblage makes it largely unproductive to interpret, but it appears as a rather low production input, generalized, large-item assemblage, with a focus on bidirectionally produced edges.

3. Sundial Phase Limited Activity Sites (FLT: N = 189; NFLT: N = 231)

For both FLT and NFLT, this assemblage has a great many unusual characteristics, as is common for limited activity sites from all phases. There is an extremely low proportion of local FLT materials, both cherts (1.6 percent) and quartzites (7.9 percent). The group demonstrates very low proportions of utilized flakes (14.3 percent), used and unused cores (0.5 and 2.6 percent), complete items (49.2 percent), and items retaining cortex on both dorsal and ventral surfaces (18.5 and 4.7 percent). There are unusually high proportions of high-production-input items, such as thin unifaces (12.7 percent), thin bifaces (18.0 percent), and projectile points (15.3 percent).

The NFLT assemblage is approximately 60 percent broken, unidentifiable items. As a result, the proportion of NFLT items in the lithic assemblage is high (55.0 percent), particularly for limited activity sites, and there are very low proportions of hammerstones (0.0 percent), two-hand manos (3.9 percent), trough metates (0.0 percent), hafted items (0.0 percent), and ornaments (0.0 percent). Very few of the items are complete (9.1 percent), few are well shaped (10.0 percent), and the mean weight is very small (573 grams, standard deviation = 1718).

Interpretation of specific site-group functions should be based on more complete data, but it is important to note the significant variability among the groups, as well as their distinction from the Sagehen-McPhee profiles.

Anasazi Habitations (FLT: N = 12269; NFLT: N = 6401)

As stated earlier, the nature of the DAP lithic analysis attributes indicates that functional site groupings should demonstrate lithic variability more clearly than either temporal groupings or within-culture spatial groupings. It should be stressed that permanent habitation site groupings on the basis of size are also unlikely to demonstrate significant lithic variability, on the assumption that both the range and proportion of activities for which stone tools are used will remain roughly equivalent regardless of site size. Groups of villages, large hamlets, and small hamlets are compared with each other, and the results very strikingly confirm this assumption.

1. Anasazi village (FLT: N = 5808; NFLT: N = 3455)

2. Anasazi large hamlets (FLT: N = 1782; NFLT: N = 784)

3. Anasazi small hamlets (FLT: N = 4679; NFLT: N = 2198)

The three major groups have slightly different patterns of FLT raw-material use, with the major differences being a higher proportion of local cherts (16.6 percent) and quartzites (31.0 percent) in large hamlets, and slightly lower proportions of local quartzites (15.0 percent) in small hamlets. For all technological and morpho-use attribute states, however, the three groups are amazingly similar. There is no way, with any degree of confidence, to separate Anasazi habitations on the basis of size using FLT variables.

For NFLT variables there is some indication that the site groups are slightly different. Small habitations have more one-hand manos (18.2 percent), fewer two-hand manos (10.2 percent), fewer trough metates (5.4 percent), and fewer well-shaped items (10.1 percent). In addition, the NFLT items are noticeably smaller (mean weight = 1680 grams, standard deviation = 4535). Large hamlets have a slightly increased proportion of hafted items (5.7 percent), and tools are significantly larger (mean weight = 3265 grams, standard deviation = 7242). Villages demonstrate only a slightly increased number of well-shaped NFLT items (28.0 percent).

If the Anasazi in fact had an increasing dependency on corn through the Sagehen and McPhee Phases, and since settlement pattern shifted from smaller to larger habitation sites, and if nonflaked stone tools reflect the increasing corn processing, then the NFLT variability seen here is, in at least a general way, to be expected.

Anasazi Seasonal Use Sites (FLT: N = 982; NFLT: N = 642)

This group of sites should display some similarity with habitation sites, and perhaps less similarity with more specialized limited activity sites. For many variables, in fact, this group should have intermediate values between the two, since activities at these sites are likely to comprise both everyday living tasks as well as specific resource procurement and processing tasks. Comparisons given here are with Anasazi habitations.

FLT (N = 982)

A lower proportion of nongranular raw materials (16.9 percent)

Low proportions of both local chert and quartzite (5.5 and 13.4 percent)

A lower proportion of utilized flakes (30.4 percent)

A higher proportion of thick unifaces (5.7 percent)

A lower proportion of thin unifaces (3.5 percent)

A slightly higher proportion of specialized items (5.7 percent)

Increased proportions of well-worked dorsal and ventral tool faces (13.5 and 12.6 percent)

An increased proportion of items with produced edges around some (35.5 percent) or all (11.9 percent) of the item

A decreased proportion of unspecialized cores (12.5 percent)

An increased proportion of specialized cores (6.8 percent)

NFLT (N = 642)

A reduced proportion of two-hand manos (6.9 percent)

A reduced proportion of hafted items (1.1 percent)

A reduced proportion of complete items (37.1 percent)

A reduced proportion of well-shaped items (5.6 percent)

A reduced item size (mean weight = 1503 grams, standard deviation = 3718)

Anasazi Limited Activity Sites (FLT: N = 81; NFLT: N = 54)

Even though the size of this grouping makes interpretation highly tentative, the profiles are given here because of their very distinctive nature, and because they closely approximate their anticipated values. Comparisons are again with Anasazi habitations.

FLT (N = 81)

A high proportion of nongranular raw material (37.9 percent)

A high proportion of local chert (24.7 percent)

A very low proportion of utilized flakes (23.5 percent)

A very high proportion of thin unifaces (19.8 percent)

A low proportion of thick bifaces (4.9 percent)

A high proportion of thin bifaces (12.3 percent)

A high proportion of projectile points (11.1 percent)

A low proportion of complete items (77.8 percent)

A high proportion of items with both dorsal and ventral cortex (41.9 and 9.9 percent)

High proportions of well-worked dorsal and ventral tool surfaces (23.5 and 19.8 percent)

High proportions of unidirectionally (32.1 percent) and bidirectionally (29.6 percent) worked edges placed around some (50.6 percent) or all (12.3 percent) of the item margins

NFLT (N = 54)

A reduced proportion of hammerstones (5.6 percent)

A very high proportion of one-hand manos (35.2 percent)

A reduced proportion of two-hand manos (5.6 percent)

A reduced number of complete items (29.6 percent)

A very low proportion of well-shaped items (3.7 percent)

A reduced item size (mean weight = 800 grams, standard deviation = 1813)

Archaic/Anasazi Limited Activity Sites (FLT: N = 419; NFLT: N = 297)

Since these sites are a major portion of the Archaic Tradition site grouping discussed at the beginning of this data summary, they will not be considered further. A quick check of the two sets of profiles indicates that they are practically identical, with only very slight individual attribute differences.

A preliminary evaluation of the lithic profiles for the preceding site groupings produces a great deal of confidence in the DAP lithic analysis systems, their consistent application, and the interpretability of their results. The lithic data are well structured for response to both general and specific Research Design questions, and more definite responses await only more precise questions.

RESPONSE TO RESEARCH DESIGN

The DAP lithic data structure, since it is organized by attribute rather than by complete item, is extremely flexible in dealing with a wide range of research questions. If questions are direct — "which," "what," or "how many," — appropriate attributes can be selected, either individually or in conjunction with related attributes, grouped or arranged according to a wide variety of temporal and/or spatial cultural units, compared, and directly interpreted in response to the question(s). This level of response to the DAP Research Design is essentially in place and lacks only completion of the temporal/spatial definition of culturally significant data units.

Response to the more complex and significant "how" and "why" questions in the Research Design requires a logically intermediate modeling or hypothesizing step: a series of "If...then..." statements which permit data interpretation at this level. When this modeling is completed, the attribute-level structure of the lithic data will prove even more useful and efficient than for less complex research questions. This modeling-hypothesizing analytic activity is explicitly outlined in the general methodological considerations of the project Research Design (Kane, Lipe et al. 1981).

The DAP lithic data structure, as well as preliminary analytic results, has recently been reviewed for its adequacy and responsiveness to the program Research Design. Structurally, as noted above, the DAP lithic analysis and recording systems seem very well suited for appropriate, even innovative response to the Research Design. Several summaries of lithic analysis programs presented elsewhere in this synthetic report attest to the adequacy and relevance of the data produced (chapter 5, section 6).

The separation of the Research Design into general problem domains, each with specific questions, recognized the hierarchical nature of both cultural systems and analytic methods. Problem Domains 1 through 4 have been designed to produce a series of integrated, synchronic descriptions of Dolores Anasazi culture, while Problem Domain 5 is intended to produce a diachronic perspective of cultural development in the Escalante Sector.

Problem Domains 1 through 4 are directed toward a cultural description of "each temporal unit," which presents some difficulty with respect to lithic analysis in terms of comparison across such units. Only the larger temporal units, certainly no smaller than phases, are expected to demonstrate much securely interpretable lithic variability, since the production and use of stone tools is a rather stable cultural subsystem. Lithic data are therefore expected to have their greatest utility in defining and interpreting variability within these large temporal units, such as variability in function of site or subsite situations.

The following lithic data summations and interpretations for the problem domains should be considered preliminary and tentative. They are often based on very small sample sizes; known or suspected biases exist in both the samples and the data universe for which adequate controls have not yet been applied; and there has been little opportunity for concentrated effort toward planned, coordinated, multi-data set cultural interpretation of the materials. These preliminary results should, however, provide general trends and good direction for more specific analysis.

Problem Domain 1: Economic Adaptation

This general research topic deals with the availability and structured use by aboriginal populations of various categories of project area resources. The questions posed by Problem Domain 1 concern the identification and availability of resources, patterns in their selection and use, and integration of these patterns into more general subsistence systems.

The needs of aboriginal populations for lithic materials would certainly focus in two areas: building materials and materials for producing stone tools. The latter may be further divided into material for producing tools by flaking, such tools as scrapers and projectile points, and those produced by pecking-grinding-polishing, such as manos, metates, or axes. Lithic materials in the DAP collection, both archaeological and nonarchaeological, are evaluated by a series of three attributes: a general petrologic classification, an evaluation of grain size, and a specific lithologic/stratigraphic identification.

The bedrock geology of the DAP area consists of variable stratigraphic formations of late Jurassic and early Cretaceous times: Junction Creek ("Entrada") Sandstone, Morrison Formation, Burro Canyon Formation, Dakota Sandstone, and Mancos Shale. Both the Morrison and Burro Canyon Formations contain a wide range of cherts, chalcedonies, and silicified sediments, many of which are of good-to-fine flaking quality. These formations are well exposed throughout the project area in canyon walls of the Dolores River, Dry Creek, Beaver Creek, and House Creek, as well as the House Creek Fault escarpment. In addition, both the full range of these local materials plus a wide range of sedimentary, metamorphic, and a few intrusive igneous materials are available to at least some degree in the Dolores River gravels.

Materials for ground stone tools and for architectural use are also widely available in the project area, primarily from the Dakota Sandstone, which forms the uppermost, resistant bedrock throughout much of the project and immediately adjacent areas. This sandstone frequently occurs as thin-to-medium-bedded, coarse-grained, well-cemented material which is ideal in its structure and shape for both building stone and the manufacture of grinding tools.

While many areas of the Southwest have adequate lithic resources to attract and support aboriginal populations of considerable size, seldom is the project area range of desirable variability and relative ease of procurement matched. Only materials of spectacular appearance and flaking qualities are not known at present from within the project area variability. Many of the fine-grained silicified sediments from both the Morrison and Burro Canyon Formations are of completely adequate quality to produce even 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. If modern availability of these resources from natural exposures is roughly equivalent to prehistoric availability, they represent a virtually unlimited resource.

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 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 only minimally, and continue with other activities. Such an expedient approach to raw material procurement should be accompanied by a similar approach to both production and use of stone tools. When little effort is involved in raw material procurement, there is little motivation for high labor investment in production, maintenance, and curation of most tools. Exceptions to this generalization should be those specialized, high-production-input items necessary for specific and critical tasks, such as some manos, metates, projectile points, drills, or thin bifaces. Most general cutting or scraping tasks could be readily performed with quickly and expediently produced tools from easily procured raw material. It was probably more efficient to produce another tool than to re-edge or resharpen an existing one, and such items would seldom be transported long distances.

Such expedience-oriented technological systems could 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 and small in size; they should be located only at particularly desirable resource availability locations; and reduction of raw material at the quarry sites should not be extensive. Most sites should contain highest proportions of the most readily available, closest raw material.

On the basis of preliminary evaluation, the DAP archaeological assemblage conforms well to these expectations, with some notable exceptions. Based on a 1-person, 3-week survey in September and October 1980, 11 quarry sites were located and surface collected in the project area. Three were rock outcrops of good-quality material, and the remainder were gravel or erosional remnant situations. A total of 3663 artifacts were collected and analyzed, but only two of the sites produced as many as 500 flakes, flake fragments, or broken artifacts. A 1-person, 1-week survey also located 10 nonsite material resource locations, and 339 material specimens were collected. These specimens demonstrate less than 5 percent of the DAP archaeological raw material variability.

The DAP archaeological materials demonstrate considerable variability in raw material patterning. (Note: Additional details concerning raw material variability are included in several of the lithic profiles in chapter 5, section 6, of this report.) Assemblages with Archaic components demonstrate a far less intense use of the project area materials and a much more curated approach to item manufacture and maintenance. Anasazi assemblages demonstrate a much greater, and an increasingly expedient, tool manufacture and use, as well as an increasing tendency to use the closest available raw material. By McPhee Phase times, large village site assemblages demonstrate as high as 80 to

90 percent usage of immediately available raw material. For example, Mancos hornfels and Mancos silicified siltstone strongly dominate the FLT assemblage at the McPhee Village sites, Morrison Formation varieties predominate at Grass Mesa sites, and Burro Canyon varieties predominate at Rio Vista sites. A problem exists, however, in that no known Morrison Formation quarry sites exist in the immediate vicinity of Grass Mesa, although there are Morrison exposures nearby. In addition, although there are geological possibilities that the House Creek faulting phenomenon could have provided the heat necessary to produce metamorphic hornfels from the Mancos Shale in the vicinity of McPhee Village, this has not yet been demonstrated from field observations. In both cases, theoretic and archaeological indications are that such resources should exist in these respective locations, but fieldwork has not yet been conducted which could confirm these sources.

Within the Anasazi materials there are also definite patterns of raw material selection for certain tool types. Larger tools generally are of coarser-grained materials, while smaller tools are usually made of finer-grained or microcrystalline materials. This holds true, with the notable exception of projectile points and small, high-input bifacial items, which are predominantly of the slightly coarser Burro Canyon white-to-gray orthoquartzites. The microcrystalline cherts and chalcedonies of the Morrison, and especially of the Burro Canyon Formations, have quite poor flaking qualities due to the presence of numerous internal fractures. These materials are almost never used for either large unifaces or bifaces, or for projectile points, because they seldom occur in adequately large, fracture-free chunks. However, various slightly coarser-grained silicified sediments from these same formations have very predictable fracture characteristics, and they occur in rather large pieces. These materials were used to make the very great majority of large and/or high-input items, and Burro Canyon orthoquartzite varieties comprise most Dolores Anasazi projectile points.

A great many of the questions in Problem Domain 1, both general and specific, are being addressed and answered with project lithic data. Planned field activity and the completion of project temporal/spatial forms will make it possible to more accurately quantify and map both geological and archaeological variability in the project area and to examine that variability in smaller spatial and temporal units.

Problem Domain 2: Paleodemography

This problem domain, which reflects focused effort to determine the size, structure, and characteristics of aboriginal populations in the project area, outlines three relevant demographic estimation methods: habitation, carrying capacity, and rate of accumulation studies. Of all Research Design probem domains, lithic data are perhaps least applicable in any direct way to this one. It may be possible in carefully controlled spatial, temporal, and site type contexts to estimate number of households in an unknown situation by extrapolating from known situations on the basis of lithic tool kit size and/or constituency. However, given the rather circuitous logic, the rigid context requirements, and the high degree of outcome uncertainty, such analytic approaches would seldom be justified. Lithic data are best used for interpreting the behavior of households rather than for defining them. It is quite likely that other habitation studies based on lithic data would be similarly obtuse and costly.

Carrying capacity studies are potentially useful in establishing upper limits for population at a given time. However, in the situation of the DAP project area, the carrying capacity for all categories of lithic resources is virtually unlimited. Certainly, the area's nutritional carrying capacity would have been reached long before a shortage of lithic material became critical.

Rate-of-accumulation studies examine interaction of the variables population size, occupation duration, and use intensity within temporally and spatially defined cultural units. When any two of these variables are known or assumed as constants, the third can be estimated. Much of the lithic data collected by the DAP is suitable for use in such time-rate studies to derive aboriginal population size when cultural units are reliably defined and when use intensity and occupation duration are known. Such studies should be very carefully considered, since adequate control of all factors involved is likely to be difficult.

Problem Domain 3: Social Organization

The Research Design clearly presents this research topic as very broad; as structural, functional, and ideological in nature; and as heavily dependent upon other problem domains. In addition, the general topic of social organization is subdivided into separate but interdependent social, economic, political, and ideological subdomains. The questions and concerns expressed throughout the problem domain are very generally and anthropologically oriented. They involve many of the goals toward which archaeologists have been working for decades, with extremely varying levels of success. Even ethnologists have difficulty identifying and explaining these detailed patterns of social organization, and the Research Design clearly states that the included list of questions "should be considered as setting out general lines of inquiry and suggesting a number of fruitful specific problem areas" (Kane, Lipe et al. 1981:29).

This difficulty in dealing effectively and convincingly with questions of prehistoric social organization is not the result of poor planning or of poor excavation or analysis. It is a result of the generally weak theoretical fit between most

archaeological data and questions which are relevant in the understanding of social organization. This is not to suggest that the DAP Research Design questions are in any way inappropriate, but that considerable care should be exercised in selecting the most relevant and suitable specific research questions. The most responsible way to exercise this care is through precisely the kind of judicious and considered modeling called for by the Research Design. Behavior cannot be reasonably inferred from artifacts unless artifacts first have been modeled or theorized from behavior. The modeling necessary for this level of effective analytic response has been begun by the DAP task specialists and Senior Staff, but there has not yet been an opportunity to extend it to a useful level. However, a preliminary evaluation of project lithic data indicates that such a carefully modeled research structure will produce very satisfactory and interpretable responses to a great many questions relevant to northern Anasazi social organization.

The attribute-level structure of the lithic data will allow efficient consideration of both specific and general questions by selecting only those attributes or attribute combinations which the model(s) identifies as potentially significant. Analysis will focus on defining and interpreting lithic content variability within and among various spatially and temporally bounded data sets or subsets which are inferred to represent the behavior of various social groups. Lithic content is not normally a good definer of social groupings, or their archaeological expressions. It is, however, an effective delineator of behavioral similarity or difference among groups which have been identified on the basis of other evidence. An exception to this generalization is the identification of smaller-scale social groupings with behavior focused rather directly on the procurement and reduction of lithic resources.

Some preliminary indications from lithic data which are being carefully examined as productive approaches to Problem Domain 3 include at least the following items.

1. Stylistic similarity in such high-input items as some projectile points has suggested that the Escalante Sector Anasazi participated to at least some degree in a larger regional system of shared information, technology, and subsistence pattern which included the Mesa Verde Anasazi. The degree of this participation might be estimated from the similarity of lithic assemblages in carefully controlled contexts, but it has already been indicated that some significant differences also exist between the Dolores and Mesa Verde assemblages (Subdomain 1).

2. Group integration may possibly be evaluated by quantifying specified types of lithic variability between carefully defined temporal-spatial-functional subassemblages: the greater the similarity, the greater the level of integration within or between the situation(s) examined (Subdomain 1).

3. Differential status among Escalante Sector Anasazi may be indicated by differential occurrence of "exotic" or nonlocal lithic materials such as obsidian or unusually colorful cherts or jasper. Whether such differences are primarily due to status, to economic, or to ritual-ceremonial causes will be difficult to assess without carefully controlled coordination of multiple data sets (Subdomains 1 through 4).

4. A rather clear bipolar distribution of technological input for several FLT assemblages may indicate some form of labor division in the production of some flaked stone tools. This could range from a sexual division of labor within each household, to a community craft specialization, to the importation of finished items. Again, careful control of temporal-spatial-functional data groupings, plus appropriate modeling, will be necessary to confirm the most likely alternative (Subdomains 1 and 2).

5. Preliminary indications from the NFLT data indicate that during the McPhee Phase, the Grass Mesa site contains noticeably greater proportions of high-input ornaments than other sites or site groups. The extent of this difference, as well as its implications for economic, status, or even ritual interpretation may be clarified with appropriately planned analysis (Subdomains 1 through 4).

6. Both the FLT and the NFLT analysis systems are well structured to recognize artifact production. If artifact "consumption" is relatable to archaeological occurrence, then any important differences between maps of production and consumption may be interpreted as distribution. Such an analysis would be rather involved, but in carefully selected data situations, could be extremely insightful (Subdomain 2).

7. To the extent that some tool types are associated with sex-role behavior, lithic data may provide information concerning whether, and to what extent, these sex-role behaviors are represented in given subassemblages (Subdomain 1).

8. The identification of ideological or ritual situations in the archaeological record is necessarily indirect, and will depend heavily on adequate and appropriate modeling. There are, however, several possible lithic indications of "special" situations which may have ritual significance. These include the occurrence of very small, well-worked manos and metates; "average" items made with above-average input or from some special materials; high-input items without obvious functional interpretability; very high production input in assemblages from unusual archaeological context; or "killed" metates (Subdomain 4).

Problem Domain 4: Extraregional Relationships

Within the DAP lithic assemblages, the identification of foreign materials has been largely restricted to "that which

is not recognized as local." It is obvious that as the recognition of local raw material variability improves and increases, the proportion of unrecognized and therefore "not-local" items decreases. While this analytic approach is definitely inferior to the positive identification of nonlocal materials, it has been economically necessary and can, when coupled with appropriate modeling and literature review, provide useful information. Most red-colored jaspers, for example, come from west and northwest of the DAP area, while most obsidian is likely to come from southwest or southeast of the project area. By careful selection of the archaeological temporal-spatial-functional context, differential occurrence of these materials may be interpreted.

Preliminary lithic indications, along with traditionally applied basic cultural models, suggest that the more mobile groups of Archaic hunter-gatherers accumulated a wide range of lithic raw materials, probably as a direct result of their mobility. The more sedentary Anasazi horticulturalists demonstrate a greatly reduced range of nonlocal materials, most of which are concentrated in such high-input items as projectile points and thin bifaces. Just how or from where the Anasazi procured this small but significant proportion of lithic raw materials is not known, but several analytic possibilities are potentially available. The DAP assemblage contains approximately 200 obsidian items, most of which can potentially be traced to their geological origin by nondestructive X-ray analysis. Funds have been allocated for this analysis in FY1981. Once the items have been source located, the Denver office of the U.S. Geological Survey has tentatively agreed to provide obsidian hydration dates for at least some of the artifacts. This should provide valuable information regarding Anasazi foreign interactions.

A very preliminary comparison between patterns of nonlocal lithic materials procurement and nonlocal ceramic materials procurement suggests that the two are not the same in either temporal trends or direction of interaction. If traditional models of female-dominated ceramic and male-dominated lithic technological systems can be applied, some intriguing interpretive possibilities are suggested. Appropriate modeling and coordinated multiple data set analysis will be needed to verify and quantify these tentative indications.

Problem Domain 5: Cultural Process

Problem Domains 1 through 4 of the Research Design present a structural approach for coordinated analysis of the Dolores Anasazi which results in a series of similarly considered and expressed cultural descriptions. This has been vital for structuring data recognition, collection, analysis, and interpretation during the early phases of the DAP. However, even a well-ordered sequence of synchronic descriptive statements does not equal a diachronic expression of culture change, and the Research Design explicitly recognizes the continuing need "to advance Domain 5 to a higher level of specificity" (Kane, Lipe et al. 1981:1). The opportunity to trace and attempt to explain the development of the Dolores Anasazi from their earliest arrival, living as scattered households of subsistence horticulturalists, to highly integrated village dwellers is the unique opportunity and responsibility of the DAP. The statement of this highest-order analytic concern as the last of the problem domains should not indicate that it is the final step in project analysis. Lithic analysis has progressed to the point where some trends are apparent which, while they are not adequate responses to "why" questions in themselves, can be used to guide the analytic process into appropriate channels for effective treatment of cutural process.

Recognition of the complexity and the interrelatedness of the many aspects of cultural systems and their archaeological expressions indicates the need for a truly synthetic approach to analysis and interpretation, particularly in dealing with higher-order explanations for culture change. The analytic approach most likely to produce efficient and satisfactory results in dealing with Problem Domain 5 is to develop a series of increasingly specific models of cultural process against which all categories of DAP data can be viewed and interpreted. Within this analytic approach, the critical steps are the judicious selection of the most appropriate models, the definition of data situations which respond most effectively to the models, and the use of the results as feedback information to further refine the models.

Intermediate results of lithic analysis, such as trends in raw material acquisition and use, increasingly expedient production technology, differential item curation, change and continuity in projectile point style, or increasing technological input into corn-processing implements, are informative in themselves. Their greatest significance, however, will be their use, along with preliminary results from other data categories, in selecting and developing appropriate models for examining the "why" questions of northern Anasazi cultural development.

Appendix E

HUMAN SKELETAL REMAINS

by Ann Lucy Wiener

INTRODUCTION

Excavation during the 1978, 1979, and 1980 field seasons produced 28 human burials from 16 prehistoric and 2 protohistoric sites. Isolated human skeletal elements have been recovered from 140 field proveniences at 21 excavated sites.

The prehistoric sample consists of 31 relatively complete individual skeletons from sites dating from the early Sagehen Phase to the Sundial Phase, Marshview Subphase (A.D. 600-1125). This small assemblage is comprised of 8 adult females, 7 adult males, 10 adults of indeterminate sex, 1 infant, and 5 children, aged 3 to 8 years. The sex, age, and temporal distributions of these individuals are presented in table 48.

In addition, excavation at two protohistoric sites yielded human burials. Burial 14 from Site 5MT5399 consists of the remains of a young adult female aged 19 to 23 years. Fragmentary and poorly preserved, these remains are insufficient for a determination of racial affiliation. The remains of an older adult individual of indeterminate sex (Burial 25) were found in a mortuary structure of sandstone slabs placed in a natural rock crevice at Site 5MT5380. These remains were also too fragmentary for an assessment of racial affiliation.

DIRECTION AND METHODOLOGY OF ANALYSIS

The two major objectives of the DAP skeletal material analysis are (1) to utilize this small sample to whatever extent possible to address the relevant aspects of the problem domains outlined in the DAP Research Design; and (2) to generate data that conform to that extant for other skeletal populations from the Mesa Verde Region in order to provide a basis for comparison between the various populations and to continue to build on the regional data base.

Addressing the questions posed by the problem domains in the Research Design requires an assessment of the demographic, physical, and epidemiological characteristics of the local population, i.e., the age, sex, and health structure of the population as it relates to biocultural processes. Information regarding the cultural/behavioral aspects of burial practices is also potentially important in considering social organization and ritual.

While the excavated Anasazi sites in the DAP area cover the Basketmaker III-Pueblo II/III time span, the very limited number of well-preserved human skeletons recovered to date precludes any meaningful diachronic analysis of trends in physical and cultural aspects of the information presented in this report. Even by treating the sample as a biological cohort, potential analysis is limited and the results of standard analysis on such a small sample can be misleading. It is hoped that the analytical potential of this sample will be augmented through comparison of the DAP skeletal data with similar data derived from Mancos Canyon, Yellow Jacket Canyon, and Mesa Verde skeletal samples. Perhaps more important, the collection of a consistent body of data from the DAP and other small samples in the Mesa Verde Region will enable future integration of the Mesa Verde Anasazi skeletal data as a basis for local diachronic as well as interregional research.

DEMOGRAPHY

Table 49 presents the mortality data derived from the 31 individuals in the prehistoric skeletal sample. The individuals are grouped into age categories based on the known rates of biological development in preindustrial human populations: infant (0-2 years), child (3-12 years), adolescent (13-16 years), young adults (17-24 years), middle adults (25-34 years), older adults (35-50+ years), and adults of indeterminate age. It is important to note that the DAP skeletal sample underrepresents infants, adolescents, and older adults.

The problems of small sample size and of underrepresentation of infants and subadults in skeletal populations are well known to physical anthropologists. In part, these problems are the result of the differential preservation of elements in the immature and mature human skeleton. Infant bones are easily fragmented and dispersed by natural, animal, and human disturbance factors, and may be

Table 48. Age, sex, and phase distribution of the DAP skeletal sample, 1978-80*

Age group	Sagehen Phase				McPhee Phase			Sundial Phase	Total pre-historic	Percent of mortality in age groups
	Early	Middle	Late	Total	Early	Late & indet.	Total			
Infant 0-2				0		B-3	1	0	1	3
Child 3-12			B-12 B-18	2	B-23	B-8	2	B-13	5	16
Adolescent 13-16				0		B-24	1	0	1	3
Young adult 17-24			B-15(F)	1	B-26(M) B-20(M) B-22(F) B-27 B-19(M)	B-16(F)	6	0	7	23
Middle adult 25-34			B-10(F) B-11(M)	2	B-17(F)		1	0	3	10
Older adult 35+		B-4(M)		1	B-28(F)		1	0	2	6
Indeterminate adult	B-21(F)	B-7	B-6	3	B-5	B-9(M) B-8 B-2 (F) B-1 (M)	3	B-13 B-13 B-13 B-13	12	39
TOTALS	1	2	6	9	9	8	17	5	31	100

*Listed by burial number (B).

ABBREVIATIONS:
M = male
F = female
Blank = no determination possible
Indet = indeterminate

Table 49. Mortality data from the DAP skeletal sample, 1978-80

Age group	N	%	Adjustment*	Corrected %	% Surviving	Cumulative mortality, %
0-2	1	3.2		3.2	96.8	3.2
3-12	5	16.1		16.1	80.7	19.4
13-16	1	3.2		3.2	77.5	22.6
17-24	7	22.6	+7 (22.6%)	45.2	32.3	67.7
25-34	3	9.7	+3 (9.7%)	19.4	12.9	87.1
35-50	2	6.4	+2 (6.5%)	12.9	0.0	100.0
50+	0	0	+0 (0.0%)			
Indet. adult	12	38.7				
Total	31	100.0	12 (38.8%)	100.0		

*Adults of indeterminate age (Indet. adult) were distributed to adult age groups in the proportions in which ageable adults occurred.

difficult to recognize as human to the untrained eye. Skeletal remains of children and adolescents are also particularly vulnerable because deterioration of the cartilaginous tissue attaching the epiphyses to the main portion of the bone permits the segments to be easily separated.

The bias that the uneven age distribution introduces into the DAP skeletal sample is indicated by the comparative data in table 50. The percentages of the population dying during infancy, 3.2 percent, and by reproductive age (0-16 years), 22.6 percent, are quite low and certainly not representative.

It is reasonable to assume that with a more genuinely representative sample, the demographic characteristics of the Dolores River valley population would conform to those documented by analyses of other Mesa Verde Anasazi populations. Infant mortality in these groups has been reported to be between 12 and 21 percent from the Basketmaker III-Pueblo III periods (Bennett 1975:7; Swedlund 1969:100). A high mortality rate among children in prehistoric and preindustrial populations is generally attributed to the weaning stress syndrome and vulnerability to bacterial infection and malnutrition. The mortality rate drops among adolescents and subadults and then increases in association with maternal and reproductive stress in women of childbearing age. The mortality rate increases steadily thereafter, the result of normal degenerative aging processes among the population.

BURIAL PRACTICES

Although the analysis of the burial contexts is incomplete at the time of this report, preliminary tabulation of burial locations and their associated fill assemblage positions and types indicates that 13 of the 26 prehistoric burials were recovered from the antechambers, main chambers, or ventilator systems of pithouses (fig. 136); 3 from abandoned jacal surface rooms; and at least 4 from midden or trash deposits. None of the six burials of infants and children were recovered from the surfaces or postoccupational deposits of pithouses, with the exception of one child, part of a mass, secondary inhumation at Sundial Phase Site 5MT2235. Two children were recovered from midden areas, two were recovered from jacal surface rooms, and one was recovered from a bin feature in a masonry room at Site 5MT4475. This pattern suggests that there may have been a practice of interring young and middle-aged adults in abandoned pithouses, and children and older persons elsewhere, but is more likely a function of sampling error due to small sample size.

Figure 136. Photograph of burial found in pithouse ventilator system at Site 5MT4671, Area 4 (DAP 040323).

Of the burials, 13 are single, primary inhumations; 2 are double, primary inhumations of female adults and young children (Burial 2, Site 5MT4475 and Burial 8, Site 5MT23). Two of the burials are single, secondary inhumations, and one, Burial 13 (Site 5MT2235), is a secondary burial of four adults and one child. Three individuals were found on occupation surfaces, with no evidence of deliberate burial. The mode of interment for the remaining five burials could not be determined.

The possible cannibalized nature of the remains in Burial 13 has been carefully addressed in the examination of the

Table 50. Comparative regional data for infant and prereproductive age mortality — cumulative percentages

Population	Infant mortality, % (0-2 years)	Cumulative prereproductive mortality, % (0-16 years)	Source
Dolores River valley	3.2	22.6	Present study
Mesa Verde	12.4	36.6	Bennett (1975:7)
Mancos Canyon	22.6	45.3	Robinson (1976:129)
Yellow Jacket Canyon	21.7	52.2	Swedlund (1969:100)

skeletal remains. The material does not display the dense, highly mineralized, calcined type of preservation that has been described for other supposedly cannibalized remains in the Mesa Verde Region, nor does it exhibit a predominant pattern of spiral fractures such as is attributed to intentional breakage of bone for marrow extraction (Nickens 1975a, 1979). While cannibalism is not implied, this assemblage of very fragmentary remains does appear to have been subject to some type of violent treatment. Some of the more robust longbones appear to have been broken as the result of a forceful blow rather than by the weight of roof fall or postabandonment fill. Several ceramic vessels and animal effigies were found accompanying the human remains, and portions of some of these reconstructible vessels were found in midden deposits and surface structures of the site, implying transportation of the vessels and the skeletal materials from an original place of interment to the pitstructure. The motive behind, and the method of, the apparent violent treatment of the remains are unknown.

Orientation of the burials is predominantly north-northeast, with three being oriented east-southeast, and only one west-southwest. Of the 11 individuals in whom flexure could be observed, 5 were in a semiflexed position, and 6 were flexed. Only four burials have definitely associated grave goods, as summarized below.

Sagehen Phase: Burial 4, Site 5MT4545—adult male: shell beads
McPhee Phase: Burial 2, Site 5MT4475—adult female and child: gray ware jar
McPhee Phase: Burial 1, Site 5MT4475—adult male: shell bracelets; one turquoise bead
Sundial Phase: Burial 13, Site 5MT2235—four adults and one child: several Mancos and McElmo Black-on-white reconstructible vessels; bone beads

With the exception of Burial 13, mortuary practices seem to have been unelaborate; individuals were interred where graves were easily dug, as evidenced by the disturbance of many burials by rodents and vandals.

MORPHOLOGY

Mean stature of adult females in the DAP skeletal sample is 155.4 cm (s = 4.75 cm), or 5 ft 1 in, and that of adult males, 165.5 cm (s = 3.13 cm), or 5 ft 3 in (formula used is from Genovese 1967). Corrections for age have not been made in these calculations because the number of older adult individuals is so small. As indicated in table 51, these figures are within the range of variability indicated in stature estimates for other Mesa Verde Region populations.

Intensive analysis of the relatively complete prehistoric skeletons in the DAP sample has included (1) the recording of 93 metric traits (measurements of specific cranial and postcranial features); (2) an assessment of the presence or absence of several discrete traits; and (3) the recording of several types of anthroscopic data (features on the skelton which exhibit different classes or degrees of development). By comparing the mean values and frequencies of these traits between males and females of a single population, and between two or more distinct populations, one can assess the degree of inter- and intrapopulational morphological variation. Information on discrete traits and anthroscopic data provides the basis for inferences of biological distance between populations. Differential frequencies of traits controlled by known genetic mechanisms imply degrees of interbreeding.

While the data compiled in this study comprise an addition to the regional data base and indicate the Dolores River valley sample to be within an expectable range of variability for the region, the small sample size precludes both statistical treatment and the delineation of meaningful comparisons between males and females in this population, or between this and other populations.

CRANIAL DEFORMATION

As indicated in table 52, all 10 of the sufficiently preserved crania from the DAP Anasazi skeletal sample exhibit

Table 51. Estimated mean stature of males and females in the DAP and other Mesa Verde Region populations

Population	Mean stature females* (cm)	Number of individuals	Mean stature males* (cm)	Number of individuals	Source
DAP	155.40	4	162.50	4	Present study
Yellow Jacket	160.52	8	158.80	3	Swedlund (1969:101)
Mancos Canyon	157.50	6	168.50	4	Robinson (1976:14)
Mesa Verde	152.00	29	162.00	47	Bennett (1975:9)
Alkali Ridge	150.40	3	164.70	8	Brues (1946)

*Formula used is from Genovese (1967).

lambdoidal or horizontal flattening at the back of the skull, and none of the individuals in this sample exhibit occipital or vertical deformation. While both of these types, or styles, of cranial deformation are attributed to contact of the growing crania of infants with cradleboards used for carrying children, their respective temporal and spatial distributions are considered culturally significant. As noted by Reed (1949), lambdoidal deformation appears in Southwestern skeletal populations of the Rio Grande and San Juan areas during the Pueblo I period. By the end of the Pueblo III period (around A.D. 1300), occipital deformation was predominant in Anasazi populations. The cranial deformation observed in the DAP sample fits well within this framework.

PATHOLOGY

Dental Pathology

The frequencies of dental caries, alveolar resorption, calculus formation, dental abscessing, and enamel hypoplasias in the DAP skeletal material and, where available, in other regional populations, are presented in table 53. The 60-percent frequency of dental caries observed in the DAP sample is higher than in both the Yellow Jacket and Mancos

Table 52. Cranial deformation observed in DAP prehistoric burials

	Type of deformation			Symmetry of deformation			
Phase	Occipital	Lambdoidal	N*	Symmetrical	Right	Left	N*
Late Sagehen	0	3	3	0	0	0	0
Early McPhee	0	4	4	2	0	1	3
Late McPhee	0	1	1	0	0	1	1
Sundial	0	2	2	1	1	0	2
Totals	0	10	10	3	1	2	6

*Number of crania adequately preserved for determination of presence or absence of deformation.

Table 53. Dental pathology in Mesa Verde Region skeletal populations

	Dolores River valley		Yellow Jacket* Canyon		Mancos Canyon**	
	N observed	% with pathology	N observed	% with pathology	N observed	% with pathology
Dental caries	20	60.0	19	52.6	16	50.0
Alveolar resorption	17	47.1	19	73.6	16	31.3
Dental abscess	20	25.0	19	26.0	16	18.8
Calculus formation	17	76.5	19	31.5	16	18.8
Slight	9					
Moderate	4					
Extreme	0					
Enamel hypoplasia	17	47.1				
Mild	5					
Moderate	3					
Extreme	0					

* Swedlund (1969)

**Robinson (1976)

Canyon populations, as is the frequency of individuals exhibiting calculus formation. Frequencies of alveolar resorption and dental abscesses in the DAP sample are intermediate between the Yellow Jacket and Mancos frequencies. While one could invoke an explanation of dietary differences or differential genetic resistance to these pathologies between the populations considered here, it is more reasonable to conclude that at least part, if not most, of the difference is due to the different age composition of these samples. The high proportion of young and middle-aged adults in the DAP sample provides a logical explanation for these comparative frequencies. One would expect to see quantitatively more caries and calculus deposition in a population of this age structure, since these are the initial manifestations in dental degenerative and aging processes. Similarly, there is a lesser frequency of the manifestations of the qualitatively more advanced disease processes in oral pathology such as dental abscesses (infectious lesions in the mandible or maxilla often associated with advanced caries development) and alveolar resorption (the healing over of a root socket after a tooth has been lost).

The degree of dental attrition (tooth wear, table 54) in the DAP sample is also typical of a predominantly young- and middle-adult population in the Anasazi nutritional environment. In 23.5 percent of the sample, the enamel on the occlusal surfaces of teeth was somewhat worn, but not to the extent that the dentin, the softer and more vulnerable tissue underlying the protective enamel, was exposed. In the sample, 35 percent of the individuals exhibited primary and secondary degrees of attrition in which dentin was visible and the cusps of the teeth were worn to a uniformly flat occlusal surface. Only 5.9 percent showed further attrition to the point where the pulp of the teeth was exposed. This small percentage of individuals exhibiting advanced attrition is significant in that exposure of the tooth pulp can lead to infection and drainage into the root canal, and hence to the spread of the infection to the upper and lower jaws and to the sinuses.

Nutrition-Related Pathology

The frequency and cooccurrence of three types of pathology with nutrition-related etiologies have been observed in the DAP skeletal sample: cribra orbitalia, enamel hypoplasia, and transverse lines of increased density. These data are presented in tables 55 through 59.

Table 54. Dental attrition in the DAP skeletal sample

Degree of dental attrition	0°	1°	2°	3°	4°
N = 17	23.5%	35.3%	35.3%	5.9%	0%

Table 55. Observed frequencies of nutrition-related pathologies in the DAP skeletal sample

	Number of individuals observed	Number with pathology present	Number with pathology absent	% with pathology present
Cribra orbitalia	14	11	3	78.6
Transverse lines	12	11	1	91.6
Enamel hypoplasia	17	8	9	47.1

Table 56. Cooccurrence of nutrition-related pathologies

	Number of individuals observed	Both pathologies present	One or both pathologies absent	% with both pathologies present
Cribra orbitalia and transverse lines	10	8	2	80
Cribia orbitalia and enamel hypoplaisa	12	3	9	25
Enamel hypoplasia and transverse lines	12	6	6	50

Cribra orbitalia consists of cranial lesions, localized in the eye orbit vaults, which result from the compensatory formation of extra blood vessels in individuals with abnormal red blood cells. Most physical anthropologists have contended that the etiology is dietary (iron deficiency) anemia in conjunction with other nutritional, physiological, and bacteriological stress factors which, acting synergistically, are particularly prevalent and severe among children of weaning age. However, the same type of lesions has been diagnosed in the Wetherill Mesa skeletal population (Miles 1975) as erythroblastosis fetalis, a fatal nondietary congenital anemia.

Table 57. Frequencies of cribra orbitalia in males and females in the DAP skeletal sample

	Number of individuals present	Number with pathology present	Number with pathology absent	% with pathology present
Females	6	5	1	83.3
Males	4	3	1	75

Table 58. Lines of increased density observed in the DAP skeletal sample

Burial number	Age	Sex	Number of transverse lines	Number of partially resorbed transverse lines	Number of bones x-rayed
12	4-6	—	0	2	1
21	16-20	M	1	0	7
16	16-22	F	15	8	5
20	27-35	F	7	12	8
22	22-36	F	11	8	9
10	19-29	F	7	5	10
15	20-25	F	0	8	9
2	Adult	F	6	0	5
4	29-39	M	0	8	4
19	20-25	M	0	9	8
26	23-27	M	0	8	10

Summary statistics of data presented in table 58:

		Female adults	Male adults
Mean number of longbones x-rayed		7.7	7.3
Mean number of transverse lines		7.7	0.25
	Standard deviation	5.05	0.5
Test of significance (student's t) and associated probability		$t = 2.3$ $.02 < p > .05$	
Mean number of partially resorbed lines		6.8	6.25
	Standard deviation	4.02	4.19
Test of significance (student's t) and associated probability		$t = 0.18$	$p > .05$

Mean number of transverse lines per adult: 4.7

Table 59. Frequencies of transverse lines in Mesa Verde Region skeletal populations

Population	Mean number of lines per adult	Number of individuals in sample	Source
DAP	4.70	10	Present study
Mesa Verde	1.18	28	Nickens (1975b)
Yellow Jacket	1.57	7	Nickens (1975b)
Mancos Canyon	1.27	11	Nickens (1975b)
Mancos Canyon*	2.20	9	Robinson (1976)

*1975 skeletal series

This exemplifies an important issue in paleonutritional studies and in interpretations of the paleoepidemiology of prehistoric populations. El-Najjar et al. (1976) have demonstrated a trend of increasing frequency of cranial lesions from Basketmaker to Pueblo populations, citing increased reliance on maize, from which the absorption of dietary iron is only about 5 percent, as a major factor in dietary anemia. Ethnographically documented use of alkali solutions in maize processing further inhibits available dietary iron (Cravioto et al. 1945).

The identification of active, partially healed, and completely healed lesions of cribra orbitalia in the DAP sample tends to refute Miles' interpretation of the anemia as fatal. Furthermore, the absence of congenital anemias in present-day Native American populations (Sievers 1966) renders the presence of these diseases in prehistoric Native American populations extremely unlikely. Due to the difficulty, perhaps impossibility, of documenting the antiquity of alkali processing of maize in the archaeological record, it is not easy to lend or deny support to the maize-iron deficiency hypothesis. A more thorough picture of the Anasazi diet and other potential sources of minerals such as salt, drinking water, culinary ash used as a cooking additive, and fermented beverages, must be considered before any degree of reliance on maize can be definitely implicated as leading to iron deficiency (Kuhnlein and Calloway 1979; Litzinger[1]).

Symmetrical osteoporosis and spongy hyperostotic lesions on the parietal and frontal bones of the cranium have been suggested as more advanced pathological processes of the same etiology as cribra orbitalia (Lallo et al. 1977). Only a few cases of symmetrical osteoporosis were noted in the DAP sample, and there were no incidences of porotic hyperostosis. X-rays of several crania were made, and these exhibit none of the hyperplasia of the marrow cavity or spiculation of the outer dipole that are clinically documented manifestations of congenital anemias and of severe dietary anemias (Jaffee 1972; Moseley 1974; Steinbock 1976).

The occurrence of active or inactive cribra orbitalia in 78.6 percent of the observable portion of the DAP skeletal sample, and the absence of the more severe manifestations noted above, suggest that the population was subject to a chronic, as opposed to acute, form of dietary anemia. Use of the Fisher's Exact Test (Siegel 1956:96) indicates that there is no significant difference in the frequency of the lesions in males and females in the sample ($p>.05$).

As indicated in tables 53 and 55, enamel hypoplasias are present in 47.1 percent of the observable portion of the sample. Hypoplasias are structural defects in tooth enamel caused by periods of metabolic stress such as trauma, infectious disease, or nutritional deficiency, which coincide with periods of active formation of tooth enamel matrix. Matrix formation ceases in response to stress and is resumed when the period of disturbance ends, resulting in the formation of irregular bands or pitting in the enamel. Mild hypoplasia was observed in five individuals and moderate defects occurred in three, indicating that a substantial portion of the population was subject to metabolic stress during the age range of tooth calcification and crown completion of the permanent dentition — from about 2.5 to 17 years of age (Hurme 1948).

The occurrence of radiopaque transverse lines (fig. 137) in the longbones of several individuals in the DAP sample has been documented, and the data are summarized in tables 58 and 59. Transverse lines are considered homologs of enamel hypoplasias. They are formed by the resumption of normal bone matrix formation after a period of nutritional, or other metabolic, distress. There is a significantly higher mean frequency of lines in females than in males in this sample, but not of partially resorbed lines. It has been clinically documented that these lines persist longer in females than in males, and that the longer persisting lines are those formed earliest in life (Gindhart 1971). This suggests that females may have experienced more stress during early life than males; however, it also suggests that the

[1]William J. Litzinger, University of Colorado, Boulder, personal communication.

greater amount of cortical bone remodeling in males may be in part responsible for the difference in the number of complete lines and the similarity in the number of partial lines.

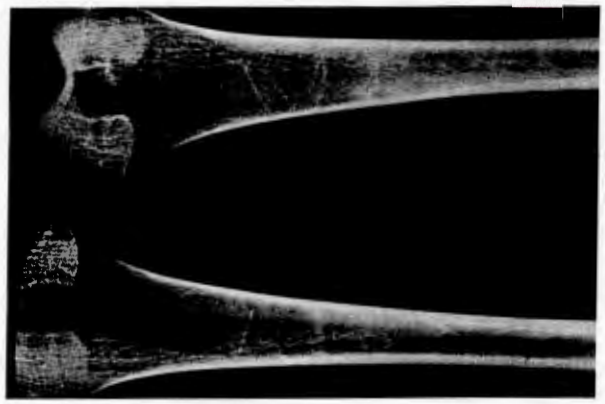


Figure 137. Photograph of transverse lines of increased density in distal femurs of young adult female from Site 5MT4477 (DAP 083012).

In comparison to other populations in the Mesa Verde Region, the mean frequency of 4.7 lines per adult individual is high. Again, a portion of this difference is due to the age bias in the DAP sample; if there were more older individuals in the sample, more of the lines would have been resorbed.

While the data regarding these three pathologies, as summarized in tables 55 and 56, are not adequate for statistical tests of correlation, there does appear to be a relationship between cribra orbitalia and transverse lines, and perhaps between transverse lines and enamel hypoplasias. The highest number of transverse lines observed in an individual was 15, and these occurred in a young adult female, Burial 16. This individual, found at a late McPhee Phase site, Site 5MT4477, also exhibited the most extreme enamel hypoplasia, as well as cribra orbitalia.

Other Pathology

Osteitis. Six individuals exhibit infectious bone inflammation in the postcranial skeleton. In three of these individuals the pathology is observable in two or more of the longbones, implying a systemic, generalized infection, the full extent of which cannot be determined without further radiographic analysis of the axial skeleton.

Osteoporosis. Symmetrical osteoporosis in the frontal and parietal regions of the cranium was observed in four individuals, three of whom also exhibited cribra orbitalia. The orbital region of the fourth individual was not preserved. Degenerative osteoporosis — abnormal thinning and demineralization of the cortical bone — was observed in X-rays of the longbones of two individuals. One of these individuals was an older adult female in whom the condition was probably endocrine-related degenerative osteoporosis similar to that occurring in the elderly today; the other was a younger male in whom the etiology of bone porosity is unknown.

Hemolytic Disorders. Included in this etiologic category are the previously discussed cranial lesions as well as the manifestation in a young adult male of a widespread, systemic, hemolytic disorder. Excessive pitting is evident at the diaphyses of the postcranial skeleton, and in the cranium, pelvis, and tarsal bones of this particular individual, who also exhibits Osgood-Schlatter's disease, a condition expressed in the enlargement of the anterior tibial tubercles and ossification of the patellar ligament. The exact etiology of this systemic disorder is uncertain; however, the distribution of pitting and lesions is suggestive of an extensive ischemia or necrosis, possibly of endocrinological origin.

Osteoarthritis. Development of arthritic exostoses was observed in two adult females affected at the shoulder, elbow, hip, and sacroiliac joints, as well as in the midcervical region of the neck, and at the knee and elbow joints. Evidence of considerably more severe osteophytosis is manifested in the lower vertebral column of a young male, related to a traumatic incident that resulted in bony fusion of the sacroiliac joint.

Trauma. Only one incidence of trauma has been noted in this sample. The individual mentioned above as exhibiting advanced arthritis in the lower back and bony fusion of the sacroiliac joints probably suffered a fall and partial dislocation of the pelvis and possibly a twist fracture in the lower back.

Neoplasia. A solitary cartilaginous exostosis is exhibited on the proximal fibula of a young adult female. This was apparently a benign tumor.

Congenital Anomalies. A small osteomata is present on the left frontal region of the cranium of a young adult. Two individuals have bifid vertebrae, one in the cervical region, and the other in the fourth, fifth, and sixth sacral segments.

Further analysis will attempt to consider these observed pathologies in a systemic framework from the standpoint of individuals in the population, and with respect to the population as a whole. In general, the frequency of trauma is very low in this sample. Disease conditions related to degenerative aging processes are rare, as is expected in a sample with this age structure. Hemolytic and systemic infectious conditions seem to represent common and probably chronic disease states and may have been primarily subclinical.

SUMMARY AND CONCLUSIONS

It is difficult to make more than suggestions as to the implications of the data presented here. Reliable demographic analysis is precluded by the underrepresentation of infants, adolescents, and older adults in the sample; the frequencies of dental, nutritional, infectious, and degenerative pathologies must be considered within this age bias. In this context, however, it is apparent that there is some degree of chronic metabolic stress in the populations, perhaps more severe in females than in males, as suggested by the radiographic analyses of the longbones.

Perhaps the strongest statement to be made in conclusion is that the recovery of additional skeletal material is essential for validation of the results of analyses and the tentative inferences presented here. The role of well-founded biocultural inference in addressing the problem domains in the DAP Research Design is crucial, and the potential for systemic analysis of the physical and demographic characteristics of the population in conjunction with other subsistence- and settlement-related data is considerable.

Appendix F

AN APPROACH TO MODELING DOLORES AREA CULTURE CHANGE, A.D. 650-950

by William D. Lipe

INTRODUCTION

A model is a simplified or abstract representation of a real system. Because it is abstract, the model-builder must select only the few variables which he or she believes are the most important in accounting for variability in the real system. To be a model of a system, the model must state the likely relationships among the variables; i.e., how change in one is likely to effect change in others.

Choice and delineation of the variables, their relationships, and the assumptions that underlie these model components are guided by previous findings and theory regarding how systems of the sort under investigation operate; knowledge to date of the characteristics of the specific system under study may also contribute. The model is testable to the extent that it can predict characteristics of the real system data that did not enter into the construction of the model itself, i.e., did not provide the basis for delineating the variables and relationships. The tests must also be capable of falsification; that is, there must be some data states that could reasonably occur which would deny the predictions of the model. Failure of some of the predictions does not necessarily mean that the model has failed, but rather that it needs to be improved. Assumptions and specific components of the model can be altered to conform to the findings resulting from the initial test; a new set of test implications can then be generated (again, independent of the data which led to the model reformulation). Ideally, several such cycles of testing and reformulation would be carried out, but in practice this has seldom been done.

A model is powerful to the extent that it (1) accounts for (predicts) a variety of characteristics of the real system data and (2) is abstract enough so that the results of its application can contribute to general theory about the processes controlling variability in systems of the sort under study in the specific case.

Archaeological modeling operates under the burden of having to work with data that are removed from the cultural system being modeled. That is, a satisfactory answer must be provided to the question, "How are these variable states of the cultural system manifested in the archaeological record?" To use Binford's (1977b) terminology, the model must not only incorporate theory about how sociocultural systems work, but must also provide middle-range theory about how the behavioral and systemic phenomena of interest are expressed in the archaeological record.

Problem Domain 5 of the DAP Research Design refers to cultural process and sets forth several approaches to defining and understanding the processes of cultural change and continuity that account for the characteristics of the Dolores archaeological record. Subquestion 1 of this problem domain envisions a systematic assembling of archaeological data for various periods, with systematic comparison across periods in order to arrive at data patterning through time. Subquestion 2 envisions a similar procedure, but raised to the level of cultural reconstruction. That is, a kind of ethnography for each phase or period is expected, with emphases guided by the other four problem domains. Generalizations about cultural continuity and change are arrived at by systematic comparison of cultural categories across the various periods.

Subquestion 3 of Problem Domain 5 addresses a yet higher level of abstraction and suggests that the "why" of culture continuity and change be addressed by construction and testing of "theoretical explanatory models." The type of model envisioned appears to be the kind described in the opening paragraphs of this section.

Although these three main subquestions in Problem Domain 5 are presented in a sequence of less to more abstract, it does not follow that they must all be addressed in that sequence. Subquestions 1 and 2 appear to be linked in that the data pattern analysis is instrumental in the development of the cultural reconstructions called for in Subquestion 2. I would submit, however, that cultural reconstruction is not a necessary prerequisite to modeling, but that both can most productively be done side-by-side. The modeling approach is much more selective of data than

is the cultural reconstructive approach; furthermore, modeling may require data sets that crosscut, on an abstact level, several of the categories likely to be used in cultural reconstruction. I would also argue that in some and perhaps many cases the data required for the modeling process may be easier to come by than those required for cultural reconstruction. In the area of social structure/social organization, for example, it may be easier to obtain evidence for the abstract process of role differentiation than for the specific content of roles, as presumably implied by the reconstructive approach. Certainly also, the modeling approach will require fewer data sets than the reconstructive approach, though some of the data sets may be quite large. In general, the two approaches can best be viewed as complementary. The results of modeling should indicate which aspects of culture we need to know more about in substantive detail, while the results of cultural reconstruction can potentially serve as high-order or synthetic data sets usable in the model testing cycle.

In the sections that follow, a very preliminary and often speculative attempt is made to outline a modeling approach for DAP. Theoretical justifications for the choice of primary variables are presented. I have attempted, insofar as possible, to justify the choice of these variables in terms of knowledge of and theoretical literature about cultural systems of the general sort represented by the main body of Dolores data — socioeconomically and sociopolitically fairly simple systems with an economic base which incorporates agriculture but does not fully depend on it. References to Southwestern, Anasazi, and Dolores area prehistoric cultures have crept in, however, as parts of various arguments justifying the choice of variables and discussions of the relationships among these variables. The section entitled "Predicted Relationships Among Primary Variables" presents a brief listing and definitions of the variables thought most applicable to the Dolores case, plus a series of predicted relationships among these variables. The concluding section suggests some of the kinds of data sets that could be used to monitor the variable states at several points in time and space in the Dolores archaeological record.

This set of suggestions for modeling has relied very substantially on the work of others, but I have not taken the time to cite them, or to show how particular pieces of previous work contributed to the formulation used here. Some, but by no means all, of the works that have been helpful are Cordell (1975), Cowgill (1975), Drennan (1976), Hassan (1978), Hunter-Anderson (1980), Nardi (1981), F. Plog (1974), S. Plog (1980), Rappaport (1971), and Zubrow (1975).

The purpose of this report, then, is to serve as a framework for discussion, and potentially as an outline for development of a working model. The latter use would require a systematic return to the literature in order to determine whether the assertions made here hold up under closer scrutiny, and to find additional materials that would support the development of more relevant statements of the model components and more appropriately and precisely designed variable state indicators for use in tests.

THEORETICAL BASES FOR MODELING PRIMARY VARIABLES

Environment, Resource Value, and Resource Availability

For the purposes of this type of model, the environment is viewed as a set of patches or locations of resources important to adapation of the group under consideration. The value of a particular kind of resource on a particular parcel of land is determined by the amount and intrinsic properties of the resource (e.g., caloric value, nutrients per unit weight, etc., for foods) as well as by the characteristics of the adaptive system under consideration (e.g., coal was not a fuel resource for most prehistoric formative-level North American societies). For a particular kind of resource within a given region, the resource values of land parcels will vary both temporally and spatially. In the northern Southwest, for example, much spatial variability in the agricultural potential value of land parcels is associated with variability in soil type and physiography. The latter may also influence moisture in a given soil through elevation, slope, and exposure. Both short-term and long-term temporal variability in precipitation and temperature also seem well-documented for this region. Temporal variability of this sort can either increase or decrease the value of a particular resource in a particular location. Anthropogenic factors such as soil disturbance or depletion of soil fertility can also contribute to both spatial and temporal variability in factors affecting resource value.

It is assumed that within a particular region, and at a particular point in time, the relative values of particular parcels for particular resource types can be assessed. That is, land parcels can be arranged in an order relative to, say, their agricultural potential under the type of farming technology believed to be operative at the time of interest. Furthermore, it is assumed that this ordering by the investigator has some similarity to a scale of values upon which the prehistoric group of interest based certain types of decisions, e.g., settlement location. There is no way this last assumption can be confirmed directly, nor does it need to be. But by proceeding as if it were true, implications can be derived which can be tested against the archaeological record. The assumption that prehistoric peoples were acting "as if" they shared the investigators' assessment of their resources can thereby be falsified. To the extent that this assumption is not falsified, it can be said to be supported, though never "proved."

Major types of resources that can potentially be considered include subsistence resources, which can be broken down

into those exploited by agriculture, foraging, and hunting; and facilitation resources, which include materials needed for constructing facilities, for manufacturing tools, clothing, etc., and for use as fuel in cooking and heating. In addition, locations suitable for settlement and domestic water supplies can be considered to be in this latter category.

To elaborate somewhat on these categories, agricultural resources in an area such as the Dolores region would in a direct sense be the domesticated food plants themselves. Since these cannot be measured directly, agricultural potential of land parcels must be measured in order to establish the parcel's relative agricultural resource value. Variables that are more directly mappable than past crops and that are likely to have been related to domestic plant productivity include soil type, depth, and moisture-holding capacity; precipitation and runoff; exposure, insolation, and evaporation rate; and seasonal and daily temperature regimes. Experimental cultivation of domesticates and consideration of regional paleoclimatic records from tree-ring studies and palynology may aid in calibrating present-day observations with past conditions.

Foraging resources include wild plants and small animals edible by humans; hunting resources are considered to be the larger game animals. Again, what is required is mapping of the main edaphic and microclimatic variables that govern the abundance and distribution of plants identified from the archaeological (and ethnographic) record as being of resource value. Habitat types for animals can also be mapped by reference to their key plant communities, physiographic components, etc. Past distribution of these resources must be modeled with the aid of paleoenvironmental and archaeological information. Facilitating resources have already been generally characterized above. Locations and supplies of some (e.g., building stone, pottery clay, lithic raw materials) are unlikely to have changed greatly since the period of interest; others, such as sources for supplies of building timbers and of large animal hides, will have to be modeled with the same approaches (and problems) that apply to nondomesticated subsistence resources.

In modeling past environmental resource values, not only natural sources of temporal and spatial variability must be taken into account, but anthropogenic ones as well. This operates on two levels — one requires assessing the degree to which recent human activities have overridden or altered the natural processes which affect contemporary environmental characteristics and variability, while the other requires a consideration of anthropogenic effects in the past. For example, if a large number of prehistoric foraging resources tend to be associated with early successional plant communities, then prehistoric soil disturbance from cultivation may have enhanced the foraging value of certain land parcels. Presence of cultivated fields, or of abandoned fields, may have tended to attract larger game such as deer, but the human populations associated with these fields may have tended to drive them away or to overexploit them. If fuel and building timber resources were overexploited, the values for these resources in the vicinity of settlements would decline also (see chapter 5, section 4, this report).

In addition to local resource distributions, spatial and temporal variability at a large pan-regional level may need to be modeled. Assessment by individuals or groups of the relative resource values of their own versus adjacent regions is likely to have been a factor in population movement as an adaptive strategy.

In attempting to model the resource value states for land parcels in an area at various points in time, it is obviously impossible to take all variables into account, to make very fine discriminations among values, or, in most cases, to use more than an ordinal scale of measurement. It is assumed, however, that gross variation in the spatial and temporal distribution in the major kinds of resources can be modeled, and that at least rough orderings of the resource values of different locations or land parcels can be achieved. As noted above, the principal strategy would be to use the archaeological record and ethnographic analogy to identify variables of interest, to map the present-day (or recent historical) distribution and values of these, and to retrodict past states through reliance on such paleoenvironmental and archaeological data as are available. To the extent that this can be accomplished through reliance on relatively slowly changing environmental variables such as physiography and general soil depth and type, the reliability of the exercise can probably be enhanced.

Assigning resource value to land parcels within the region of interest presents one set of problems; modeling resource availability for prehistoric groups in question presents another set. Resource availability refers to the degree to which the population had access to high value resources. Another way to look at this concept is as resource cost; as high value resources become more difficult for some or all members of the group to obtain, they become more costly.

Because we are dealing with past behavior, resource availability cannot be measured directly. There are effects of differing states of resource availability, however, that should be represented in the archaeological record. If in fact land parcels can be ranked by relative resource values, then it is expected that a population entering an area would first exploit land parcels having high resource values, and especially those parcels having high aggregate values for several important resources. In order to minimize effort in obtaining these resources, the population should establish settlements in locations close to the areas yielding desired resources. If population grows, the highest value parcels should become increasingly less accessible to new population members (especially if these are new immigrants). This

will be so either because the resources are all being used by the existing population, or because the existing population has established some type of limit (e.g., ownership, inheritance system, territoriality) which excludes some or all new population members. Consequently, settlement of an area should proceed from areas of highest resource value to those of lower value, with respect to resources most important in subsistence and in manufacture of facilitating structures and items. Consequently, when several areas or time periods are compared, the extent to which settlements are associated with low as well as high resource areas should be interpretable as an indirect measure of resource availability for the population of interest. Also, to the extent that particular resources, independent of their locations, can be placed in a resource value hierarchy, then the pattern of occurrence of low and high value resource items in archaeological deposits may also indicate resource availablity.

Population growth is, of course, not the only factor that can affect resource availability. As noted above, both natural (e.g., climatic change) and anthropogenic (e.g., soil disturbance or depletion) factors can increase or decrease the value of a particular resource in a particular area. Consequently the relationship between the supply of a resource of a given value and the demands of the consuming population can change, even if the population remains the same size.

It is assumed here that individuals and groups in a society will make culturally patterned evaluations of the extent to which resource availability is increasing, remaining stable, or declining. Furthermore, it is assumed that the perception of declining resource availability may trigger an adaptive response prior to serious deterioration in the standard of living or the onset of Malthusian solutions to resource-population imbalance. For example, if perception of declining resource availability is coupled with an increased requirement of labor or facilities to maintain the same standard of living, adaptive responses such as out-migration, economic intensification, or possibly, population regulation, might be forthcoming. To the extent that both substantial population growth and approximate stability in the resource base and technology can be documented, it can be inferred that there has been an increase in density-dependent relationships between resources and population, or rather, between resources and the cultural adaptive devices by which the population maintains itself. This inference would be strengthened by evidence of settlement expansion into areas having lower resource values, or by evidence of increased appearance in archaeological deposits of low-value resource materials.

This type of model attempts to avoid some of the pitfalls of the "carrying capacity" approach to investigating population/resource relationships. It does not require estimation of absolute amounts of resources available or of absolute amounts consumed by a population; only the construction of a resource value hierarchy and evidence of "how far down" the hierarchy the population is "reaching" to obtain resources. Here, its use for inference is also relative — in the most workable case, an area can be compared at different points in time to determine whether resource availability has increased or declined through time. Comparisons among areas are also possible, provided approximately the same kinds of resources are present in both. This approach also attempts to avoid the unrealistic assumption that Malthusian limits must be felt before adaptive response is made, by assuming instead that perception of decline in resource availability can lead to corrective action.

Population Growth in Agricultural Societies

Hunting-gathering societies in general appear to have very low rates of population increase. Societies in which agriculture plays an important economic role appear to show much greater rates of population increase, although generally not at the high levels documented in recent years for a number of modern "third world" societies.

The processes which account for these differences are not very clear, but may include the following:

(1) In hunter-gatherer societies, prolonged lactation and the burdens of carrying small children may lead to relatively long intervals between births. In sedentary agricultural societies, greater availability of soft, processed foods and the reduced need for transporting infants, and possibly, fewer periods of very low calorie intake may permit closer birth spacing.

(2) In hunter-gatherer societies, subadolescent children contribute relatively little to subsistence, particularly in hunting. This may be because of the greater mobility and greater degree of skill demanded by hunter-gatherer as opposed to agricultural economic activities, and/or it may be related to the difficulties of intensifying economic efforts in the hunter-gatherer situation, where human inputs have little effect on the supply of resources. In an agricultural society, on the other hand, the simple, routine, close-to-home nature of many agricultural tasks (such as weeding, scaring away pests, and carrying produce) enable children to make a more valuable contribution to subsistence activities. There may also be differential contributions of children to old-age security of parents, though this does not seem to have been explored in literature I am familiar with. To the extent that simple agricultural societies have greater household autonomy, and individuals have lesser dependence on diffuse networks linking them to the more productive members of a group, this could be true. In other words, the relationship of an individual to providers may be more diffuse in a hunter-gatherer society and is less susceptible to intensification by the individual in question. In agricultural societies having relatively great household economic autonomy, the individual may build insurance

for the future by building a larger household — by having more children.

(3) Hunter-gatherer societies depend on individual skill and knowledge, as well as on the natural distribution of wild plant and animal foods, to make a living. If these natural food resources fail, there is often little a group can do about it. To the extent that intensification of effort can ameliorate such problems, it may be that this takes the form of traveling greater distances or hunting longer hours for accustomed foods. Children probably can contribute relatively little to these alternatives. Children could contribute, however, in circumstances where the response takes the form of greater reliance on close-to-home foraging resources where large numbers of small "packages" of food must be gathered. Consequently, in many cases hard times provide little incentive for increased household or group size. In an agricultural situation, however, the interests of at least the household may be served by larger size during hard times. This is because yields of domestic crops, as opposed to wild, are more capable of being increased by intensification of labor, including unskilled labor. To the extent that intensification degrades soils or supplementary resources, the interests of the household may be at cross-purposes with the interests of the group. Eventually, of course, Malthusian controls will take over if all or most of the intensification effort fails; the point is, however, that there may in some cases be an inverse relationship between demand for children in a household and adaptive success of the population.

For these reasons, we will assume that local populations in the Dolores area had a tendency towards internally generated growth during the period of interest, and that this tendency would be overridden only by severe adaptive stress. Out-migration or the aforementioned economic intensification would be likely to come into play in most cases prior to such stress, and hence to preserve the tendency toward internal population increase. Population regulation could also occur, of couse. I am inclined to think it an alternative less likely to be used than out-migration or intensification, but I cannot support the argument well at this point.

Immigration-Emigration as Adaptive Strategies

Movement of population (at the individual, household, subcommunity, or community levels) depends on the individual or group's (1) perception of their own standard of living and of the costs of maintaining or increasing it in the existing local social and natural environment; and (2) the individual or group's state of knowledge of adjacent social and natural environments and the relative cost of maintaining or increasing their standard of living there. Costs of moving include losses of facilities and valued relationships in the old situation, as well as costs of social integration and of obtaining other facilities in the new situation. Consideration of these relative costs will condition decisions to stay or move. Logically, direction of movement should follow this kind of distribution: If we hold population and level of socioeconomic organization constant across source and target areas, movement will be to areas of more favorable natural resources. If we hold resource environment and the level of socioeconomic organization constant, movement will be to areas of lesser population. If we hold population and environment constant, movement should be to areas having socioeconomic organization providing greater productivity and/or security per capita.

Generally speaking, it is probably more difficult for households to become integrated into a new situation than it is for individuals, and more difficult for large groups and whole communities than for households. Also, the greater the degree of group integration, the greater should be the difficulty of moving as a subset of that group. In general, receptivity to newcomers in the targeted area will probably be conditioned by perceived per capita resource supply (including access to land) on the part of the target population, by the degree of existing intra- and intergroup integration within the target population, and by the size of the incoming group. Cultural similarity between migrating and target groups may enhance assimilation because of ease of communication and perhaps because of preexisting relationships based on exogamy, extension of unilineal group membership, trading partnerships, etc., but this alone should not be able to override other considerations.

There appears to be evidence of considerable disparity among regions adjacent to the Dolores area in kinds and densities of resources, and in type of response to climatic fluctuation (e.g., precipitation regimes that are too dry for farming in some areas may be favorable for farming in adjacent, higher elevation areas). Consequently, it is reasonable to assume that population movement is an adaptive strategy likely to have been employed in the Dolores area during at least part of the period of interest. It also seems likely that the Dolores area's receptivity to immigration and emigration would have varied through time.

Economic Intensity and Intensification

Economic intensity refers to the input of labor or capital goods, relative to the output of products, for a particular economic activity or group of related activities. Economic intensification refers to changes in economic intensity which result in higher production of goods and services important in the adaptation of a group. In societies such as the ones with which we are dealing here, these changes should focus on the subsistence system, either directly, or through development of goods and services which can be exchanged for foodstuffs, or through development of organizational strategies which enhance the production and distribution of subsistence items.

Technological improvements. One way in which economic intensification can be brought about is by improvement in subsistence technology. Developing or obtaining hardier or more productive domesticated plants or animals would be the most direct way of improving productivity. There are also opportunities for developing tools which have greater efficiency for raising, harvesting, and processing domesticated plants and animals, or for harvesting and processing wild plants and animals. Selective weeding to favor certain wild plants, and garden hunting may fall somewhere between these two strategies.

Better facilities for food processing may also contribute to intensification of subsistence activities; improved storage facilities likewise. For example, to the extent that the cultivation of marginal land and/or temporal variability in weather made maize harvests unpredictable, larger storage facilities would be a form of intensification. Storage could also be improved through construction of tighter, more pest-proof facilities and through control of temperature and moisture variations. Secure storage of seed corn and provision for maintaining segregation of seeds of differing varieties would be important. Ease of access to stored foods is another factor subject to modification, as is privacy of access; the latter presumably would become important in situations where there was unequal access to food resources within a neighborhood or community.

Organizational strategies. In addition to these relatively direct technological approaches to intensifying a subsistence economy, there are a number of devices which can be loosely grouped as organizational. Intensification can be accomplished by increased labor inputs into food acquisition, harvesting, or processing and storage. There are three possibilities here — the same number of workers can put in longer hours per capita, a larger proportion of the population can be recruited in the work force, or both can be done. The efficiency of labor can also be increased by improved scheduling and organization of work. Extensive increases in this type of intensification probably result eventually in the development of stronger managerial roles and/or cognitive/symbolic systems which promote increased labor output and efficiency.

Related to this is the development of cooperative work parties, as for house building, maintenance, or posssibly planting. Simple cooperative efforts can be developed on the basis of reciprocity or kinship obligations. More complex scheduling or work organization efforts may lead to the differentiation of institutionalized leadership or administrative roles. In the kinds of societies with which we are dealing, it seems unlikely that any very formal administrative hierarchy would have developed, but economic intensification might have promoted tendencies in this direction, perhaps as an added dimension to certain existing kinship or ceremonial roles.

Changes in division of labor may also make a contribution to economic intensification. Generally this will result in an elaboration of the division of labor or a greater formalization of existing divisions. A tendency for men to clear fields, do long-distance hunting, and construct major facilities while women, children, and older males cultivate crops, do local hunting and gathering, and maintain facilities might be intensified by some relative decline in the per capita availability of high priority resources. That is, if farmers increasingly had to make use of distant or hard-to-clear fields, to go longer distances for wood for construction, and to make extended hunting trips for large game because of local game depletion, such a division of labor might be reinforced. To the extent that economic intensification relied on exchange of goods, at least part-time craft specialization would also be favored, and would contribute to an elaborated division of labor.

Exchange. As noted above, exchanges and transfers of goods and services may contribute to economic intensification by allowing individuals or groups to obtain goods or services to which they do not have direct access by their own efforts. Because craft skills are seldom uniformly distributed in a group, a skilled potter or knapper might be able to exchange products for other items, including food. Differentiated production based on skill would probably support exchange largely on an individual or household level, and probably most often within a community or between adjacent communities. Different communities or, posssibly, groups within a community, may also have differential access to resources that are not uniformly distributed across the area — for example, pigments, flakeable stone, clays, even certain subsistence resources. Thus, a group or community might become known as a source for certain kinds of items, even though actual exchanges would likely occur among individual trading partners. Access to resources that were scarce regionally might thus enable individuals from a community to widen their geographic range of trading partnerships.

Given the diversified nature of northern Southwestern environments, both in space and time, the opportunity for using exchange as a mode of economic intensification would seem to be great. That is, all individuals, groups, or communities would not have uniform access to all desired subsistence or other resources because of their spatial variability; the extreme temporal variability of environment, particularly in factors affecting crop yields, would also provide motivation for individuals or groups to manufacture items which could be exchanged for food when the need arose. The fact that temporal variability in rainfall — particularly in summer rainfall — is not highly correlated from place to place makes such possibilities even more evident. In other words, it is quite possible for one locality to have good crops while another only a few kilometers away experiences failure.

If exchange was developed as a mode of economic intensification in the societies with which we are dealing, it seems

unlikely that even long-distance intercommunity trade was managed by an elite class or by trade specialists as may have been the case in some emerging civilizations. This requires a degree of structural differentiation of society, the support of a greater nonfood-producing superstructure and more elaborate recordkeeping and administrative control than our evidence suggests for any Southwestern system. Nevertheless, the point can be made that some economic intensification could have been accomplished in the Dolores area by the development of fairly simple exchange mechanisms.

Tranfers of goods and services in which reciprocation in kind is lacking are also common features of primitive economic systems. These generally appear to be related to kinship obligations and might also serve to accomplish the same ends of buffering spatial and temporal resource variability as does exchange.

Limitation of access. A final mode of economic intensification is increased regulation of access to resources. If times are becoming harder, it may be necessary to say "no" with regard to critical resources such as land or stored food. In the western Pueblos, for example, access to land is controlled by membership in dispersed matrilineal clans. Regulating access to land might be an intensification response in cases where the area was subject to considerable immigration pressure. Increased ethnic labeling (via distinctive clothing, housing, etc.) might also be an intensification response to the extent that ethnic groups were associated with land or other resources.

In the Dolores area during the target period, it seems likely that some economic intensification responses would have taken place if population was increasing to the point where increasingly lower-value resources were being used and where high-priority resources, such as large game, were becoming available only with considerably greater expenditure of effort. This prediciton should at least hold during times at which out-migration options were not very attractive because adjacent areas had unfavorable environmental conditions or dense populations, or both.

Role Differentiation

Differentiation refers to the proliferation of roles that characterize an increase in societal complexity. Obviously, one source of role differentiation is an increasingly complex division of labor, as discussed above. Differentiation may also be associated with increased population aggregation; as numbers of persons in face-to-face contact increase, the presence of loosely defined, multifunctional roles may lead to conflict, with numerous individuals attempting to do the same things at the same time. Greater role specialization and complementation may avoid this kind of problem. And, as with economic intensification, the problems of arranging an orderly existence for dense populations may promote the development of roles having managerial, administrative, or integrative functions. Permanence of membership in a group may also facilitate role differentiation. In some hunting-gathering bands, individuals and households may move fairly freely through a regional network to kin and associational relationships. Under certain circumstances, migration may continue to be an option even for members of farming societies, as discussed above. Given this type of mobility, investment by a group in preparing an individual for a specialized role may not pay off. To the extent that group membership remains fixed for life, however, such an investment may be rewarded. Group exogamy and unilocal residence may continue to work counter to such investment. If the community is large enough or population density great enough, however, the kinsman or associate who has "married out" of a clan or other group may remain within the community or at least close enough to continue to interact with the kinsmen and other associates who were responsible for his socialization.

To the extent that it rewards increased technological efficiency in the manufacture of complex or high-input tools and containers, or in the construction of facilities, etc., economic intensification should promote increased homogeneity in some aspects of cultural material. If an increasingly differentiated division of labor requires differing sets of tools and facilities, however, there should be more kinds of tools, or at least of tool kits, and more kinds of facilities. Activity areas in confined spaces might be expected to become more distinct, both spatially and in content.

Moving away from economic role differentiation, recognition of status, age, kin group membership, etc., may foster development of sociotechnic attributes or items — cultural materials which identify to others a particular role or bundle of roles. Such items may or may not also play a technical or economic function. Differences in housing — amount of space, quality of construction and decoration, etc. — might indicate status differences. Burial associations have commonly been used as evidence upon which some inferences of role differences might be based. In balance, Anasazi data in general suggest that role differentiation did not move very far in the direction of status differentiation, but variability in cultural material should be examined with this and other types of role differences in mind. Even though it might not be possible to reconstruct the content of specific roles, it may be possible to measure changes in cultural variability — that may correlate with changes in role structure — towards more or less differentation.

Integration

Integration refers to those roles, institutions, and symbolic/cognitive systems which operate to promote harmony, cooperation, and effective complementation, and, in general, the smooth meshing of the various components of society. Such mechanisms are needed at the household, suprahousehold, community, and intercommunity levels,

and are probably proportional in strength to the amount of interaction, mutual interdependency, and friction that arise at each of these levels. Another way to look at it is to see the need for explicit integrating mechanisms as proportional to the amount of differentiation and the amount and residential density (aggregation) of population in a given social segment. Where population and differentiation in a given segment are low, multifunctional mechanisms such as kinship and friendship will perform most integrative functions. As differentiation and aggregated residential population size rise, however, the potential for conflict and awkward meshing increases, so the development of more explicit integrative roles, institutions, and cognitive systems will be promoted.

Even in relatively differentiated, densely populated societies (as opposed to "typical" hunter-gatherer bands), explicit integrative mechanisms may remain weak if the degree of economic interdependency among small segments such as households remains weak and if out-migration is an option for resolving social conflict and/or adaptive problems. To the extent that out-migration is not an option, or to the extent that loss of small segments such as households weakens the overall adaptive ability of the larger entity, explicit integrative mechanisms would probably be reinforced.

In thinking about what kinds of explicit integrative mechanisms might have arisen in the Dolores area during the period of interest and about what the archaeological expression of these might be, it may be useful to think in terms of institutions and roles; facilities associated with institutions or roles; and supporting cognitive/symbolic systems which may also have material expression.

Facilities which may have been used by institutions having integrative functions include "great" kivas not clearly associated with a particular group of habitation structures; "large" kivas, associated with a specific large block of habitation structures; and "true," or small kivas, each associated with a specific small block of habitation structures. The kinds of institutions which may have been involved are problematical, but may have ranged from sodalities with specific membership, to political/ceremonial leadership groups representing particular social segments, to whole communities or even multiple communities. Ethnographic search for possible analogs should focus on the kinds of integrative problems that arise in simple agricultural societies, and the kinds of social mechanisms used to resolve these problems, rather than on specific correlations between form of facility and function of activity carried on therein.

The aggregation of households into densely populated villages during one portion of the Dolores sequence may have been a function of economic intensification, in that aggregation would have facilitated cooperative construction and maintenance of facilities, and would have promoted a higher level of intracommunity exchange of other services and of subsistence and other goods, etc. Since this aggregation density for any given individual or household, there would very likely have been increased potential for conflict as well as for cooperation. Hence, the development of some additional integrative devices or intensification of existing integrative activities would be expectable. The appearance of "large" kivas in some aggregated communities of the late 800's may be a reflection of this. Also, communities were certainly more discrete entities at this time than they had been in the 700's and early 800's, when communities appear to have been composed of very loose, not clearly bounded, clusters of one or two household habitations. In the formation of aggregate, bounded villages, cognitive/symbolic devices promoting community identity and cohesiveness might have been useful in assisting integration. If these devices were reflected in attributes of material culture, some greater intercommunity differentiation in artifact design or other formal attributes might be expected.

To the extent that economic intensification is related to rising anxiety about adaptation, and if differentiation and increased aggregation increase conflicts, cognitive systems and ceremonial activities emphasizing the sacredness of societal norms may have been promoted. Such cognitive systems and activities would reinforce beliefs in the ultimate rightness of socially approved behavior, would enhance motivations to intensify socially approved behavior, and would enlist the assistance of supernatural agents in resolving adaptive and social problems. If these activities involved paraphernalia or symbolic representations, some of these items might enter the archaeological record. If these cognitive systems and ceremonial activities became complex, specific role assignments in maintaining the systems would be promoted. In the societies with which we are concerned, such roles are unlikely to have achieved the status of full-time ceremonial specialist. Whether subtle increases in role differentiation in this direction could be detected in the archaeological record is problematical, but the prospect should be kept in mind. That the need for specifically integrative roles in part arises from greater role differentiation in general, and that this aspect of integration contributes to further differentiation, should be considered. As previously noted, it may be possible to detect in the archaeological record evidence of increasing role differentiation in general, even if the content of specific roles cannot be inferred.

In light of the preceding discussion, it seems likely that pressures for increased integration would have been greatest when local populations were densest, or at least when residential populations were most aggregated, when role differentiation as a result of economic intensification and other sources was highest, when anxieties over adaptive problems and social conflict were high, and when out-migration was not a viable option for resolving social and adaptive problems.

PREDICTED RELATIONSHIPS AMONG PRIMARY VARIABLES

The preceding discussions have led to tentative identification of several primary variables which may be important to monitor in modeling culture change. The variables which seem most appropriate to the Dolores case are listed below with brief definitions:

1. Subsistence resource value. Relative value of food obtainable from a given parcel of land. Can be subdivided into agricultural, foraging, and hunting resource value; this probably represents order of importance in Dolores case.

2. Resource availability. Degree to which population can obtain subsistence resources from the more productive, highest resource value, land parcels.

3. Economic intensity. Amount of labor, organizational, and/or capital input per unit of economic output. Economic intensification can be achieved through changes in technology (including crops, tools, and facilities), organizational strategies, exchange patterns, and/or access to resources. It seems to maintain or increase resource acquisition per capita.

4. Role differentiation. Proliferation of roles through narrowing of role definitions, decrease in multifunctional roles.

5. Population size. Number of persons in target area at any given time.

6. Population aggregation. Population size of average settlement at any given time. (Definition of settlement essentially corresponds to archaeologist's definition of site — i.e., it has more or less continuous evidence of occupation and is separated from other such entitites by area in which such evidence is lacking; it may or may not be co-terminous with community.)

7. Integration. Institutions, roles, or cognitive/symbolic systems which promote intragroup harmony, resolve conflict, etc.

8. Immigration. Movement of population into target area.

9. Emigration. Movement of population out of target area.

The discussions in "Theoretical Basis for Modeling Primary Variables" have also led to tentative conclusions about the probable relationships among these variables. All statements require the qualification "all other things being equal." These are as follows:

1. As resource value decreases, resource availability decreases, and vice versa.

2. As population increases, resource availability decreases, and vice versa.

3. As resource availability decreases, economic intensity should increase.

4. As economic intensity increases, role differentiation should increase.

5. As economic intensity increases, population aggregation should increase.

6. As population size and/or population aggregation increases, role differentiation should increase.

7. As emigration decreases, economic intensity should increase.

8. As immigration increases, integration should increase.

9. As role differentiation increases, integration should increase.

10. As population aggregation increases, integration should increase.

11. As population increases, resistance to immigration should increase.

12. As emigration increases, integration should decrease.

A hypothetical model, depicting relationships among these variables through time, is shown in figure 138. The goal of the modeling effort is to construct such a graph for the Dolores area, using indicators of the sort described in the following section and to further analyze the ways in which

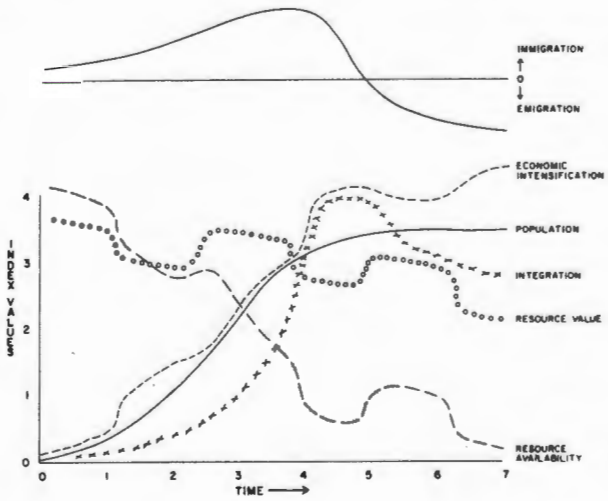


Figure 138. A hypothetical model depicting relationships among variables through time.

the Dolores indicators agree with or disagree with the predictions made above.

It will be noted that the predictions made above do not attempt to state the form of the relationships between and among the variables. At present, it is implicitly assumed that some type of linear relationship obtains. Given what we know about the instability of complex systems, it seems unlikely that these relationships are actually linear. It will also be noted that for some relationships above, converse or vice-versa forms are stated, but that this has not been done for all. This is because it is suspected that some structural change in society, particularly in role differentiation and integration, is not easily reversible, or at least not at the same rate at which change developed in the initial direction. Perhaps some progress on these topics can be made in developing the model, or perhaps an attempt to apply the model will result in some findings that will increase knowledge about the form of these relationships.

Possible Indicators of States for Variables to be Modeled

The most difficult part of any modeling exercise is "getting it on the ground"; that is, making the variables operational in terms of the available data. This requires development of linking arguments as to why particular archaeological data should in fact be indicators of the variables of interest, and some kinds of scales that enable the indicators to be quantified. This presentation only attempts to sketch some of the approaches that might be taken in the development of indicators. In my opinion, thinking through the linking arguments is the most critical step. One must not only think in terms of the material consequences of the kinds of processes recognized in the variables, but one must think about how these material consequences are represented in the archaeological record. With regard to quantification of the indicators, it may be possible to make progress even if we can only recognize rank-order scales, provided we phrase our predictions in general enough terms and emphasize direction of change rather than absolute amount of change.

1. Subsistence Resource Value

This will be one of the most difficult to evaluate. I suggest that the target area be subdivided into parcels, perhaps 1 km^2. Each parcel should be assigned a relative agricultural value on the basis of soil type, exposure, slope, growing season, and precipitation. Then transformations of these values can be estimated for different states of winter-spring precipitation, summer precipitation, length of growing season, and length of time the parcel is thought to have been used for agriculture. Then, using such paleoenvironmental evidence as is available, the agricultural subsistence resource value can be calculated for each parcel for the time period of interest, and a value for the target region as a whole can also be arrived at for particular points in time. I should think that agricultural resource value would have the greatest weight in calculating subsistence resource value, but we should also make a stab at foraging value as well. As a result of secondary succession attendant upon soil disturbance, wild plant resources and small animal resources might be expected to rise to some extent with population; large game resources might be expected, however, to go down.

2. Resource Availability

It will not be possible to measure this directly, but there are several possible indirect indicators.

a. Settlement shifts. The resource value model sketched above should allow us to rank parts of the target area in terms of desirability for agriculture and perhaps for other subsistence pursuits. If density-dependent relationships are taking place in agriculture, the most desirable areas should be settled first, followed by the next most desirable, etc. Survey data should allow us to document such shifts if they occur and can form the basis for an indicator of "how far down" on the agricultural resource value scale settlement has proceeded.

b. Wild food desirability index. From ethnobiological and biological sources, wild plant and animal foods from this area can be arranged in some kind of scale or scales which express relative ease of acquisition and relative palatability and/or nutritional value. The extent to which items low on these scales appear in archaeological deposits might be taken as an index of density-dependent relationship to wild food resources and hence as an index of availability of this kind of resource.

c. Long-distance hunting. A shift from evidence of local acquisition of large game to long-distance aquisition would be evidence of decline in local availability in such resources, and could be used as evidence of declining resource availability. This indicator may also provide some insight into role differentiation, since regular absence of adult males for extended periods should result in greater differentiation of male and female roles.

d. Conservation of materials. Evidence of recycling of materials, especially of construction wood that would have to be brought from some distance, might be a good indicator of depletion in this resource. If we could ever get enough tree-ring dates from individual structures, increased reuse of beams might be picked up from the patterning of dates. A decline in the burning of pitstructure roofing materials, or evidence that larger beams were taken out before burning, might also indicate increased conservation, and hence decline in availability of the wood resource. Another good indicator would be increased recycling of items made from large game — leather, bone, antler.

e. Shifts in construction materials. A shift to increased use of *Populus* as a building material in late structures has been

noted. Kohler et al. (chapter 5, section 4, this volume) have suggested that this may be a response to the depletion of better quality construction wood (e.g., ponderosa pine, Douglas-fir) in areas near the sites.

3. Economic Intensity

a. Secure storage/habitation space. The amount of facilities devoted to storage may well be an indicator of economic intensity.

b. Trade. To the extent that individuals or groups are exchanging craft products for subsistence-related items, trade should be an indicator of economic intensification. There will be some problem in separating items introduced by trade from those introduced by immigration. It will also be easier to identify craft products traded in than those traded out of the area; the latter, however, would probably be a more direct indicator of local economic intensification. However, amount of introduced trade items may still be useful as a general indicator of the level of exchange. This also will work best for interregional exchange, while subsistence-related exchange may more likely operate on an intraregional level. Identification of variation in craft production among households or communities and amount of exchange within or among Dolores area communities would therefore be a high priority. Recent analysis of Dolores area ceramic and lithic materials source areas suggests this may be a real possibility.

c. Settlement spacing. It has been argued in the geographic literature that an increased regularity in spacing among population centers is an indicator of increased competition for land, trade, etc. If arguments can be made that this reflects increased territoriality or definition of exclusionary boundaries, then perhaps we could use this kind of phenomenon as an indicator of economic intensification. Such schemes work best, of course, on ideal uniform planes having homogeneous resource distributions; the Dolores area obviously does not fit. If the peaks and valleys of resource distribution and the peaks and valleys of actual topography can be somehow taken into account, such an indicator might be calculated. If we can hold resource value constant across time (difficult) as well as across topography, we might be satisfied that movement toward or away from regular spacing was a satisfactory indicator. It is likely that this type of analysis will work better for study of spacing of large settlements than for small.

d. Tool and facility specialization. By specialization I mean a shift from doing a variety of things reasonably well to doing a few things quite well. A good example is the shift from basin milling slabs and cobble manos to trough metates with two-hand manos. Ethnographic evidence indicates the former are good for breaking, crushing, mashing, and grinding a variety of seeds and probably other materials. The latter are very good at controlled grinding of large quantities of small, hard, dry seeds. A variety of other things can be done with the equipment, but not as well as with the grinding basin and cobble mano; the latter also appear to be much more easily manufactured. In economic intensification, one would expect specialization to occur in tools and facilities used to obtain, store, or process those foods which were regularly handled in bulk. Tools used in manufacturing would probably become specialized to the extent that the process involved demanded close tolerances and/or to the extent that certain kinds of manufactures were being produced in bulk, probably by making lots of them in a short period of time. Processes like weaving or basketry, where it takes a long time to produce something, but where many repetitions of the same motions are required, might also lend themselves to specialization.

e. Functional differentiation of economic activity areas and facilities. To the extent that role differentiation is partly a product of increasing division of labor, this indicator serves as an indicator for role differentiation also. If division of labor was increasing, one might expect activity areas to become more distinct in content and in spatial segregation. Variability in the form (though not necessarily the size?) of facilities such as containers, hearths, and storage structures would probably become more discrete, less continuous.

4. Role Differentiation

a. Sociotechnic items. Frequency of sociotechnic items relative to house floor area, to quantities of sherds, or to some other quantity thought to remain relatively constant while role differentiation varied.

b. Differentiation of noneconomic activity areas and facilities. Do some people really live in pitstructures and some in surface structures year-around? Do households with large houses also have disproportionately large amounts of material items and "neat stuff?" Do men's and women's areas of a house become more distinct through time? Are kivas really lacking evidence of women's activities? etc., etc.

c. Burial goods. The standard approaches to interpretation of burial goods. Since few burials are being found in the Dolores area sites, the monitoring of construction activities should focus on whether burials are being encountered away from obvious sites. Any cemeteries so encountered should have a high priority for emergency data recovery.

5. Population Size

There are a number of approaches to the estimation of population size based on amount of area occupied by an individual or household, or on the rates at which individuals or groups output materials of various kinds into the archaeological record. DAP work is being done on this

topic (chapter 5, section 3, this volume) and there are numerous examples in the literature, so I don't think this needs further elaboration.

6. Population Aggregation

This is pretty straightforward. Indicators should be evident from the definition.

7. Integration

a. Appearance of "integrative structures," as defined in project systematics. We should probably look at feature and item content of these, and at their activity areas, to see how well the assignment — based on architectural form and position in settlement — is holding up. If we can find some distinctive patterns of features/items/activity areas associated with these structures, we might want to look for these patterns in other kinds of structures as well.

b. Frequency of ideotechnic items relative to some class of items thought to vary relatively constantly with population. Definition of ideotechnic items can be arrived at by archaeological and ethnographic analogy (fetishes, pahos) or by contextual analysis (see 7. a).

c. Increase in ethnic identity markers at community or regional level. That is, increasing distinctness in design styles or other easily recognized, visible, formal or stylistic attributes of cultural material, as seen from community to community or between the Dolores area communities as a whole and those in adjacent areas. Technological attributes probably won't work, nor will things that have to be seen with a microscope, or things usually kept indoors.

8. Immigration/Emigration

This is a tough one, almost as difficult as resource value. But it is very important.

a. Interregional demographic response. It may be possible, in a rough way, to assess relative populations in the Dolores area and adjacent regions at various points in time. Using general physiographic and soil characteristics of these regions, it may be possible to develop some rough sort of estimation of their gross agricultural resource values under differing climatic regimes. Using such paleoclimatic data as we have, it may be possible to estimate which areas are becoming more or less favorable for agriculture at various points in time. I made a very rough trial stab at this and the results looked promising. At some time periods, when modeled agricultural conditions were poor in my modeled "drought sensitive" environment, they were good in my "temperature sensitive" environment. The reverse was also true in some cases; yet at other times, both types of environment were "bad" or "good."

b. Indicators from the archaeological record. *Immigration at the individual level*: the most likely situation is in case of marriage into a community from a community outside the target area; the individual would therefore be integrated into an existing household. There would probably be no architectural expression (construction of facilities would probably be a group effort). The individual might bring items of personal equipment which were recognizably from outside the Dolores area. To the extent that the individual would become integrated into an exisiting household, he/she would probably not maintain the previous community's decorative traditions, etc. This case is probably difficult to distinguish from trade.

Immigration at the household (or other small group) level: there should be introduction of portable personal equipment. These might be distinguishable from trade because they would comprise a functionally related complex of items. To the extent that the group becomes rapidly integrated into the community (expectable, else they would probably leave), exotic traditions of item manufacture or decoration should rapidly extinguish. The incoming household would probably have to build its own facilities, however, so it might be likely to perpetuate some features of the architectural tradition of the home community. This might be particularly true for features not commonly seen by neighbors, e.g., inside the house. It seems unlikely that the architectural tradition would last beyond a single generation, however.

Immigration at the large group or community level: this might be able to establish a cultural subtradition that lasts several generations and that is recognizable in a complex of artifact and architectural variables. The longevity would depend on the extent to which ethnicity was a viable adaptive strategy in the social context.

Internal population growth: frequent remodeling of household facilities and expansion of facilities, would be expected, as would growth in size of communitites by accretion or reduplication of household clusters. The lack of cultural discontinuities of the sort described above would not be expected. If we could distinguish children's items or children's activity areas, these should be more common in a growing population than in a stable or declining one. Immigration by individuals would also not likely be by individual children, but rather by adults. Immigrating households or larger groups would be likely to contain children, however, and thus would not provide a contrast.

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