

CHAPTER 10 – PALEONTOLOGY

10.1 INTRODUCTION AND RESOURCE OVERVIEW

Paleontology is a biological and geological scientific discipline involving the study of fossil materials. Paleontological resources, or fossils, include the body remains, traces, or imprints of plants or animals that have been preserved in the Earth's crust. Among paleontologists, fossils are generally considered to be scientifically significant if they are unique, unusual, or rare; diagnostically or stratigraphically important; or add to the existing body of knowledge in a specific area of the science. The BLM considers all vertebrate fossils to be scientifically significant. Invertebrate and plant fossils may be determined to be significant on a case-by-case basis.

Most fossils occur in sedimentary rocks where they may be extensively distributed vertically and horizontally throughout the units in which they occur, or they may occur in discontinuous pockets. Few sedimentary rock sequences, or formations, are uniformly fossiliferous, and some formations are more richly fossiliferous than others. The types of fossils preserved in a sedimentary rock sequence depend on the geologic age of the rocks in which they occur and the environment in which the sediments that comprise the rocks accumulated. Rocks that crop out (are exposed) at the surface of an area and can potentially yield fossils are the result of geologic (depositional, structural, and erosional) history.

Geologic formations and sediments exposed at the surface in the Monticello FO planning area range from Pennsylvanian to Recent in age. General geologic mapping of the Monticello FO area is available as Hintze's (1975) Geological Highway Map, digitally by Hintze et al. (2000), and in published USGS 2 degree sheets (scale 1:250,000) by Haynes et al. (1975) and Hackman et al. (1973). More detailed descriptions of the geology of the Monticello FO area are provided in the Mineral Potential Report.

In the Monticello FO planning area, fossil-bearing sedimentary rocks range in age from Pennsylvanian to Quaternary and represent parts of the three great periods of Earth history during the Phanerozoic (*phaneros* = visible, *zoic* = life) eon: the Paleozoic, Mesozoic, and Cenozoic. Fossils preserved in these deposits include invertebrate, vertebrate, plant, and trace fossils. Mesozoic age rocks are most abundant and the only Cenozoic rocks are Quaternary in age. Cenozoic rocks older than Quaternary age that may have been present have been removed by erosion. Vertebrate fossils from the Monticello FO planning area include the body remains of fish, amphibians, reptiles (including dinosaurs), and mammals, as well as tracks and traces of terrestrial animals. These fossils occur in rocks of Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, and Quaternary age and include some specimens known from nowhere else. Perhaps best known of these fossils are the following:

- fish and amphibian remains and track ways from the Cutler Group (Permian)
- fish and reptile (including dinosaur) remains and track ways from the Chinle Formation (Triassic)
- vertebrate trackways from the Chinle and Moenkopi formations (Triassic)
- vertebrate trackways from the San Rafael and Glen Canyon groups (Jurassic)
- dinosaur remains from the Morrison (Jurassic) and Cedar Mountain (early Cretaceous) formations
- invertebrates from the Carmel Formation (Jurassic)

A search of the Utah Geological Survey (UGS) fossil database in Salt Lake City revealed a total of 311 fossil localities in the Monticello FO planning area (Hayden 2003). Of these, 74 yield vertebrate fossils; 135 yield invertebrate fossils; 88 yield plant fossils; and 42 yield vertebrate trace fossils. Information from this database supplemented by published references and personal experience documents that

vertebrate fossils (which the BLM considers of scientific significance) are known from 19 geologic units (formations or members). Listed in descending stratigraphic order, these units include the following:

- unnamed Quaternary units (terrace and river gravels, and Packrat [*Neotoma*] nests)
- Mancos Shale (including the Buck Tongue, Tununk Shale, Blue Gate, and Ferron Sandstone members)
- Dakota Sandstone
- Cedar Mountain Formation (Burro Canyon Formation)
- Morrison Formation (including the Brushy Basin and Salt Wash members)
- Bluff Sandstone
- Summerville Formation
- Entrada Sandstone
- Navajo Sandstone
- Kayenta Formation
- Wingate Sandstone
- Chinle Formation
- Moenkopi Formation
- Carmel Formation
- Cutler Group (Organ Rock Shale, Cedar Mesa Sandstone, Lower Cutler Beds, Halgaito Shale)
- Hermosa Group (Honaker Trail Formation)

A list of geologic units annotated with fossils they contain is provided in Table 10.1. In addition, the age of geologic units found in the area, environment of accumulation, and interpreted paleontological significance rating (BLM Paleontology Condition) is provided in Table 10.1. Based on current BLM Policies and Management Practices, an explanation of paleontological classification is presented in the table notes.

10.2 SPECIFIC MANDATES AND AUTHORITY

10.2.1 Code of Federal Regulations

Additional authority and stipulations regarding fossils on public lands are included in the Code of Federal Regulations (CFR). Paleontology is primarily covered in Title 43, which addresses public lands, but additional rules fall within other titles and sections. Most of these are discussed in BLM Handbook 8270-1; principal among those additional rules concerning fossils and fossil resources are listed below:

- Title 43 CFR, Subparts 8365.1-5 and 8360.0-7: willful disturbance, removal, and destruction of scientific resources or natural objects and description of the penalties for such violations, respectively.
- Title 43 CFR, Subpart 8365: collection of invertebrate fossils and, by administrative extension, fossil plants.
- Title 43 CFR, Subparts 3802 and 3809: protection of paleontological resources from operations authorized under the general mining laws.

- Title 43 CFR, Subpart 8200: procedures and practices for the management of lands that have outstanding natural history values, such as fossils, which are of scientific interest.
- Title 43 CFR, Subpart 3430: costs of collecting and analyzing paleontological data prior to coal mining (conducting surveys and excavations).
- Title 43 CFR, Subpart 1610.7-2: establishment of Areas of Critical Environmental Concern for the management and protection of significant natural resources, such as paleontological localities.
- Title 43 CFR, Subpart 8364: use of closure or restriction of public lands to protect resources; such closures or restrictions may be used to protect important fossil localities.
- 18 USC Section 641: unauthorized collection of fossils as a type of Government property.
- Onshore Oil and Gas Order No. 1 and Title 43 CFR, Subpart 3162: protection of natural resources and other environmental concerns; can be used to protect paleontological resources, where appropriate.
- 16 USC Section 433: addresses the theft, excavation, or destruction of any object of antiquity on Federal Lands (based on Antiquities Act of 1906, which does not wholly apply to fossils).
- 43 CFR 36, Part 3620: petrified wood is treated as a mineral material and may be collected or purchased under the Material Sales Act of 1947 (as amended), but cannot be obtained under the General Mining Law of 1872.

10.2.2 Other Authorities

- Secretarial Order 3104: authorizes the BLM to issue paleontological resource use permits for lands under its jurisdiction
- Offer to Lease and Lease for Oil and Gas Form 3100-11: provision for inventories and other short-term studies to protect objects of scientific interest, such as significant fossil occurrences, and requires that operations conducted under oil and gas leases minimize adverse impacts to natural and cultural resources
- Federal Cave Resources Protection Act of 1988 (P.L. 100-691) and Title 43 CFR, Subpart 37: protection of significant caves and cave resources, including paleontological resources
- USC Section 641: addresses the theft or unauthorized sale of Government property having a monetary value

10.2.3 General Mandates

Two federal laws and related regulations and policies serve as general mandates for BLM management of paleontological resources. These federal laws are:

- National Environmental Policy Act of 1969 (NEPA)
- Federal Land Policy and Management Act of 1976 (FLPMA)

NEPA charges the BLM to protect important cultural and natural aspects of the environment, and make decisions that are based on understanding environmental consequences, and take actions that protect, restore, and enhance the environment.

Through NEPA, the Federal Government requires three vital processes during project planning. These requirements are that:

- all Federal agencies consider the environmental impacts of proposed actions;
- the public be informed of the potential environmental impacts of proposed actions; and

- the public be involved in planning and analysis relevant to actions that impact the environment.

The primary objective of the NEPA process is to make informed, publicly supported decisions regarding environmental issues.

FLPMA charges the BLM to:

- manage public lands in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, archaeological, and water resources, and, where appropriate, preserve and protect certain public lands in their natural condition (Section 102 [a][8][11]);
- periodically inventory public lands so that the data can be used to make informed land-use decisions (Section 102[a][2]); and
- regulate the use and development of public lands and resources through easements, licenses, and permits (Section 302[b]).

Although FLPMA does not refer specifically to fossils, significant fossils are recognized in policy as scientific resources. Permits authorizing the scientific collection of significant fossils are issued under the authority of FLPMA.

10.3 CURRENT MANAGEMENT PRACTICES

BLM policy recognizes that paleontological resources found on public lands constitute a fragile and nonrenewable scientific record of the history of life on Earth and so represent an important and critical component of America's natural heritage. Once damaged, destroyed, or improperly collected, their scientific and educational value may be greatly reduced or lost forever. In addition to their scientific, educational, and recreational values, paleontological resources can be used to inform land managers about interrelationships between the biological and geological components of ecosystems over long periods of time. The BLM manages paleontological resources for these values, and mitigates adverse impacts to them. To accomplish this goal, paleontological resources must be adequately addressed and fully integrated into the Bureau's planning system and environmental analysis documents.

In meeting its responsibility to exercise stewardship of paleontological resources, it is the policy of the BLM to:

- actively work with other Federal, State, and Local Government Agencies, professional organizations, private landowners, educational institutions, and other interested parties to enhance and further the BLM's and the American public's needs and objectives for paleontological resources;
- consider paleontological resource management a distinct BLM program, to be given full and equal consideration in all its land use planning and decision making actions;
- maintain a staff of professional paleontologists to provide BLM decision makers with the most current and scientifically sound paleontological resource data and advice;
- mitigate adverse impacts to paleontological resources as necessary;
- facilitate appropriate public and scientific use of and interest in paleontological resources;
- utilize the additional skills and resources of the BLM's recreation and minerals programs to develop and implement interpretation strategies and products to enhance public understanding, appreciation, and enjoyment of paleontological resources;

- vigorously pursue the protection of paleontological resources from theft, destruction, and other illegal or unauthorized uses; and
- authorize land tenure adjustments, when appropriate, as means to protect paleontological localities.

Uniform procedural guidance for management of paleontological resources on BLM lands is provided by BLM Handbook 8270-1.

Collection of fossils from BLM-administered lands in the Monticello FO is allowed with some restrictions, depending on the significance of the fossils and the place of collection. Under existing regulations, recreational collection of common invertebrate or plant fossils by the public is allowed, except in developed recreation sites or areas or where otherwise prohibited and posted, in reasonable quantities using hand tools. The public is also allowed to collect petrified wood without a permit for personal, noncommercial purposes. Petrified wood is treated by the BLM as a mineral material rather than as a fossil. Individuals can collect up to 25 pounds plus one piece per person per day, with a maximum of 250 pounds in one calendar year. Current regulations do not allow any commercial collecting of paleontological resources, but a commercial permit may be obtained for the collection and sale of petrified wood. Recreational collecting of vertebrate fossils, as well as noteworthy fossil invertebrates and plants, is prohibited on all BLM-administered lands. Vertebrate fossils are the remains or traces of animals with backbones such as fish, turtles, dinosaurs, mammals, reptiles, and birds, and include material such as fossil bones, teeth, tracks, coprolites, and burrows. Significant plant and invertebrate fossils are determined on a case-by-case basis.

Professional paleontologists conducting research or assessment and mitigation are primarily regulated through the permit process. Two types of paleontological resource use permits are issued. The basic permit is a survey and limited surface collection permit, issued for reconnaissance work and collection of surface finds, with a one-square-meter limit on surface disturbance. If disturbance during the paleontological work will exceed this limit, or will require mechanized equipment, the researcher must apply for an excavation permit. Prior to authorization of an excavation permit, BLM must prepare an environmental assessment of the proposed location. All fossils collected under a permit remain public property, must be placed in an approved repository, and never can be sold. Yearly reports of findings including locality and specimen information are required to be submitted to the BLM. Researchers may have multiple active permits.

10.4 SENSITIVITY EVALUATION

The BLM uses two systems to classify its lands with regard to paleontological resources: the Paleontology Condition System, which is in standard use, and the Probable Fossil Yield Potential, which has been informally adopted by some state BLM offices.

The Paleontology Condition System classifies areas according to their potential to contain vertebrate fossils, or noteworthy occurrences of invertebrate or plant fossils. According to the BLM Handbook 8270-1, this system uses the following classifications:

Condition 1: Areas that are known to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. Consideration of paleontological resources will be necessary if the Field Office review of available information indicates that such fossils are present in the area.

Condition 2: Areas with exposures of geological units or settings that have high potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils. The presence of geologic

units from which such fossils have been recovered elsewhere may require further assessment of these same units where they are exposed in the area of consideration.

Condition 3: Areas that are very unlikely to produce vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils based on their surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium or eolian deposits, or the presence of deep soils. However, if possible, it should be noted at what depth bedrock may be expected in order to determine if fossiliferous deposits may be uncovered during surface-disturbing activities (BLM Handbook 8270-1).

The Probable Fossil Yield Potential is a planning tool involving the rating of geological units, usually at the formation or member level, according to the probability of yielding paleontological resources that are of concern to land managers. The classes include the following (Hanson 2003):

Class 1: Igneous and metamorphic (tuffs are excluded from this category) geologic units or units representing heavily disturbed preservational environments that are not likely to contain recognizable fossil remains.

Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Also sedimentary units of unknown fossil potential.

Class 4: Geologic units that are Class 5 units (see below) that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation.

Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant nonvertebrate fossils, and that are at risk of natural degradation and/or human-caused adverse impacts.

10.5 RESOURCE DEMAND AND ANALYSIS FORECAST

Annually, the BLM issues one or two paleontological resource use permits specifically for the Monticello FO planning area (Bryant 2003). There are also approximately 12 statewide research permits allowing surface collecting/reconnaissance that would include the Monticello FO planning area. In addition, the BLM issues approximately eight consulting permits annually in Utah, all of which are statewide and thus include the Monticello FO. The number of amateurs involved in collecting is unknown. The Monticello FO receives several inquiries each year regarding fossil collection. Further interest in fossil collection is demonstrated by the existence of local rock hounding clubs. In addition, hikers, mountain bikers, and other outdoor enthusiasts may accidentally discover fossil remains. Some of these discoveries will be passed on to the appropriate agencies, and some will not. Certainly many important paleontological discoveries have been and will continue to be made by amateurs or those who accidentally encounter fossils, but the number of such discoveries is also unknown.

Demand for economic resources within the Monticello FO area is likely to increase in the future. This future demand could necessitate further inventories, monitoring, and mitigation as a result of other land use authorization, such as minerals exploration and development, realty actions including roads and pipelines, etc. This work would be done by qualified paleontologists under a permit. It is anticipated that this type of activity might increase, especially if the BLM implements the Condition rating system and

any conditions of approval that may result. The Reasonable Foreseeable Development Scenario (RFD) presents anticipated development for the next 10 to 15 years.

10.6 CONSISTENCY WITH NON-BUREAU PLANS

10.6.1 Federal Agencies

Common Ground: The Secretary of the Interior submitted the report "Assessment of Fossil Management on Federal and Indian Lands" to Congress in May 2000

(<http://www.blm.gov/heritage/docum/fossilrpt.pdf>). The Bureau of Indian Affairs, the BLM, the Bureau of Reclamation, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the National Park Service, and the U.S. Geological Survey, together with the Smithsonian Institution, assisted in the development of that report. These parties concluded jointly and thus share the following views that administrative and Congressional actions affecting fossil resources should be governed by the following seven basic principles:

1. Fossils on federal land are a part of America's heritage.
2. Most vertebrate fossils are rare.
3. Some invertebrate and plant fossils are rare.
4. Penalties for fossil theft should be strengthened.
5. Effective stewardship requires accurate information.
6. Federal fossil collections should be preserved and made available for research and public education.
7. Federal fossil management should emphasize opportunities for public involvement.

10.6.2 Bureau of Indian Affairs (BIA)

The Navajo Indian Reservation borders the Monticello FO to the south and for that reason the treatment of fossil resources on Tribal lands is discussed here. According to the Secretary of the Interior, the authority of the BIA to manage fossil resources on Tribal lands is limited and not mandated by statute. The BIA's responsibilities are different from those of land managing agencies within the Department, such as the BLM or the NPS. Native American lands are lands that the United States holds in trust. These lands are subject to a restriction against alienation imposed by the United States because they are for the benefit of a Native American tribe or an individual Native American. The Government does not exercise the same rights of ownership or control over these lands as it does over federal lands.

Fossils that have commercial value have been found to be trust resources, and the BIA must manage the fossils as a trust resource. In managing trust resources, the BIA is limited to approving either leases of Native American lands, or contractual agreements between Native American landowners and third parties for the extraction of such fossils. The criterion for these approvals is that the arrangements are of economic benefit to the Native American landowner. The arrangements are also subject to evaluation under NEPA (42 U.S.C. §§ 4321-4347) and the NHPA (16 U.S.C. §§ 470-470x-6.).

Because Native American lands are lands held in trust, the Native American tribe or individual Native American landowners may use fossil resources (including vertebrate fossils) for their economic benefit. The BIA's role in these transactions is to ensure that the transaction benefits the Native American landowner. The BIA has no other authority to manage paleontological resources within its jurisdiction. This differs significantly from the BLM, which does not allow fossils to be commercially exploited.

10.6.3 U. S. Forest Service (USFS)

In general, the USFS and BLM treat fossil resources similarly. Vertebrate fossils are considered to be scientifically significant and a permit is needed to collect them from USFS lands. USFS policy differs from that of the BLM with regard to evaluation of the paleontological potential. The USFS uses a numerical system, called the Fossil Yield Potential Classification (FYPC), which is designed to “objectively” determine the potential of geologic units to produce certain kinds of fossils. While the FYPC has been formally adopted by the USFS, it has not yet been adopted by the BLM. However, the BLM is testing the use of this system in several pilot projects and continues its development in three states. For the majority of its projects, the BLM assesses areas using the Paleontology Condition System described above.

The FYPC and the Paleontology Condition System were developed for different uses. The FYPC rankings were intended to be developed by professional paleontologists, using extensive data supplemented with museum and library research. The Paleontology Condition System of classification was developed to be used at and by the BLM’s Field Offices, where there are few trained paleontologists.

10.6.4 National Park Service (NPS)

As required by its Organic Act, 16 U.S.C. §§ 1 et seq., the NPS strives to conserve paleontological resources in park units and provide for their preservation so that they are unimpaired for the enjoyment of future generations. The current NPS Management Policies establish the following mandates for NPS paleontological resource management:

Paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved and developed for public enjoyment, interpretation and scientific research in accordance with park management objectives and approved resource management plans. Paleontological research by the academic community will be encouraged and facilitated under the terms of a research permit when it meets all of the following criteria:

- The project cannot be conducted outside the park and involve more than simple collection of additional specimens of types already collected. The project will answer an important question about the resource.
- Information obtained through the research will be made available to the park. Management actions will be taken to prevent illegal collecting and may be taken to prevent damage from natural processes such as erosion. Protection may include construction of shelters over specimens for interpretation in the field, or collection, preparation and placement of specimens in museum collections. The localities and geologic settings of specimens will be adequately documented when specimens are collected.

NPS Management Policies, including those governing paleontological resource management, are currently under revision.

10.6.5 State of Utah

In general, the State of Utah and BLM treat fossils similarly. Paleontological resources on public lands in Utah are covered under Chapter 73 of the Utah Code, under the Geological Survey. Pertinent parts of the code include the following:

- 63-73-6: Powers and duties of survey, including, but not limited to, the following provisions to:

- ◆ assist and advise state and local governmental agencies and state educational institutions on geologic, paleontological, and mineralogical subjects;
 - ◆ collect and distribute reliable information regarding the mineral industry and mineral resources, topography, paleontology, and geology of the state;
 - ◆ stimulate research, study, and activities in the field of paleontology;
 - ◆ mark, protect and preserve critical paleontological sites;
 - ◆ collect, preserve and administer critical paleontological specimens until they are placed in a repository or curational facility;
 - ◆ administer critical paleontological site excavation records; and
 - ◆ edit and publish critical paleontological records and reports.
- 63-73-11: Protection of School and Institutional Trust Land interests relating to paleontological resources.
 - 63-73-12, 63-73-13: Permit required to excavate critical paleontological resources on state lands – removal of specimen or site.
 - 63-73-13: Permit required to excavate critical paleontological resources on School and Institutional Trust Lands - removal of specimen or site.
 - 63-73-14: Ownership of collections and resources.
 - 63-73-15: Revocation or suspension of permits – Criminal Penalties.
 - 63-73-16: Paleontologic Landmarks.
 - 63-73-17: Report of discovery on state or private lands.

Unlike the BLM, the State of Utah has issued commercial permits to collect invertebrate fossils.

10.6.6 San Juan County

Fossils, paleontology, and paleontological resources as management issues are not specifically addressed in the San Juan County Master Plan (1996). The plan acknowledges the importance of tourists to the county as a benefit to the local economy. It does note the role that historic trails, interpretive sites, and "cultural resources" play in providing recreational opportunities for residents and visitors, and includes such resources as a means of achieving their desired future condition of expanded recreational opportunities. Fossils and paleontological resources could be considered as a tourist attraction and provide opportunities for tourist related back-country tours, but recreational activities involving fossils would be restricted on BLM lands to the collection of fossil wood, plants, or invertebrates that are not considered to be noteworthy. The BLM does not encourage backcountry tours to unprotected fossil localities because of problems with theft and vandalism.

The San Juan County Master Plan expresses the belief that BLM-administered lands, unless withdrawn through Congressional Mandate, should be managed under the principles of multiple-use and sustained yield. This position is consistent with the general philosophy of the BLM.

There are, however, places where the San Juan County Master Plan is inconsistent with existing BLM management practices. Specifically, the plan expresses a strong belief that enough lands within county boundaries have been designated for National Parks, Monuments, and wilderness. In addition, the plan mentions specific concerns about designation of lands as ACECs and that it opposes additional lands administered under single management schemes.

10.7 ISSUES OR CONCERNS

The existing Monticello FO RMP does not mention paleontology. The Monticello FO planning area has many significant fossil resources and as a result, this is the primary issue and concern regarding paleontological resources. Inclusion of paleontologic resources in the revised RMP will provide the management opportunity to address this resource through the planning process and ensure that it is done in accordance with current guidance and directives. This could include incorporation of the BLM Paleontology Condition System and Probable Fossil Yield Potential rating and classification systems described above.

10.7.1 Fossil Theft and Vandalism

Fossil theft and vandalism is a potential problem that is occurring. Public interest in fossils and the commercial value of fossils have increased significantly in recent years. Fossil sales are booming via the Internet, in rock shops and through art galleries, with prices ranging from a few dollars to tens of thousands of dollars, depending on the rarity and intricacy of the fossils. As public interest waxes and the prices of fossils rise, federal land managing agencies (including the BLM) will be under increasing pressure to both protect scientifically significant fossil resources and to ensure their appropriate availability to the general public. Escalating commercial values of fossils also means that increasingly, fossils on federal lands are subject to theft and vandalism. These crimes reduce scientific and public access to scientifically significant and instructive fossils and destroy the contextual information critical for interpreting the fossils.

As described in Title 43 CFR Subparts 8365.1-5 and 8360.0-7, willful disturbance, removal and destruction of scientific resources or natural objects on federal lands is illegal and there are penalties for such violations. Often, the most pronounced damage is the loss of the context and other significant scientific data, the worth of which is difficult to evaluate in monetary terms.

10.7.2 Resource Capability and Condition

An evaluation of the present condition of fossil resources in the Monticello FO planning area, including areas of recreational collecting and possible illegal collecting, is needed. This should include an assessment of past mitigation efforts to ascertain the effectiveness of the applied mitigation efforts. This is being accomplished through development of a statewide paleontological database administered by the UGS.

10.7.3 Mitigation Procedures

The revised RMP should include provision that mitigation procedures for paleontological resources will be applied to surface-disturbing activities and land tenure adjustments in accordance with BLM Handbook 8270-1. Under general mining laws, fossils are considered part of the surface estate, so fossils on public lands are public fossils, but this may not be true in all cases. On split-estate lands, where the surface is privately owned and the mineral estate is federally owned, the surface owner must be informed of the presence of significant fossils if surface-disturbing projects are planned so that mitigation may be done if the owner requests it.

Procedures for mitigation of possible adverse impacts to paleontological resources are detailed in BLM Handbook 8270-1. Mitigation procedures are tailored to the proposed action and may vary from project to project. Mitigation may include ground survey prior to surface disturbance, monitoring during work, and inspection prior to backfilling and reclamation.

10.8 MANAGEMENT OPPORTUNITIES

Inclusion of Paleontological Resources in the revised Monticello FO RMP will help ensure that fossil resources are adequately addressed during environmental review. It will allow the FO the opportunity to manage these resources on par with other FOs throughout the country. Proposed management will result in many additional management opportunities. Public interest in paleontology is high. Evidence of this interest is found in sustained high attendance at museums, rock and fossil shows, at National Parks and Monuments, and at tourist attractions featuring fossils. Museums continue to develop new exhibits and entire halls, at costs of millions of dollars, dedicated to interpreting the evolution of life and other aspects of paleontology. Classes for children and adults involving paleontology are an expanded offering by many museums. In addition, a plethora of Internet websites has been developed by museums, universities, professional paleontologists, and amateur and commercial collectors that are available for viewing by the public. These sites record high numbers of hits or visits by the public, but may foster problems with vandalism and illegal collection of fossils from public lands.

As a result of the popularity of paleontology, there are many opportunities for public education and outreach and these are important aspects of the science of paleontology. In 1997, 108 paleontologists from 30 countries met in Frankfurt, Germany at the Senckenberg World Conference entitled "Paleontology in the 21st Century" (http://www.nhm.ac.uk/hosted_sites/paleonet/paleo21/rr/index.html). They noted the following aspects of public outreach:

- Paleontology has a disproportionately favorable public profile for the size of the discipline, and that is good. The general level of public interest, however, is vastly underexploited in outreach. Many aspects of paleontology are very visual and visceral-dinosaurs, particularly, capture public imagination - but this interest has not been capitalized on.
- Public awareness of paleontology is extremely focused on dinosaurs for the most part, while the larger part of the discipline goes unheralded and unknown.

The BLM favors the development of museum exhibits and informational kiosks or similar developments at roadside turnouts over the interpretation of areas where fossils remain in the ground. These projects provide opportunities for learning and enjoyment. There may be substantial risk of damage or unauthorized collecting of fossils by the public in interpretive areas that are not staffed.

10.9 REFERENCES

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Table 10.1 Geology And Paleontology Of The Monticello Field Office With Additional Paleontological Information From Adjacent Areas

Age	Geologic Unit	Depositional Environment	Highest Interpreted Classification
Quaternary	Landslide, alluvium, sand, terraces, gravels, colluvium, pediment ^{50, 51, 52}	Terrestrial	2-3
Tertiary	Abajo Mountain Intrusions	Intruded	3
Late Cretaceous	Mancos Shale*, **, 17, 36, 39, 40	Marine to deltaic	2
Early Cretaceous	Dakota Sandstone ^{8, 41, 47, 48}	Terrestrial, shoreline, estuarine	2
	Cedar Mountain Formation ^{13, 14, 15, 16, 18, 23, 24, 35, 47, 53}	Terrestrial fluvial	1
Jurassic	Morrison Formation	Terrestrial, fluvial	1
	Brushy Basin Member ^{9, 10, 11}		1
	Westwater Canyon Member		Unknown
	Salt Wash Member ^{9, 10, 12}		1
	Bluff Sandstone ⁶⁰	Terrestrial, eolian	2
	Recapture Member	Terrestrial, lacustine	Unknown
	Summerville Formation ^{8, 37, 60}	Tidal flats, Sabka, marginal marine	2
	Tidwell Member ⁵⁶	Tidal Flats, Sabka	2
	Entrada Sandstone *, **, 8, 20	Beach to coastal marine	2
	Moab Member ^{20, 32, 44}	Shoreline beach	2
	Slick Rock Member	Coastal dune	3
	Dewey Bridge Member	Coastal marine	3
	Navajo Sandstone **, 7, 8, 19	Eolian	2
	Kayenta Sandstone **, 8, 22	Terrestrial, eolian	2
Wingate Sandstone **, 8	Eolian	2	
Triassic	Chinle Formation *, **, 5, 6, 8, 26, 30, 31, 33, 43, 47, 53	Terrestrial, fluvial	1
	Moenkopi Formation *, **, 8, 42	Marine and terrestrial	2
	Carmel Formation ⁶¹	Marine	2
Permian	Cutler Formation	Terrestrial to marine	2
	White Rim Sandstone	Coastal dune, eolian, shallow marine	3
	De Chelly Sandstone ^{3, 57, 59}	Terrestrial, eolian	2
	Organ Rock Formation *, 1, 2, 4, 58	Terrestrial, tidal flats	1
	Cedar Mesa Sandstone *, 2, 4, 8	Coastal dune and shallow marine	1

Table 10.1 Geology And Paleontology Of The Monticello Field Office With Additional Paleontological Information From Adjacent Areas

Age	Geologic Unit		Depositional Environment	Highest Interpreted Classification
		Lower Cutler Beds ^{3, 49}	Terrestrial, coastal, eolian	1
Pennsylvanian		Hermosa Group ^{21, 29}	Terrestrial to marine	2
		Honaker Trail Formation ^{21, 29}	Terrestrial to marine	2
		Paradox Formation	Marine, estuarine	3

Summerville Formation = Wanakah Formation, Lower Cutler Beds = Elephant Canyon Formation

Key to superscript: superscript occurring next to stratigraphic interval indicates fossil occurrence; not all occur in the Monticello FO planning area, but some occur in adjacent areas and are supplied to provide evidence of paleontological potential of the unit.

* = vertebrate fossils , ** = vertebrate tracks Utah Geological Survey

- 1 = fish, xenacanth sharks, crossopterygians, lungfish, actinopterygians, phylloodonts
- 2 = amphibian grade tetrapods
- 3 = vertebrate tracks
- 4 = amniote tetrapods
- 5 = crocodilomorph
- 6 = theropod dinosaur
- 7 = dinosaur tracks
- 8 = vertebrate tracks
- 9 = dinosaurs
- 10 = mammals, reptiles, fish, invertebrates, plants, trace fossil (tracks, burrows, termite and ant nests)
- 11 = dinosaurs
- 12 = turtle tracks
- 13 = fish, turtles, rhyncocephalians, crocodiles, dinosaurs
- 14 = lizards, snakes, amphibians, fish, birds, sharks, rays, mammals, dinosaurs, birds
- 15 = ankylosaur dinosaurs
- 16 = vertebrate tracks
- 17 = mosasaur skeleton
- 18 = dinosaurs, Dalton Wells Quarry
- 19 = petrified forests
- 20 = vertebrate tracks/Moab Megatracksite
- 21 = invertebrates (brachiopods, crinoids, bryozoans, echinoderms)
- 22 = dinosaur tracks
- 23 = plants, cycadeoidales
- 24 = plants, Tempskya
- 25 = plants Osmunda
- 26 = phytosaur remains
- 27 = dinosaur eggshell
- 28 = terrestrial and freshwater invertebrate burrows and nests
- 29 = plants, floral remains
- 30 = vertebrates and invertebrates

- 31 = vertebrate and invertebrates
- 32 = petrified wood and dinosaur tracks
- 33 = megafossil plants, mollusks, fishes, tetrapods (metaposaurids, phytosaurids, aetosaurus, dicynodonts), vertebrate tracks
- 35 = ammonites, mollusks, ostracodes, algae (charophytes)
- 36 = fossil fish teeth
- 37 = dinosaur and pterosaur tracks
- 38 = shark's teeth
- 39 = invertebrates, sharks teeth
- 40 = invertebrates
- 41 = invertebrates, plants (leaves and wood)
- 42 = amphibian and reptile tracks
- 43 = fish, dinosaur, plants (leaves and wood), invertebrates
- 44 = dinosaur tracks
- 45 = dinosaurs, Allosaurus, Camptosaurus, Stegosaurus, and Camarasaurus
- 46 = dinosaur trackway
- 47 = plants (leaves)
- 48 = dinosaur (sauropod)
- 49 = invertebrate and vertebrate tracks
- 50 = plant megafossil remains from a packrat midden
- 51 = mammals (mammoth, sloth)
- 52 = mammals (mammoth)
- 53 = well known to contain vertebrate fossil throughout the US west
- 54 = fossil crocodile vertebra
- 55 = plants
- 56 = dinosaur remains, type of sauropod Dystropeus viaemalae
- 57 = arthropod tracks
- 58 = vertebrates
- 59 = vertebrate tracks
- 60 = vertebrate tracks (dinosaur and pterosaur)
- 61 = invertebrates (byozoans, brachiopods, mollusks, crinoids, corals, algae)