

CHAPTER 9 - PALEONTOLOGY

9.1 RESOURCE OVERVIEW

Paleontology is a biological and geological scientific discipline involving the study of fossil materials.

Paleontologic resources, or fossils, include the body remains, traces, or imprints of plants or animals that have been preserved in the earth's crust since some past geologic time. 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. 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.

Most fossils occur in sedimentary rocks where they may be distributed extensively 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. Experienced paleontologists can predict which formations will contain fossils and in general what types of fossils will be found based on the age of the formation and its depositional environment, but predicting the exact location where they will be found without a field survey is usually impossible. Fossils are where you find them.

The types of fossils preserved in a sedimentary rock sequence depends on the geologic age of the rocks in which they occur and the environment in which the sediments that comprise the rocks accumulated. The types of rocks that crop out (are exposed) at the surface of an area and can potentially yield fossils is the result of geologic (depositional, structural, and erosional) history. Geologic maps depict the geology of an area; however, all geologic maps are interpretive and essentially a progress report of the current understanding of the geology of an area.

Geologic formations and sediments exposed at the surface of the Moab FO area range from Precambrian to Recent in age (Figure 9-1). General geologic mapping of the Moab FO area at a 1:250,000 is provided by Williams (1964) and Cashion (1973) and at 1:100,000 by Witkind (1988). In Appendix 9-A is information on fossils found in the geologic formations that crop out at the surface in the Moab FO area. Figure 9-1 in the maps section provides a geologic map of the Moab FO area color-coded by paleontologic potential.

In the Moab FO area, fossil-bearing sedimentary rocks range in age from Pennsylvanian to Quaternary in age and include parts of the three great periods of earth history during the Phanerozoic (*phaneros*, meaning visible, *zoic*, meaning life), the Paleozoic, Mesozoic, and Cenozoic. Fossils preserved in these deposits include invertebrate, vertebrate, and plant fossils. Vertebrate fossils from the Moab FO area include the body remains of fish, amphibians, reptiles (including dinosaurs), mammals, and birds, as well as their tracks and traces. These fossils occur in rocks of Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Tertiary, 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 Mesa (early Cretaceous) formations
- dinosaur remains and trackways from the Blackhawk Formation (Late Cretaceous)
- mammalian and fish fossils from the Wasatch and Green River formations (Eocene)

A search of the Utah Geological Survey (UGS) fossil database in Salt Lake City revealed a total of 246 fossil localities in the Moab FO area (Hayden 2003). Of the 246 fossil localities identified: 22 are vertebrate localities; 24 are invertebrate localities; 23 are plant localities; and 8 are known to be trace fossil localities. Details are lacking about the fossils identified for the other 177 known localities. Information from this database supplemented by publications and personal experience document that vertebrate fossils (which the BLM considers of scientific significance) are known from at least 20 geologic units that crop out in the Moab FO area. Listed in descending stratigraphic (youngest to oldest) order these include:

- unnamed Quaternary units (e.g., terrace and river gravels and packrat [*Neotoma*] nests)
- Green River Formation
- Wasatch Formation
- Neslen Formation
- Sego Sandstone
- Castle Gate Sandstone
- Blackhawk Formation
- Mancos Shale (including the Buck Tongue, Tununk Shale, Blue Gate, and Ferron Sandstone members)
- Dakota Sandstone
- Cedar Mountain Formation (including the Mussentuchit, Ruby Ranch, Poison Strip Sandstone, and Yellowcat members)
- Morrison Formation (including the Brushy Basin and Salt Wash members)
- Summerville Formation
- Entrada Sandstone (Moab Member)
- Navajo Sandstone
- Kayenta Formation
- Wingate Sandstone
- Chinle Formation

- Moenkopi Formation
- Cutler Group (Organ Rock Shale, Cedar Mesa Sandstone, Halgaito Shale)
- Hermosa Group (Honaker Trail Formation)

A list of geologic units found in the area, their age, environment of accumulation, and interpreted paleontological significance rating (BLM Paleontology Condition) are provided in Table 9A-1 of Appendix 9-A. An explanation of paleontological ranking is provided below under current BLM Policies and Management Practices.

9.2 SPECIFIC MANDATES AND AUTHORITY

Two federal laws and related regulations and policies serve as the principal authorities for BLM management of paleontological resources. The federal laws are:

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

9.2.1 National Environmental Policy Act of 1969 (NEPA)

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:

- All federal agencies must consider the environmental impacts of proposed actions.
- The public must be informed of the potential environmental impacts of proposed actions.
- The public must be involved in planning and analysis relevant to actions that impact the environment.

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

9.2.2 Federal Land Policy and Management Act of 1976 (FLPMA)

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.

9.2.3 Code of Federal Regulations (CFR)

Additional authority and stipulations regarding fossils on public lands are included in the Code of Federal Regulations (CFR). The CFR is the codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government. It is divided into 50 titles that represent broad areas subject to federal regulation. Paleontology is chiefly covered in Title 43, which deals with Public Lands, but additional rules fall within other titles and sections. Principal among those concerning fossils and fossil resources are:

- willful disturbance, removal and destruction of scientific resources or natural objects and identification of the penalties for such violations, Title 43 CFR Subpart 8365.1-5 and 8360.0-7, respectively;
- collection of invertebrate fossils and, by administrative extension, fossil plants Title 43 CFR, Subpart 8365;
- protection of paleontological resources from operations authorized under the general mining laws, Title 43 CFR, Subparts 3802 and 3809;
- 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 8200;
- costs of collecting and analyzing paleontological data prior to coal mining (i.e., conducting surveys and excavations), Title 43 CFR, Subpart 3430;
- establishment of ACECs for the management and protection of significant natural resources such as paleontological localities, Title 43 CFR, Subpart 1610.7-2;
- use of closure or restriction of public lands to protect resources, such as important fossil localities, Title 43 CFR Subpart 8364;
- unauthorized collection of fossils as a type of government property, 18 USC Section 641;
- authorizing the BLM to issue paleontological resource use permits for lands under its jurisdiction, Secretarial Order 3104;
- protection of natural resources and other environmental concerns and protection of paleontological resources where appropriate, Onshore Oil and Gas Order No. 1 and 43 CFR Title 3162;
- provision for inventories and other short-term studies to protect objects of scientific interest, such as significant fossil occurrences, and the requirement that operations conducted under oil and gas leases minimize adverse impacts to natural and cultural resources, Offer to Lease and Lease for Oil and Gas Form 3100-11;
- protection of significant caves and cave resources, including paleontological resources, Federal Cave Resources Protection Act of 1988 (P.L. 100-691) and Title 43 CFR Subpart 37;

- addressing 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) 16 USC Section 433;
- the Antiquities Act applies to paleontological resources, but that FLPMA would prove to be sounder legal footing BLM Information Memorandum No. 77-98; and
- addressing the theft or unauthorized sale of government property having a monetary value 18 USC Section 641;
- judicial finding that fossil remains are not minerals within the mining laws, and lands containing such remains are not subject to mineral entry, Earl Douglas appeal of the decision of the Commissioner of the General Land Office to the Department of the Interior, dated July 24, 1913;
- definition of significant fossils that, being significant, require permits for collection, Solicitor's Opinion of July 10, 1963;
- recognition of fossils being not locatable under the Mining Law and generally not being part of the mineral estate in split-estate situations, and noting the BLM's statutory and regulatory authority to manage fossils, Solicitor's Opinion of January 17, 1986.

9.3 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 professionally identified and evaluated. Their values should be adequately addressed and integrated fully into the BLM's planning system and environmental analysis documents. Generally, considerable time, money and effort may be saved by considering paleontological data as early as possible in the decision making process.

In meeting its responsibility to exercise stewardship of paleontological resources as part of its management of public lands, 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 *Paleontological Resources Handbook 8270-I*, from which this was copied verbatim.

The existing Moab FO area RMP (1985) does not mention paleontology. The Moab FO area has many significant fossil resources, and because BLM regulation and policy provide specific direction for the management of paleontological resources, it is essential that the new RMP consider fossils.

Collection of fossils from BLM lands in the Moab FO area is allowed with some restrictions, depending on the significance of the fossils. Under existing regulations, hobby collection of common invertebrate or plant fossils by the public is allowed in reasonable quantities using hand tools. The public is also allowed to collect petrified wood without a permit for personal noncommercial purposes. People 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.

Collection of significant fossils, which includes all vertebrate and any so designated plant or invertebrate fossils, can only be done by obtaining a permit that is issued only to qualified researchers. Vertebrate fossils are the remains or traces of 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 and must be identified in decision documents.

Two types of paleontological use permits are issued. The basic permit is a survey and limited 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 one square meter, 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 can never 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.

9.4 RESOURCE DEMAND AND ANALYSIS

Recreational fossil collecting of common invertebrates, plants and petrified wood is appropriate on most lands administered by the BLM, except in developed recreation areas and other special

management areas, such as Special Recreation Management Areas (SRMAs) or where otherwise posted. Recreational collecting of vertebrate fossils, as well as noteworthy fossil invertebrates and plants is prohibited on all BLM administered lands.

Professional paleontologists conducting research or assessment and mitigation are regulated through the permit process. The BLM issues about a half-dozen permits a year specifically for the Moab FO area (L. Bryant, personal communication 2003). There are also about 12 statewide research permits allowing surface collecting/reconnaissance that include the Moab FO area. The BLM also issues about 8 consulting permits annually in Utah and all of these are statewide and thus include the Moab FO area.

Amateur fossil collectors and hobbyists may collect reasonable amounts of common invertebrate and plant fossils on public lands. The number of people involved in this activity is unknown. The Moab FO area deals with about 10 inquiries a year regarding fossil collection. Further interest in fossil collection is demonstrated by the existence of a local rock-hounding club known as Points and Pebbles. In addition, hikers, mountain bikers, and other outdoor enthusiasts sometimes accidentally discover fossil remains. Some of these discoveries are passed on to the appropriate agencies, but some are not. Certainly many important paleontological discoveries have been and will continue to be made by amateur or accidental paleontologists, but the number of such discoveries is also unknown.

9.5 CONSISTENCY WITH NON-BUREAU PLANS

9.5.1 Federal Agencies

9.5.1.1 Common Ground

The Secretary of the Interior submitted the report "Assessment of Fossil Management on Federal and Indian Lands" to Congress in May 2000. The Bureau of Indian Affairs (BIA), the BLM, the Bureau of Reclamation (BOR), the USFWS, the USFS, the NPS, and the USGS, together with the Smithsonian Institution, assisted in the development of this 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 available for research and public education.
7. Federal fossil management should emphasize opportunities for public involvement.

9.5.1.2 Bureau of Indian Affairs (BIA)

Tribal lands in the Ute and Ouray Indian Reservations border the Moab FO area and for that reason their treatment of fossil resources is discussed here. According to the Secretary of the Interior the authority of the BIA to manage fossil resources on Indian 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. Indian 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 an Indian tribe or an individual Indian. 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 Indian lands, or contractual agreements between Indian 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 Indian landowner. The arrangements are also subject to evaluation under the National Environmental Policy Act (42 USC §§ 4321-4347) and the National Historic Preservation Act (16 USC §§ 470-470x-6.).

Because Indian lands are lands held in trust, the Indian tribe or individual Indian 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 Indian 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.

9.5.1.3 USDA-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 Condition System described above.

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

9.5.1.4 National Parks Service (NPS)

As required by its Organic Act, 16 USC §§ 1 *et seq.*, the NPS strives to conserve paleontological resources in park units and provide for their enjoyment 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 involves 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.

9.5.2 State of Utah

In general, the State of Utah and BLM treat fossils similarly. Paleontologic 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:

- 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, paleontologic, and mineralogic 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 Lands 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; and
- 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.

9.5.3 Grand County

Unlike BLM policy and plans, the Grand County General Plan Update, completed in April 2004, does not specifically mention fossils, fossil resources, or paleontology. Fossils, however, are part of the natural environment on public lands and are to be treated accordingly. In its preamble to Section 4.2.6, the plan notes that public lands of Grand County:

- have immense social, ecological, cultural, and economic value and are of worldwide significance.
- should be managed for the enjoyment and benefit of the people of Grand County and the nation so as to maintain the integrity and value.
- are the foundation of the county's economic prosperity, both in the short term and the long term. Economic benefit is derived from the management of public lands for multiple uses, including livestock grazing, tourism, mineral exploration, recreation, watershed protection, hunting, the film industry and many other uses.

Through economic diversification and multiple use management, Grand County's goal is to achieve a stable economic base while minimizing degradation of the economic, social, ecological, and cultural resources of the public lands. Protecting public lands resources is sound policy for the long term economic well-being of Grand County.

In Section 4.2.9 of the plan, Protecting Sensitive Lands, the plan notes Grand County will make reasonable efforts to protect sensitive lands, open space, and scenic views, while respecting private property rights. The Grand County Land Use Code defines sensitive lands to include significant geological and biological sites. Fossils being both geological and biological in nature could fall under this definition and be treated accordingly. However, the county is primarily concerned with economic viability.

9.5.4 San Juan County

Unlike BLM policy and plans, fossils, paleontology, and paleontological resources are not specifically addressed in the San Juan County Master Plan (1996) as management issues. 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 noteworthy.

The County Master Plan expresses the belief that lands of the BLM, 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 Areas of Critical Environmental Concern (ACEC) and that it opposes additional lands administered under single management schemes.

9.6 ISSUES AND CONCERNS

9.6.1 Fossil Theft and Vandalism

Fossil theft and vandalism occur with some regularity throughout the Moab FO area. Only a small number of these occurrences are ever prosecuted. 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 range from a few dollars to tens of thousands of dollars, depending on the fossils rarity and intricacy. 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 mean 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. The Department of the Interior reported hundreds of annual cases of fossil theft and vandalism in several national forests and parks. Within the Moab FO area, illegal casting of dinosaur tracks is particularly a problem.

As described in Title 43 CFR Subpart 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.

9.6.2 Resource Capability and Condition

An evaluation of the present condition of fossil resources in the Moab FO area, including areas of hobby use and possible illegal collecting, is needed. This should include an assessment of past mitigation efforts to ascertain the effectiveness of the applied mitigation efforts as well.

The BLM classifies areas according to their potential to contain vertebrate fossils or noteworthy occurrences of invertebrate or plant fossils and describes them as satisfying Condition 1, 2, or 3 for significance. As described in *Paleontological Resource Management Handbook 8270-I*, these classifications are:

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.

9.6.3 Mitigation Procedures

The RMP should include the provision that mitigation procedures for paleontological resources will be applied to surface disturbing activities and land tenure actions, in accordance with *Paleontological Resources Handbook 8270-I*. Fossils are considered part of the surface estate, so fossils on public lands are public fossils. On split-estate lands, where private land is overlying federal minerals, fossils belong to the private landowner and must be protected during any federal action. Paleontological resource mitigation is conducted in similar fashion to cultural resource mitigation, but varies in the specific procedures.

Procedures for mitigation of paleontological resources are detailed in *Paleontological Resources Handbook 8270-I*. Mitigation procedures are tailored to the proposed action based on the amount of bedrock disturbance, and may vary from project to project. Mitigation may include literature review and museum record searches, ground survey prior to surface disturbance, monitoring during work, and inspection prior to backfilling and reclamation. Paleontological mitigation efforts often require monitoring and inspection during construction activities because fossils are sometimes discovered as bedrock is disturbed.

9.7 MANAGEMENT OPPORTUNITIES AND LIMITATIONS

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.

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 the evolution of life and other aspects of paleontology. Classes for children and adults involving paleontology are offered by many museums. In addition, a plethora of internet websites have been developed by museums, universities, professional paleontologists, and amateur and commercial collectors. These websites 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 in Berlin, Germany, an international conference on paleontology in the twenty-first century was held. During the conference, the following aspects of public outreach were noted:

- 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—dinosaurs again for the most part—while the larger part of the discipline goes unheralded and unknown.

The Moab FO has an array of management opportunities available for the protection and interpretation of paleontological resources.

- Vehicle routes that cross dinosaur trackways or other paleontological sites should be rerouted.
- In areas with known paleontological resources, travel should be restricted to designated roads.
- Casting of dinosaur tracks and other paleontological resources should only be allowed on a permitted basis.
- Collection of paleontological resources, including petrified wood and invertebrate fossils, within Special Recreation Management Areas (SRMAs) and Areas of Critical Environmental Concern (ACECs) should be disallowed.
- A permitting system for the collection of petrified wood and invertebrate fossils outside of SRMAs and ACECs should be considered for Condition 1 and 2 areas (see Section 9.6, Issues and Concerns).

Educational and outreach opportunities for paleontology that could be implemented by the BLM for public benefit include the following:

- developing stand-alone public displays in areas of paleontological significance at roadside locations, such as Copper Ridge, Willow Springs Road, and Poison Spider parking lot;

- developing self-guided trails through areas of geological significance, with pamphlets at the trailheads, such as Copper Ridge, Willow Springs Road, Mill Canyon, and Poison Spider;
- offering public lectures on topics of paleontological or related geological interest;
- on current websites, expanding educational content on fossil resources (e.g., providing virtual tours of various paleontologic topics; educating the public on the importance of paleontological resources, how to treat them, and how to enjoy them without endangering them; and providing hyperlinks to other websites of paleontological interest); and
- pursuing educational and partnership opportunities to increase paleontological knowledge and management.

9.8 REFERENCES

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APPENDIX 9-A

Table 9A-1. Age, Environment of Deposition, and BLM Paleontology Condition Ranking for Sedimentary Geological Units in the BLM Moab FO Area					
Age	Geologic Unit		Depositional Environment	BLM Paleontology Ranking	
Quaternary	Landslide, alluvium, sand, terraces, gravels, colluvium, pediment		Terrestrial	2-3	
Tertiary	Green River Formation	Parachute Creek Member	Lacustrine	1	
		Douglas Creek Member	Lacustrine	1	
	Wasatch Formation		Terrestrial	2	
Late Cretaceous	Tuscher Formation		Terrestrial	3	
	Mesaverde Formation		Terrestrial to marine	2	
		Farrer Formation		Terrestrial, deltaic, marine	2
		Neslen Formation		Terrestrial, deltaic, marine	2
		Sego Sandstone		Marine	2
		Castlegate Sandstone		Terrestrial fluvial	2
		Blackhawk Formation		Terrestrial, fluvial	2
		Mancos Shale		Marine to deltaic	2
		Buck Tongue		Marine	2
		Blue Gate Member		Marine	2
		Prairie Canyon Member		Marine	2
		Ferron Sandstone Member		Deltaic	2
Tununk Member		Marine	2		
Early Cretaceous	Dakota Sandstone		Terrestrial, shoreline, estuarine	2	
	Cedar Mountain Formation		Terrestrial, fluvial	1	
		Mussentuchit Member		1	
		Ruby Ranch member		1	
		Poison Strip Sandstone		1	
		Yellow Cat Member		1	
		Buckhorn Conglomerate		3	
Jurassic	Morrison Formation		Terrestrial, fluvial	1	
		Brushy Basin Member		1	
		Salt Wash Member		1	
	Summerville Formation		Tidal flats, Sabka, marginal marine	2	
		Tidwell Member		Tidal flats, Sabka	2
	Entrada Sandstone		Beach to coastal marine	2	
		Moab Member		Shoreline beach	2

Table 9A-1. Age, Environment of Deposition, and BLM Paleontology Condition Ranking for Sedimentary Geological Units in the BLM Moab FO Area				
Age	Geologic Unit		Depositional Environment	BLM Paleontology Ranking
		Slick Rock Member	Coastal dune	3
		Dewey Bridge Member	Coastal marine	3
	Navajo Sandstone		Eolian	2
	Kayenta Sandstone		Terrestrial, eolian	2
	Wingate Sandstone		Eolian	2
Triassic	Chinle Formation		Terrestrial, fluvial	1
	Moenkopi Formation		Marine and terrestrial	2
Permian	Cutler Formation		Terrestrial to marine	2
		White Rim Sandstone	Coastal dune, eolian, shallow marine	3
		Organ Rock Formation	Terrestrial, tidal flats	1
		Cedar Mesa Sandstone	Coastal dune and shallow marine	1
		Arkosic Facies	Terrestrial	3
	Lower Cutler Beds	Terrestrial, coastal, eolian	1	
Pennsylvanian	Hermosa Group		Terrestrial to marine	2
		Honaker Trail Formation	Terrestrial to marine	2
		Paradox Formation	Marine, estuarine	3

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