United States Department of Agriculture

Forest Service

Southwestern Region

December 2013

Paleontological Resources Existing Conditions Specialist Report

Forest Plan Revision Draft Environmental Impact Statement (DEIS)

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Date: September 1, 2011

Revision Date: December 23, 2013

Preface

The information in this specialist report reflects analysis that was completed prior to and in conjunction with the completion of the Draft Environmental Impact Statement (DEIS) for the revision of the 1987 Coconino National Forest Land Management Plan (the Plan). The primary purpose of specialist reports associated with the DEIS is to provide detailed information to assist in the preparation of the DEIS. As the DEIS was prepared, review-driven edits to the broader DEIS resulted in modifications to some of the information contained in some of the specialist reports. As a result, some reports no longer contain information and analysis that was updated through an interdisciplinary review process and is included in the DEIS in its entirety. This is a complete specialist report which includes all the information that was summarized in the DEIS and other supplemental information. Efforts have been made to ensure that the retained information in the specialist reports is consistent with the DEIS. If inconsistencies exist between specialist reports and the DEIS, the DEIS should be regarded as the most current, accurate source of analysis.

Executive Summary

This existing condition specialist report evaluates and discloses the affected environment and existing conditions of Geologic Resources focusing on Paleontological Resources that may result with the adoption of a revised land management plan.

The Forest has many Paleontological Resources most of which are generally only well known by paleontologists associated with universities, the Museum of Northern Arizona, the U.S. Geological Survey and the Arizona State Geological Survey. The Coconino Forest Archaeologist also has knowledge or paleontological resources on the Forest and several localities are recorded. The Museum of Northern Arizona has provided copies of some of their paleontological sites locality records to the Forest and is willing to search their database for more records. The Coconino Forest has a need to develop a paleontological record keeping system separate from the Heritage database, and a GIS database of known paleontological resource locations.

The forest has a variety of paleontological resources which include:

- Invertebrate fauna such as brachiopods, corals, sponges, trilobites, mollusks, stromatolites, forams, radiolarians, conodonts
- Plants such as ferns, horsetails, conifers, cycads and palm fronds
- Trace fossils such as arthropods, spiders, ant lions, and other insects
- Vertebrate fauna such as fish, shark teeth, reptiles, amphibians, horses, camels, gomphotheres, mastodons, rodents and tracks and trackways of these fauna.

The forest will follow the Paleontological Resource Protection Act and future implementing regulations for the Forest Service. On May 23, 2013 the Forest Service published proposed implementing regulations for public comment in the Federal Register (USDA Forest Service 2013). These are anticipated to be finalized approved sometime in 2014 and published in the Federal Register. See the references folder in the project record for a copy of the Act and proposed implementing regulations.

The Forest Service uses a tool called the “Probable Fossil Yield Classification”. This is a planning tool wherein geological units, usually at the formation or member level, are classified according to the probability of yielding paleontological resources that are of concern to land managers. Existing statutes and policies regulate the collection and disposition of vertebrate fossils, but not non-vertebrate fossils except in special circumstances. Therefore, this classification is based largely on how likely a geologic unit is to produce vertebrate fossils

Most of the Forest’s paleontological resources are Class 3, however, we do have examples of Class 5 vertebrate tracks that are poorly covered and have significant value because of the preservation status and the diversity of fossil tracks that are preserved at a locality.

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List of Tables and Figures

Introduction

This report describes the affected environment and existing conditions for paleontological resources on the forest. Environmental consequences of the four alternatives analyzed for the Forest Plan are found in the EIS in Chapter 3 under Geological Resources and are not repeated here. Please see other separate specialist reports for Minerals and Energy, Geologic Resources, and Caves, Cliffs and Talus Slopes for analyses of these resources. This report is very limited in scope. Paleontological resources are protected resources similar to heritage resources. Heritage resources are addressed in the Heritage Specialist Report.

Relevant Laws, Regulations and Policy

All alternatives are designed to guide the Coconino NF's management activities in meeting all applicable Federal and State laws, regulations, and policies. The following is a list of key policies, laws and regulations that guide geologic resource management as applicable to the Forest.

Federal Laws and Regulations

The following list of laws and regulations comes directly from the Paleontology Handout No. 1, March 2005, **http://fsweb.wo.fs.fed.us/mgm/paleo_notebook.html**

Organic Act of 1897 (16 USC 551); Bankhead-Jones Tenant Act of 1937 (7 USC 1101): Power to regulate occupancy and use, and promulgate regulations on NFS lands and National Grasslands.

7 CFR 2.60: Delegation of Authority from Secretary of Agriculture to Chief, Forest Service to regulate use and occupancy of National Forest System Lands; and to issue appropriate regulations under 36 CFR 261, Prohibitions.

1906 Antiquities Act *: Authority for permit issuance for collection and preservation -- FS Special Uses Manual 2701.1-2.

43 CFR Part 3 *: 1906 Act codified for collection and preservation procedures.

7 CFR 3100.41(a) *: USDA will protect paleontological resources under the 1906 Antiquities Act

36 CFR 251: For use and occupancy under special-use authorization. 251.53(a) and (f) permits for vertebrate fossil collection for scientific and education purposes only.

36 CFR 261.2, 261.9(i), 261.70(a)(5): Prohibitions Section, includes definition of paleontological resources, theft of federal property in general, and theft of paleontological resources. Orders, special closures, and ability for regions to issue regulations for protection of paleontological resources.

36 CFR 228.62(e): Free-use permit may be required for limited collection of petrified wood for personal use by amateur collectors and scientists. Material cannot be bartered or sold.

National Environmental Policy Act of 1969: 42 U.S.C. 4321, sec. 101(b). Preserve important natural aspects of our national heritage.

Forest and Rangeland Renewable Resources Planning Act of 1974, as amended: Land-use management planning: standards and guidelines, restrictions or special management areas, preservation of important aspects of national heritage

1979 Archeological Resources Protection Act: Protects paleontological resources only when associated with archeological resources. Section 12(b) allows for amateur collecting for private purposes. See 36 CFR 296.5(b)(2).

1988 Federal Cave Resources Protection Act: Protects cave resources including paleontological resources. See 36 CFR 290

Hells Canyon National Recreation Area: 36 CFR 292.41, second definition of paleontological resources

Picketwire Canyonlands: PL 101-510 (H.R. 4739, sec. 2825) Transfer of lands to Secretary of Agriculture (Comanche National Grassland) for protection of archeological and paleontological resources.

Paleontological Resources Preservation Act of 2009 (PL 111-011): Defines paleontological resources and "casual collecting" but leaves the terms "reasonable amount" "common invertebrate and plant paleontological resources" and negligible disturbance" to be defined by the Secretary of the Interior and Secretary of Agriculture. Management and protection of paleontological resources on Federal land using scientific principles and expertise. Cover collection of paleontological resources

*Indicates discrepancy: the 1906 Antiquities Act does not cover paleontological resources according to the courts.

The Forest Service, along with other interagency partners and scientists, is developing implementing regulations for the Paleontological Resources Preservation Act of 2009. On May 23, 2013 the Forest Service published proposed implementing regulations for public comment in the Federal Register (USDA Forest Service 2013). The proposed rules address management, collection, and curation of paleontological resources from Federal lands managed by the Forest Service. Specifically the rule covers scientific management of paleontological resources, collecting resources with and without a permit, curation in approves repositories, maintaining confidentiality of specific locality data, penalties for illegal collecting, sale, damaging or otherwise altering or defacing paleontological resources. These regulations will be finalized by the Secretary of Agriculture and published in the code of federal regulations sometime in 2014. The Coconino National Forest (Peter J. Pilles, Polly Haessig, and Judy Adams) submitted comments on the internal review draft of the regulations in February 2011. The terms listed above, for example "reasonable amount" of common invertebrate fossils are defined in these implementing regulations.

Forest Service Manuals and Handbooks

FSM 2800 Minerals and Geology

Chapter 2880 Geologic Resources, Hazards and Services – briefly discusses management of paleontological resources.

FS Manual 2701.1-2 *

Paleontological resources management under 1906 Antiquities Act.

FS Manual 2860

Recreational collecting of mineral and fossil material under acquired lands. See also 43 CFR 3505.11.

Methodology and Analysis Process

Scope of Analysis and Units of Measure

The analysis focuses on the the existing known and potential (unknown) paleontological resources on the forest. Paleontology resources are generally described using information from available literature and from external agency information mainly found on Department of the Interior web sites containing geologic resource information for Tuzigoot, Montezuma Castle and Well, Walnut Canyon, Sunset Crater and Wupatki National Monuments.[1] Other information on paleontology resources known on the Forest comes from past investigations and reports. Because by law, paleontological resource information is confidential for vertebrate fossils, information will not be disclosed that could be used to determine the location of fossil localities on the forest. Management concerns with paleontological resources are also identified.

The alternatives are compared in the EIS on the basis of how they would protect and preserve paleontological resources and conserve the scientific values of the areas. This will be a qualitative analysis.

Revision Topics and Issues Addressed in this Analysis

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund or carry out any project activity. There are implications or longer term environmental consequences of managing the forest under this programmatic framework. The focus of this environmental analysis is on the consequences of the alternatives on the desired conditions for the geological and botanical special area resources.

Revision Topics

The Analysis of the Management Situation (AMS) (Forest Service May 2010) and the Ecological Sustainability Report (ESR) (Forest Service May 2010) did not discuss paleontological resources on the forest.

Issues and Concerns

To date, there have been no specific public comments related to management of paleontological resources on the forest.

Assumptions

The following assumptions have been made as part of this analysis:

Forest Plan

- The land management plan provides a programmatic framework for future site-specific actions.

[1] http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

- Land management plans do not have direct effects. They do not authorize or mandate any site-specific projects or activities (including ground-disturbing actions).
- Land management plans may have implications, or environmental consequences, of managing the forests under a programmatic framework.
- The plan decisions (desired conditions, objectives, standards, guidelines, management areas, monitoring) will be followed when planning or implementing site-specific projects and activities.
- Laws, regulations, and policies will be followed when planning or implementing site-specific projects and activities.
- Monitoring will occur and the land management plan will be amended, as needed.
- We will be funded similar to past budget levels (past 5 years).
- The planning timeframe is 15 years; other timeframes may be analyzed depending on the resource (usually a discussion of anticipated trends into the future).

Paleontological Resources

The forest will follow the Paleontological Resource Protection Act and future implementing regulations for the Forest Service. On May 23, 2013 the Forest Service published proposed implementing regulations for public comment in the Federal Register (USDA Forest Service 2013). These are anticipated to be finalized approved sometime in 2014 and published in the Federal Register. See the references folder in the project record for a copy of the Act and proposed implementing regulations.

Summary of Alternatives

Four alternatives are analyzed in detail in this Specialist Report: Alternatives A through D. Alternative A is the current 1987 Coconino National Forest Plan as amended (Forest Service 1987) and Alternative B is the Preferred Alternative/Proposed Action, drafted over the past several years and refined with several periods of internal and informal public feedback. Alternative C considers increases in the amount of wilderness and special areas, as well as increased opportunities for quiet semi-primitive recreation, while Alternative D considers slightly fewer restrictions than Alternatives B and C on human access and use of the Forest and its resources.

The following summaries of the alternatives focus on the components that may have consequences on management of paleontological resources.

Alternative A, 1987 Plan

There are no sections pertaining to Paleontological Resources Management in the 1987 Plan.

Alternative B, Modified Proposed Plan

Direction for Paleontological Resources is found in the Draft Land and Resource Management Plan that accompanies the Draft EIS (Forest Service October 2013 and Forest Service November 2013). The proposed revised forest plan is the preferred alternative. It would provide strategic, program-level guidance for managing the Forest and its natural resources over the next 10 to 15 years. The Paleontological Resources part of Forest-wide Standards and Guidelines contains desired conditions, guidelines and management approaches for paleontological resources.

Alternative C

The Forest proposes Alternative C to be responsive to public recommendations for more wilderness areas on the Forest, as well as other special and management areas to provide additional protection to botanical and wildlife resources. This alternative is the same as Alternative B with respect to Paleontological Resources desired conditions, guidelines and management approaches.

Alternative D

Alternative D is different from Alternative B and C in that it allows mechanized recreation (e.g., bikes) on designated trails in botanical and geological areas and proposed no new wilderness areas. Otherwise this alternative is the same as Alternative B with respect to the Paleontological Resources.

Description of Affected Environment

Definitions (from the Paleontological Resources Preservation Act of 2009 (Public Law 111-011).

- Paleontological Resource: The term ''paleontological resource'' means any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth, except that the term does not include—
    - (A) any materials associated with an archaeological resource (as defined in section 3(1) of the Archaeological Resources Protection Act of 1979 (16 U.S.C. 470bb(1)); or
    - (B) any cultural item (as defined in section 2 of the Native American Graves Protection and Repatriation Act (25 U.S.C. 3001)).
- Casual Collecting: The term ''casual collecting'' means the collecting of a reasonable amount of common invertebrate and plant paleontological resources for non-commercial personal use, either by surface collection or the use of non-powered hand tools resulting in only negligible disturbance to the Earth's surface and other resources. As used in this paragraph, the terms ''reasonable amount'', ''common invertebrate and plant paleontological resources'' and ''negligible disturbance'' shall be determined by the Secretary.

Definitions from the Forest Service Proposed Rules, Parts CFR 261 and 291

The proposed rules slightly redefine what casual collecting, collection and common invertebrate and plan paleontological resources are as follows.

- The term *casual collecting* would restate the definition contained in 16
- U.S.C. 470aaa of the Act. To be considered *casual collecting*, the activity would mean all of the following: Collecting of a reasonable amount of common invertebrate or plant paleontological resources for non-commercial personal use, either by surface collection or the use of non-powered hand tools, resulting in only negligible disturbance to the Earth's surface and other resources.
- The term *collection*, as used in Sections 291.21 through 291.26 of the proposed regulations, would mean paleontological resources and any associated records resulting from excavation or removal from Federal lands under a permit.

- The term *common invertebrate and plant paleontological resources* would clarify the types of paleontological resources that may be casually collected in accordance with the Act and the proposed regulations. The proposed definition would incorporate the plain meaning of common, which means plentiful and not rare or unique. The proposed definition would also incorporate a geographical factor of wide-spread distribution, which means that the resource is distributed over a relatively large geographical area. The proposed definition would also clarify that not all invertebrate and plant paleontological resources are common; some are not common because of their context or other characteristics and, therefore, are not eligible for casual collection. The determination of whether invertebrate and plant fossils are common or not common will be made by the authorized officer using scientific principles and methods in accordance with section 291.9(c).

Current Forest Service Policy

The following policy is the current Forest Service Policy relating to paleontological resources including petrified wood. The source is the March 2005 Paelontology Handout No. 1. http://fsweb.wo.fs.fed.us/mgm/paleo_notebook.html. Note that this policy predates the Paleontological Resources Preservation Act of 2009.

Fossil Collecting Policy on National Forest System Lands:

Forest Service Policy: Unless otherwise prohibited through law, regulation, order, land-use plan or closure, a special use permit is not required for amateur collecting of invertebrate and plant fossils for personal use (longstanding practice.) Collecting of vertebrate fossils is only allowed for scientific or educational purposes, and requires a special use permit in accordance with 36 CFR 261.9(i) and 36 CFR 251.53. Commercial collection of any type of fossil specimen is prohibited except for petrified wood as authorized under 36 CFR 228 Subpart C.

Invertebrate and Plant Fossils -- Unless otherwise prohibited through order, regulation, land use plan or closure, a permit is not required for collection of invertebrate and plant fossils for personal non-commercial recreational use. No commercial collection allowed, except for petrified wood.

Vertebrate Fossils -- Collection for educational and scientific research are authorized by special-use permits. No commercial collection is allowed. Applicants must meet certain qualifications.

Petrified Wood -- Commercial collection and free use of petrified wood is authorized by the 1947 Mineral Materials Act, as amended, through a mineral materials sales contract. Petrified wood, a fossil plant, was designated by Congress to be a mineral material. Unless otherwise prohibited, small quantities of petrified wood for personal non-commercial recreational use may be collected on NFS lands without a permit. A free-use permit may be issued to amateur collectors and scientists to take limited quantities of petrified wood for personal use. The material taken may not be bartered or sold. Free-use areas may be designated within which a permit may not be required.

Curation Agreements: Storage and Preservation in Non-federal Repositories

No formal FS policy or manual guidelines on storage and preservation of fossil resources; refer to the American Association of Accredited Museum and/ or Department of the Interior

Manual, DM 411 standards for curation and storage procedures. Vertebrate fossil specimens are stored in accredited or approved repositories via cooperative or other agreement. Fossils remain property of the United States held in perpetuity.

As stated previously, Forest Service policy will change with the implementing regulations of the Paleontological Resources Preservation Act of 2009.

Paleontological Resources

The Forest has many Paleontological Resources most of which are generally only well known by paleontologists associated with universities, the Museum of Northern Arizona, the U.S. Geological Survey and the Arizona State Geological Survey. The Coconino Forest Archaeologist also has knowledge or paleontological resources on the Forest and several localities are recorded. The Museum of Northern Arizona has provided copies of some of their paleontological sites locality records to the Forest (2011) and is willing to search their database for more records. The Coconino Forest has a need to develop a paleontological record keeping system separate from the Heritage database, and a GIS database of known paleontological resource locations.

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- Trace fossils such as arthropods, spiders, ant lions, and other insects
- Vertebrate fauna such as fish, shark teeth, reptiles, amphibians, horses, camels, gomphotheres, mastodons, rodents and tracks and trackways of these fauna.

The following table lists the bedrock formations on the Coconino National Forest by geologic time period and the known or potential paleontological resources that could be associated with each bedrock unit. Information for this table was derived from discussions with David Gillette, Paleontologist at the Museum of Northern Arizona (August 15, 2011), Timothy Rowe, Director of the Vertebrate Paleontology Laboratory at the University of Texas at Austin (2010, 2011), other local geologists and from literature references, and information from geologic resource inventories conducted by the national monuments within or nearby the Forest including Sunset Crater, Wupatki, Walnut Canyon, Montezuma Well and Castle and Tuzigoot National Monuments (Table 1). Bedrock units across the forest were mapped using the Digital Map of Arizona: A Digital Database Derived from the 1983 Printing of the Wilson, Moore, and Cooper 1:500,000-scale Map (Figure 1).

To date, the forest has documentation of several reports pertaining to fossil resources. Fossil tracks and trackways are known from the Verde Formation sediments near Camp Verde, Cornville and Cottonwood, and Montezuma Well that include tracks of camels, ancestors of the saber-toothed cat, sloths, and the gomphothere (Pliocene elephant) (National Park Service 2006a, 2006b). Other camel tracks have been noted in the Verde formation along the Verde River near Beasley Flat and in the Cottonwood Basin near the Teepee Rocks (Cottowood Basin Fumeroles).

The Forest has several paleontological resource sites that have been evaluated and are significant resources. In 2005, paleontological resources consisting of shark teeth, invertebrates, and nautiloids have been recorded and previously collected by the Museum of Northern Arizona from the Kaibab Formation along the Lake Mary Road (Gore 2005). In 2004, during a pipeline construction project along Highway 179 near Sedona, slabs of rock containing large examples of Permian plant fossils

were found associated with the Hermit Formation (Gillette 2004). These slabs containing the fossils were never removed/collected from the site due to their large size but were covered over with other rock and soil to protect them. In 2013, paleontology resources consisting of two trackways were recorded and investigated by Gillette and Haessig (2013) in the Hermit Formation near Sedona. The trackways are of vertebrate tetrapods, most likely of synapsid reptiles which are considered "early mammal-like" reptiles of Permian age.

Figure 1. Bedrock Geologic Map of the Coconino National Forest Service

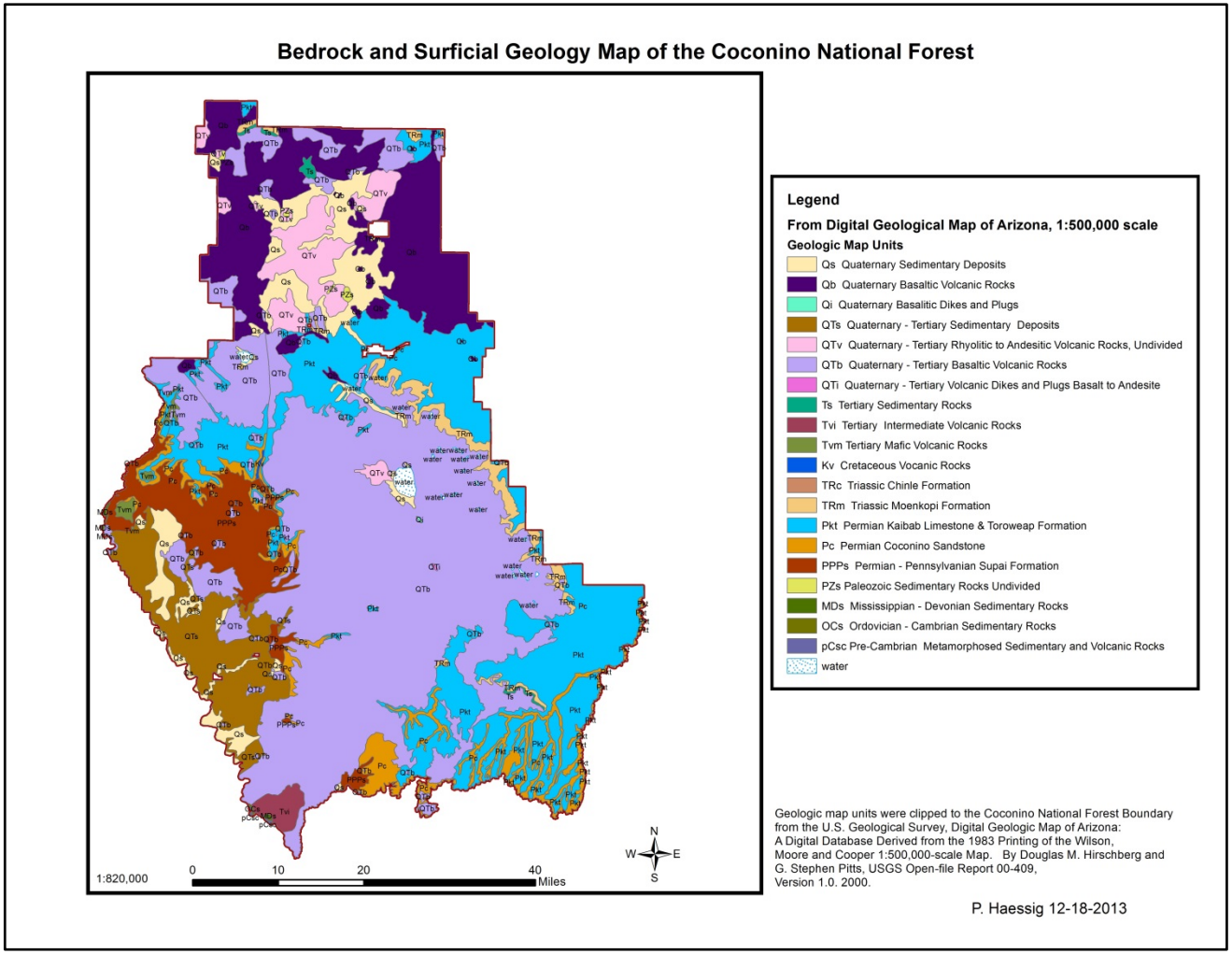

Table 1. Potential Paleontological Resources on the Coconino National Forest.

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
				Information sources used in the Explanation column: *Hirschberg, D. M., & Pitts, G. S. (2000). Digital geologic map of Arizona: A digital database derived from the 1983 printing of the Wilson, Moore, and Cooper, 1:500,000 map, 2000-409. Weir, G. W. , Ulrich, G. E. and L. D. Nealey, 1989, Geologic Map of the Sedona 30' X 60' Quadrangle, Yavapai, and Coconino Counties, Arizona. USGS Miscellaneous Investigations Services Map I-1896.*			
Quaternary	Pleistocene - Holocene	Qs	Sedimentary rocks	Sedimentary rocks: Mainly alluvial gravel, sand, and silt in flood plains, terraces, fans, and pediment cappings but locally includes dune sand, lake deposits, and landslide masses.	Large mammal bones of Quaternary Age. Tracks and trackways. Packrat middens containing plant material, small mammal bones and food waste.	112,048	Graham, J. 2011. Wupatki National Monument: geologic resources inventory report. Natural Resource Report NPS/NRSS/GRD/NRR—2011/416. National Park Service, Fort Collins, Colorado.
Quaternary	Pleistocene - Holocene	Qb	Volcanic rocks	Volcanic rocks: Basaltic flows, agglomerate, tuffs, and cinders distinguished from older basalts by recognizable cinder cones, craters and other geomorphic evidence of recent formation.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	230,810	
Quaternary	Pleistocene - Holocene	Qi	Volcanic rocks	Dikes and plugs, mainly basaltic in composition.	None	154	

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
Tertiary - Quaternary	Miocene-Pliocene	QTs	Sedimentary rocks	Sedimentary rocks: Includes Verde formation and other stream and lake deposits mainly in intermontane areas. Consists of loosely to firmly consolidated gravel, sand, and silt, local clay, gypsum, marl, limestone, diatomite and some intercalated basalt flows and felsic tuff beds.	Vertebrate fossil bones, teeth and tracks. Large and small mammals. Birds and salamanders. Small mammals include rodents. Large mammals include camel bones and camel tracks, ancestors of the saber-toothed cat, sloths, gomphothere (Pliocene elephant).	112,966	National Park Service, Geologic Resource Evaluation Scoping Summary, Montezuma Castle National Monument, Arizona. 2006 National Park Service, Geologic Resource Evaluation Scoping Summary, Tuzigoot National Monument, Arizona, 2006 http://www.nature.nps.gov/geology/inventory/publications/s_summaries/MOCA_GRE_scoping_summary_2006-0627.pdf
Tertiary - Quaternary		QTv	Volcanic rocks	Volcanic rocks: Undivided rhyolitic to andesitic flows and pyroclastic rocks; includes some plugs and dikes. Includes units interfingering with Quaternary Tertiary sediments and some possibly older units whose debris is in Quaternary Tertiary sediments.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	71,347	
Tertiary - Quaternary		QTb	Volcanic rocks	Volcanic rocks: Basaltic flows, agglomerate, tuff, and cinders. Includes units interfingering with Quaternary Tertiary sediments and some possibly older units whose debris is in Quaternary Tertiary sediments. Widespread flows on the Coconino Plateau and present in the Verde Valley.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	817,420	
Tertiary - Quaternary		QTi	Intrusive rocks	Dikes and Plugs, mainly andesitic to basaltic in composition. Hutch Mountain area.	None	165	

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
Tertiary	Paleocene - Eocene	Ts	Sedimentary rocks	Sedimentary rocks: Mainly conglomerate, sandstone, siltstone, limestone, and tuffaceous beds but locally includes volcanic units ranging from rhyolitic to andesitic in composition. "Rim gravels" of the Coconino Plateau, chiefly conglomerate locally interbedded with sandstone, mudstone and limestone. Stream, lake and fan deposits of several generations and source areas. Paleocene -Eocene	Scarce fossils. Invertebrate fossils: Viviparus, Physa and Lioplacodes freshwater gastropods (snails). Pollen.	4,039	Elston, D. P., Young, R. A., Mckee, E. H., & Dennis, M. L. (1989). Paleontology, clast ages, and paleomagnetism of upper Paleocene and Eocene gravel and limestone deposits, Colorado Plateau and Transition Zone, northern and central Arizona. *Geology of Grand Canyon, Northern Arizona (With Colorado River Guides): Lee Ferry to Pierce Ferry, Arizona*, 155-165.
Tertiary		Tvi	Volcanic rocks	Volcanic rocks: Intermediate volcanic rocks, flows, tuffs, breccias, and agglomerates interfingering in part with Tertiary sedimentary rocks. Includes some plugs and dikes.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	12,629	
Tertiary		Tvm	Volcanic rocks	Volcanic rocks: Mafic volcanic rocks, flows, tuffs, breccias, and agglomerates interfingering in part with Tertiary sedimentary rocks. Includes some plugs and dikes.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	5,048	
Mesozoic	Cretaceous	Kv	Volcanic rocks	Volcanic rocks: Rhyolitic to andesitic flows and tuffs.	Fossil vertebrate mammal bones within lava tubes where lava tube caves exist.	589	
Mesozoic	Upper Triassic	TRc	Sedimentary rocks	Chinle Formation. Light-gray and grayish-red siltstone, mudstone and minor yellowish-gray sandstone. The stratigraphic position of the Chinle Formation on the Forest is unknown.	Petrified logs and wood fragments. Vertebrate fossils. Teeth and bones of tetrapod reptiles. Bones of amphibians, fish. Invertebrate fossils, plants (trees, ferns, etc.), insects, trackways and burrows.	25	Murry, P. A., & Long, R. A. (1989). Geology and paleontology of the Chinle Formation, Petrified Forest National Park and vicinity, Arizona and

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
							a discussion of vertebrate fossils of the southwestern Upper Triassic. *Dawn of the age of dinosaurs in the American Southwest. New Mexico Museum of Natural History, Albuquerque*, 29-64.
Mesozoic	Middle? And Lower Triassic	TRm	Sedimentary rocks	Moenkopi Formation. Slope-forming, alternating sequence of red-brown claystone, siltstone and sandstone. Bedding surfaces often contain small-scale ripple marks. Trough crossbedding and ripple marks are evidence of fluvial origin. Unconformably overlies the Kaibab Formation.	Vertebrate body fossils, teeth and bones of amphibians, reptiles. Tracks and trackways, tetrapod tracks. Invertebrate fossils (ammonites) and megafossil plants as impressions and casts.	37,826	Lucas, S. G., Heckert, A. B., Spielmann, J. A., Tanner, L. H., and A.P. Hunt. (2007). Second day: Early and Middle Triassic stratigraphy, paleontology and correlation in northeastern Arizona. *2007a*, 181-188.
Paleozoic	Permian	Pkt	Limestone	Kaibab Limestone and Toroweap Formation. Kaibab Formation. Yellowish-gray, silty to sandy dolomite, limestone, commonly dolomitic and cherty and lenses of light-brown fine-grained sandstone. Toroweap Formation. Light-gray to yellowish-gray very fine to fine-grained quartzose sandstone in medium - scale sets of cross beds and rare horizontal beds. Base generally marked by conspicuous horizontal recess in cliffs formed by combination of Toroweap with the Coconino Sandstone.	Kaibab Formation: Rare mollusks (gastropods). Invertebrate marine fossils including brachiopods, trilobites, crinoids from sandy limestones; sponge spicules and bryozoans from chert nodules and chert beds. Shark teeh+F6t also known. Fossil vertebrate mammal bones in caves and sinkholes. Toroweap Formation: corals, brachiopods crinoids and other invertebrate fauna.	388,819	Santucci, V. L., & Santucci Jr, V. L. (1999). An inventory of paleontological resources from Walnut Canyon National Monument, Arizona. *National Park Service Paleontological Research*, *4*, 118-120. Weir, G. W., Ulrich, G. E., & Nealey, L. D. (1989). Geologic map of the Sedona 30' by 60' Quadrangle, Yavapai and

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
							Coconino Counties, Arizona.
Paleozoic	Permian	Pc	Sandstone	Coconino Sandstone	Tracks and trackways of invertebrates and vertebrates such as arthropods, scorpionids, amphibians and reptiles. Trace plant fossils as impressions or casts.	82,764	Santucci, V. L., & Santucci Jr, V. L. (1999). An inventory of paleontological resources from Walnut Canyon National Monument, Arizona. National Park Service Paleontological Research, 4, 118-120. Brand, L. R., & Tang, T. (1991). Fossil vertebrate footprints in the Coconino Sandstone (Permian) of northern Arizona: Evidence for underwater origin. Geology, 19(12), 1201-1204. Brady, L. F. (1947). Invertebrate tracks from the Coconino Sandstone of northern Arizona. Journal of Paleontology, 466-472.

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
Paleozoic	Upper Pennsylvanian - Lower Permian	PPPs	Sedimentary rocks	Supai Formation. Includes Schnebly Hill Formation, Hermit Formation and Esplanade Sandstone. Reddish brown sandstone, siltstone. Gray limestone and dolomitic limestone. Conglomerate. Forms steep slopes, cliffs, and locally buttes and pinnacles, thin to thick bedded ledges.	Diverse marine and non-marine/terrestrial fauna. Fossils generally scarce. Tracks and trackways of vertebrates including tetrapod reptiles. Fish fossils known. Plant fossils known including stems, leaves, logs and possible bark impressions. Ferns, horsetails, conifers, cycads, and tree ferns. Invertebrate tracks and trackways and worm burrows. Invertebrate fossils include pelecypods, gastropods, brachiopods, corals, and more rarely, trilobites, bryozoans, crinoids and echinoids. Microfossils include conodonts, fusulinids and foraminifers.	110,144	McKee, E. D. (1982). *The Supai Group of Grand Canyon* (Vol. 1173). US Department of the Interior, Geological Survey. H8
Paleozoic	Mississippian - Permian	PZs	Sedimentary rocks	Paleozoic sedimentary rocks undivided. Includes exposures and fault blocks of Paleozoic sedimentary rocks not covered by Quaternary volcanic flows of Eldon Mountain, Dry Lake Hills and White Horse Mountain and Slate Mountain. Includes Kaibab Limestone Coconino Sandstone, Schnebly Hill Formation, Hermit formation, Supai Group, Redwall Limestone Martin Formation and Temple Butte Formation.	see formation descriptions above and below	1,811	Geological Survey (US), & Holm, R. F. (1988). *Geologic map of San Francisco Mountain, Elden Mountain, and Dry Lake Hills, Coconino County, Arizona*. The U.S. Geologic survey, Miscellaneous Investigations Series Map I-1663.
Paleozoic	Upper - Middle? Devonian - Mississippian	MDs	Sedimentary rocks	Sedimentary rocks: Includes Redwall Limestone, (Upper and Lower Mississippian) and Martin Formation (Upper and Middle? Devonian). Limestone, light-yellowish -gray and pinkish-gray, micrograined to coarse grained. Abundant fine to coarse shell fragments. Contains reddish-gray to dark-gray chert in irregular layers and concretions. Redwall Limestone unconformably overlies the Martin Formation. Martin Formation: dolomite and minor limestone, sandstone and	Invertebrate fossils include brachiopods, corals, bryozoans, mollusks, crinoids, blastoids, trilobites and foraminifers.	673	McKee, E. D. (1958). The Redwall Limestone. In *Guidebook of the Black Mesa Basin, northeastern Arizona: New Mex. Geol. Soc. 9th Field Conf* (pp. 74-77). Beus, S. S. (1978). Late Devonian (Frasnian) invertebrate fossils

Period	Epoch	Bedrock Unit Symbol	Rock type	Explanation	Potential Paleontological Resources	Acres on Forest Service	Information Source
				siltstone. Dolomite mostly medium-gray and reddish-brown, micrograined to fine-grained. In parts, cherty and calyey to sandy, locally grading to and interbedded with limestone in part, laminated. Interbedded with reddish-gray siltstone and fine to medium -grained sandstone. Outcrops along the Verde River and Sycamore Canyon.			from the Jerome Member of the Martin Formation, Verde Valley, Arizona. Journal of Paleontology, 40-54.
Paleozoic	Cambrian - Ordovician	OCs	Sedimentary rocks	Paleozoic sedimentary rocks undivided. Includes Martin Formation, Tapeats Sandstone. See Martin Formation description above. Tapeats Sandstone is yellowish-orange to dusky-red, medium to coarse grained and locally pebbly conglomerate arkosic in thin horizontal beds and crossbeds. Resistant, forms ledges. Outcrops along the Verde River.	Trace fossils of amphipods (crustaceans) and arthropods including Corophioides also called Arenicolites. Sedimentary fossil traces include worm burrows. Trilobites and trilobite trackways not known.	305	Hereford, R. (1977). Deposition of the Tapeats Sandstone (Cambrian) in central Arizona. *Geological Society of America Bulletin*, *88*(2), 199-211.
Proterozoic	pre-Cambrian	pCsc	Metamorphic rocks	Metamorphosed sedimentary and volcanic rocks, undifferentiated. Outcrops along the Verde River.	None	241	
		water	(blank)	(blank)		7,948	
					Total Acres	**1997771**	

Fossil Potential Classification for the Coconino National Forest

The Forest Service uses a tool called the "Probable Fossil Yield Classification". This is a planning tool wherein geological units, usually at the formation or member level, are classified according to the probability of yielding paleontological resources that are of concern to land managers. Existing statutes and policies regulate the collection and disposition of vertebrate fossils, but not non-vertebrate fossils except in special circumstances. Therefore, this classification is based largely on how likely a geologic unit is to produce vertebrate fossils. The classes are described below, with some examples of corresponding management considerations or actions. This system is based on **probabilities**, not certainties or special circumstances. There will be exceptions to each criterion used as the basis for classification. These are expected and should be handled as unique cases.

Most of the Forest's paleontological resources are Class 3, however, we do have examples of Class 5 vertebrate tracks that are poorly covered and have significant value because of the preservation status and the diversity of fossil tracks that are preserved at a locality.

Class 1

Description: Igneous and metamorphic (volcanic ashes are excluded from this category) geologic units that are not likely to contain recognizable fossil remains.

Basis: Fossils of any kind known *not* to occur except in rare circumstances. Igneous or metamorphic origin.

Example: Tertiary Basalt Flows, except where lava tubes may contain paleontological resources.

The land manager's concern for paleontology resources on Class 1 acres is negligible. Ground-disturbing activities will not require mitigation except in rare circumstances.

Class 2

Description: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant non-vertebrate fossils.

Basis: Vertebrate fossils known to occur *very rarely or not at all*. Age greater (older) than Devonian. Age younger than 10,000 years before present. Deep marine origin. Aeolian origin. Diagenetic alteration.

Example: Cambrian – Ordovician Sedimentary Rocks, undivided. Trace fossils of arthropods and amphopods in some localities may be considered uncommon and significant for poretection.

The land manager's concern for paleontology resources on Class 2 acres is low. Ground-disturbing activities are not likely to require mitigation.

Class 3

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

Basis: Primarily marine origin with sporadic known occurrences of vertebrate fossils (other than fish scales and shark teeth). Vertebrate fossils and significant non-vertebrate fossils known to occur inconsistently--predictability known to be low. Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Example: Kaibab and Coconino Formation, Rim Gravels. Exceptions are within karst cave formations containing paleontological resources.

The land manager's concern for paleontology resources on Class 3 acres may range from requiring very little management and providing high levels of unregulated access, while other areas may require annual intense management. Ground-disturbing activities may require sufficient mitigation to determine whether significant paleontology resources occur in the area of a proposed action. Mitigation beyond initial findings will range from no further mitigation necessary to full and continuous monitoring of significant localities during the action.

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

Basis: Significant vegetative cover; outcrop is not exposed. Areas of exposed outcrop are smaller than 2 contiguous acres. Outcrop forms cliffs of sufficient height that most is out of reach by normal means. Other characteristics that lower the sensitivity of both known and unidentified fossil sites (see Criteria for Sensitivity Ranking--Locality).

Example: Covered acres of the of the Verde Formation.

The land manager's concern for paleontology resources on Class 4 acres is toward management and away from unregulated access. Ground-disturbing activities will require mitigation to determine whether significant paleontology resources occur in the area of a proposed action. Mitigation beyond initial findings will range from no further mitigation necessary to full and continuous monitoring of significant localities during the action.

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

Basis: Vertebrate fossils and/or scientifically significant nonvertebrate fossils are *known and documented* to occur consistently, predictably, and/or abundantly. Outcrop is exposed: little or no vegetative cover or unconsolidated sedimentary. Extensive exposed outcrop; discontinuous areas are larger than 2 contiguous acres. Outcrop erodes easily, may form badlands. Easy access to extensive outcrop in remote areas (increased potential for illegal collection; damage by vandals). Other characteristics that increase the sensitivity of both known and unidentified fossil sites.

Example: Hermit Formation, upper units of Verde Formation, Tertiary to Quaternary sedimentary and alluvial units.

The land manager's highest concern for paleontology resources should focus on Class 5 acres. These areas are likely to be poached. Mitigation of ground disturbing activities is required and may be intense. Frequent use by the full range of interested publics is to be expected. Areas of special interest and concern should be designated and intensely managed. Field-based, technical training in paleontology resources management should be provided to Forest and District staff and to Law Enforcement Officers. Memoranda of Understanding, Challenge Cost Share, and/or Participating agreements with professional academic paleontologists should be sought and maintained in order to provide a consistent source of outside expertise. Curation Agreements should be maintained with area museums so that there is always a repository for fossils collected and turned over to the Forest.

Class 5 areas are likely to yield appropriate recreational opportunities, though it is more difficult to isolate opportunity acres from surrounding critical acres and therefore access must be more intensely regulated. Opportunities exist for closure to casual fossil collecting or would require a permit for such collecting. This would be very protective for the areas as a whole which contain other resources in addition to paleontology resources.

Environmental Consequences and Cumulative Effects

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan does not authorize or mandate any site-specific projects or activities (including ground-disturbing actions), there can be no direct effects. However, there may be implications, or long-term environmental consequences, of managing the forests under this programmatic framework.

Please see the Geological Resources section of Chapter 3 of the EIS which contains a description of environmental consequences to paleontology resources with respect to the alternatives analyzed.

Relationship of Short-Term Uses and Long-Term Productivity

Factors to evaluate under NEPA include irreversible or irretrievable commitment of resources, short-term versus long-term, and any adverse environmental impacts that cannot be avoided (40 CFR 1502.16).

Unavoidable Adverse Impacts

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Before any ground-disturbing actions take place, they must be authorized in a subsequent environmental analysis. Therefore, none of the alternatives cause unavoidable adverse impacts. Mechanisms are in place to monitor and use adaptive management principles in order to help alleviate any unanticipated impacts that need to be addressed singularly or cumulatively.

Irreversible and Irretrievable Commitment of Resources

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan does not authorize or mandate any ground disturbing actions, none of the alternatives cause an irreversible or irretrievable commitment of resources.

Adaptive Management

All alternatives assume the use of adaptive management principles. Forest Service decisions are made as part of an ongoing process. The land management plan identifies a monitoring program. Monitoring the results of actions will provide a flow of information that may indicate the needs to change a course of action or the land management plan. Scientific findings and the needs of society may also indicate the need to adapt resource management to new information.

Monitoring and stabilization of Paleontological Resources is a management approach to determine visitor impacts and protect the conditions of key resources. Paleontological resources/localities are evaluated continually as to how well they are meeting desired conditions. Throughout the life of the forest plan, the forest will evaluate any new or ongoing impacts that conflict with the desired conditions for PR. Environmental analysis and appropriate NEPA would be used to assess impacts. The line officer has various options to relieve impacts which include but are not limited to: administrative actions such as area closures; project mitigations; or various recreational use restrictions. Projects or management actions that could affect or impact PR would be analyzed and any necessary mitigation would be developed at the site specific level with the approval of the line officer.

Climate Change

Climate change could affect the distribution of vegetation in general by affecting biotic and abiotic factors and by increasing the extent and severity of disturbances bedrock and surficial deposits containing fossils or tracks (USDA, Forest Service 2010) under all alternatives. Flood severity may also increase and there could be a subsequent increase in erosion rates and this could cause covered fossil localities to lose their cover and be subject to weathering, erosion or vandalism. These processes may be slow and not generally noticeable.

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Education and Professional Experience

I have a Bachelors of Arts degree in Anthropology from Occidental College, in Los Angeles, CA and have studied undergraduate level geology at Occidental College and Washington State University, in Pullman, WA for a combined total of more than 4 years. I have a Master of Science degree in geology from Oregon State University (1988). My professional experience totals 25 years, including more than 17 years working as a geologist for the Forest Service and the Army Corps of Engineers, and more than 6 years working as a NEPA Specialist/Partnership Coordinator. My geologic area of expertise in is landslide mapping and hazard assessment, watershed analysis and restoration, abandoned mine reclamation and minerals administration. I am a registered Geologist in Oregon (#G1170) and California (#6565), and a registered Engineering Geologist in California (# 2313). I have been a contributing author on several unpublished internal Forest Service studies, and have been a senior or contributing author on some short scientific publications relating to geology and forest management and mine reclamation.