

APPENDIX Y – PALEONTOLOGICAL
RESOURCES

GEOLOGIC FORMATIONS CONTAINING SIGNIFICANT VERTEBRATE, INVERTEBRATE AND PLANT FOSSILS IN THE PLANNING AREA

Major Geologic Units	Probable Fossil Yield Classification (PFYQ) 1	Known Fossil Resources
Quaternary ² Alluvium		Shrub Ox
San Jose Formation ^{2 3}		Diverse early Eocene vertebrate fossils along the eastern margin of the SJB
Nacimiento Formation ²		Brachiopods; fish, crocodiles, turtles, various mammals, and temperate flora in central SJB, outside planning area
Animas Formation ^{2 3 4}	3	59 species of fossil plants, consisting of 3 ferns, 1 palm, 55 dicots; various vertebrates including Triceratops, Discoscaphites, and Sphenodiscus; abundant petrified wood; typical late-Paleocene mammalian fossils
Kirtland Shale ^{2 4}	5	Baculites; various vertebrates, invertebrates, and plants in western SJB
Fruitland Formation ^{2 4}	5	Baculites, vertebrates including dinosaurs; various vertebrates, invertebrates, and plants in western SJB
Pictured Cliffs Sandstone ^{2 4}	5	Ammonites, cephalopods, baculites, ophiomorpha burrows, palm fronds, leaf impressions, petrified and carbonized palm wood
Navajo Sandstone ⁴	3	Vertebrate and invertebrate tracks and traces
Chinle ^{3 4}	5	Vertebrate (fish) and Plants
Cutler ³		Vertebrate
Lewis Shale ²		Ammonites, baculites, partial skeleton of a mosasaur, Exiteloceras
Dolores Formation ^{3 4}	3	Flowering Plants
Mancos Shale ^{3 4}	2-3	Invertebrates (ammonites, oysters, brachiopods, clams, crayfish burrows), sharks, large marine reptiles, fish, dinosaurs, pollen, plants
Mesaverde Group,	3	Theropod dinosaur tracks, baculites, scaphites, Plants, dinosaurs, mammals, crocodilians, turtles, snails,

¹ Probable Fossil Yield Classification - (PFYQ) Developed by the Paleontology Center of Excellence and the R-2 Paleo Initiative, 1996. accessed 1/2007 <http://fsweb.wo.fs.fed.us/mgm/fspaleoclassification.htm>

² Adapted from: BLM et al. 2000, Carroll et al. 1999, Kues and Lucas 1987.

³ BLM Colorado Oil and Gas Leasing Draft Environmental Impact Statement. April, 1990.

⁴ Working Preliminary Draft West Wide Energy Corridor PEIS D-1 January 2007 & APPENDIX D: POTENTIAL FOSSIL YIELD CLASSIFICATIONS (PFYC) FOR GEOLOGIC FORMATIONS INTERSECTING PROPOSED CORRIDORS UNDER ALTERNATIVES 2 AND 3 (BY STATE)

undivided 2 3 4		oysters
Burro Canyon 3 4	3	plant and invertebrate,
Dakota Sandstone 3 4	5	Plant, dinosaur bones and tracks
Morrison Formation Brushy Basin Member Salt Wash Member 2 3 4	5	Dinosaurs, lizards, other reptiles, birds, mammals, amphibians, fish, invertebrates, plants
Cliff House Sandstone 2 4	5	Ammonites, crustaceans, clams, oysters, snails, starfish, sea urchins, shark teeth, amphibians, turtles, mosasaur, plesiosaur
Menefee Formation 2 4	5	Leaf impressions, palm fronds, conifers, reptile bones, fossil tree trunk
Point Lookout Sandstone 2 4	5	Worms, crustaceans, clams, ammonites, various animal tracks, driftwood

DESCRIPTION OF MAJOR FOSSIL-BEARING GEOLOGY FORMATIONS IN THE SAN JUAN PLANNING AREA

Dakota sandstone (Upper Cretaceous)

The Dakota sandstone consists of dominantly yellowish-brown to gray, quartzitic sandstone and conglomerate with subordinate thin, lenticular beds of gray claystone, impure coal, carbonaceous papery shale, and gray, friable, carbonaceous sandstone. Depositional environments are marine near the top and fluvial near the base. The Dakota sandstone and its fossils characterize the beach and nearshore sands associated with the initial stage of the encroaching Cretaceous epicontinental seaway.

Dinosaur tracks, *Tempskya* wood, wood impressions, coals, and invertebrate traces are the types of fossils known to be present in the Dakota sandstone.

Burro Canyon Formation (Lower Cretaceous)

The Burro Canyon Formation is composed of light-gray and light-brown, fluvial, quartzose sandstone and conglomerate in thick beds with lenticular, greenish-gray, locally purplish, siltstone, shale, and mudstone. The Burro Canyon Formation is a continuation of the basin fill atop the Morrison Formation, but with sediments derived from Sevier highlands in central Utah (Aubrey 1992).

Dinosaur bones and tracks, limonitic wood, seed pod, and leaf impressions are known in areas of the Four Corners region.

Morrison Formation (Upper Jurassic)

Dominantly fluvial, subordinately lacustrine, sandstone and mudstone alluvial deposits make up the Morrison formation. The Morrison Formation is a vast shallow-basin deposit that extends across nine western states. In the Four Corners region, the Morrison records the deposition of detritus derived from Jurassic Mogollan highlands of central Arizona. The coarser-grained lower members of the Morrison preserve remains of large river deposits with associated floodplain and shallow ponds and lakes. The Morrison Formation of the western U.S. is famous for its dinosaur fossils. Gymnosperm fossils are also known to occur. All of the four members of the Morrison formation are fossiliferous. The Brushy Basin member has been studied by Brigham Young University at a location on Horse Range Mesa site which contains dinosaur fossils.

The Brushy Basin member consists of variegated bentonitic lacustrine mudstone with a few lenses of chert-pebble conglomeratic sandstone, some of which contain uranium-vanadium deposits. Significant fossils include carnivorous dinosaurs like *Allosaurus*, sauropod dinosaurs including *Camarasaurus*, gastroliths (stomach stones), and petrified wood including *Hermanophyton* and *Xenoxylon*.

The Brushy Basin member and remaining members of the Morrison Formation generally contain dinosaur bones, petrified wood, and plant fossils in the Four Corners region.

Junction Creek sandstone (Upper Jurassic)

Pink or reddish-orange fine- to coarse-grained, poorly sorted eolian crossbedded sandstones make up the Junction Creek Sandstone. The Junction Creek sandstone, and the fossils it bears, records the sand dune deposits derived from winds off of the retreating Curtis Sea.

PROBABLE FOSSIL YIELD CLASSIFICATION DESCRIPTIONS - (PFYQ)

Developed by the Paleontology Center of Excellence and the R-2 Paleo Initiative, 1996.

Introduction

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 nonvertebrate fossils except in special circumstances. Therefore, this classification is based largely on how likely a geologic unit is to produce vertebrate fossils of terrestrial (i.e., non-marine) origin. The classes are described below, with some examples of corresponding management considerations or actions. Useful references are the Paleo resources Use and Management Action Spectrum (PUMA), Criteria for Scientific Significance - Specimen, Criteria for Sensitivity Ranking - Locality.

Note: 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.

PALEO CLASSES

Class 1

Description: Igneous and metamorphic (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 the rarest of circumstances.
- Igneous or metamorphic origin.

Example: Vishnu schist

Management examples:

- Paleo acres not weighted the Geology Resource Base Acres budget allocation criterion.
- No Class 1 paleo acres included in Geology Management Acres budget allocation criterion.
- Acres with this classification not included in paleontological reconnaissance work plans.

The land manager's concern for paleo resources on Class 1 acres is negligible. Ground-disturbing activities will not require mitigation except in rare circumstances. Plans do not need to address the range of potential uses or management options described in the

Paleo resources Use and Management Action Spectrum (PUMAS). Budgets do not need to allocate dollars for paleo-weighted geology acres. Much of the acreage of high altitude, mountainous districts will be determined Class 1.

Class 2

Description: Sedimentary geologic units that are not likely to contain vertebrate fossils nor scientifically significant nonvertebrate fossils.

Basis:

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

Example: Mancos shale

Management examples:

- Paleo acres not weighted in the Geology Resource Base Acres budget allocation criterion.
- Paleo acres *generally not* included in Geology Management Acres, but rare exceptions are likely to be scientifically significant and require some management prescription.
- Class 2 Paleo *generally not* included in paleontological reconnaissance work plans. There may be rare exceptions.

The land manager's concern for paleo resources on Class 2 acres is low. Ground-disturbing activities are not likely to require mitigation. Management alternatives should tend toward the middle of the PUMA (high access--low management), in all but exceptional cases. Recreational fee-based or user-based opportunities unlikely.

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 nonvertebrate 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: Chinle formation

Management examples:

1. Some Class 3 paleo acres may *be* weighted in the Geology Resource Base Acres budget allocation criterion.
2. Some Class 3 paleo acres may *be* included in Geology Management Acres budget allocation criterion and reported in MAR:
 - Opportunity areas - see below
 - Highly sensitive areas needing special protection (see Criteria for Sensitivity Ranking - Locality).
 - Areas actively being researched
3. Acres with this classification may *be* included in paleontological reconnaissance work plans, if this designation is made on the basis of criterion 3 above.
4. Fee -based and/or user based recreational opportunities possible.

The land manager's concern for paleo resources on Class 3 acres may extend across the entire PUMAS, with some areas requiring very little budget and management and providing high levels of unregulated access, while other areas may require annual budget allocations for intense management. Ground-disturbing activities will require sufficient mitigation to determine whether significant paleo 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. Recreational opportunities should be identified where appropriate and utilized under recreation fee authorities to produce revenues that can be applied to paleoresource management.

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 two 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 Morrison Fm.

Management examples:

1. Class 4 paleo acres *are* weighted in the Geology Resource Base Acres budget allocation criterion.
2. Some Class 4 paleo acres may *be* included in Geology Management Acres budget allocation criterion and reported in MAR:
 - Opportunity areas - see below
 - Highly sensitive areas needing special protection (see Criteria for Sensitivity Ranking - Locality)
 - Areas actively being researched
 - Paleo reports likely to be counted in Geology Reports MAR (permits, agreements, contracts, etc.)
 - Acres with this classification *should be* included in paleontological reconnaissance work.
 - Scientific and educational use likely. Paleo special use permits and challenge cost-share agreements likely.
 - Ongoing curation agreements with regional accredited museums recommended.
3. Fee-based and/or user-based recreational opportunities most likely.

The land manager's concern for paleo resources on Class 4 acres is toward management and away from unregulated access. Ground-disturbing activities will require mitigation to determine whether significant paleo 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 paleo acres are the most *likely to* yield appropriate recreational opportunities. These should be identified and optimized under recreation fee authorities. Class 4 paleo acres are the most likely to generate revenues that can be applied to managing highly sensitive Class 5 paleo resources.

Class 5

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

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.
- 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; vandalism).
- Other characteristics that increase the sensitivity of both known and unidentified fossil sites (see Criteria for Sensitivity Ranking - Locality).

Example: White River formation/group

Management examples:

1. Class 5 paleo acres *are* weighted in the Geology Resource Base Acres budget allocation criterion.
2. Some Class 5 paleo acres *may be* included in Geology Management Acres budget allocation criterion and reported in MAR:
 - Opportunity areas - see below
 - Highly sensitive areas needing special protection (see Criteria for Sensitivity Ranking--Locality)

- Areas actively being researched
- Paleo reports likely to be counted in Geology Reports MAR (permits, agreements, contracts, etc.)
- Paleontological reconnaissance work should focus only on poorly known areas of Class 5 acres because they are already considered a management priority.
- Scientific and education use highly likely. Highest number of paleo special use permits expected for Class 5 acres. Challenge Cost Share agreements with a broad spectrum of professional and avocational paleontologists expected.

3. Fee-based and/or user-based recreational opportunities possible.

Ongoing curation agreements with regional accredited museums recommended.

The land manager's highest concern for paleo 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 paleoresource 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 paleo acres 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. These should be identified and utilized under recreation fee authorities, but the delicate balance between opportunity and potential degradation of critical Class 5 Paleo resources must be recognized and addressed in planning for such use.

LOCALITY/SITE SENSITIVITY RANKINGS FOR FOSSIL RESOURCES

Paleontological sensitivity rankings are composite evaluations derived from individual consideration of the following factors. Sensitivity rankings apply to paleontological sites and localities, not to individual specimens.

1. *Scientific significance* of specimens associated with the site.
2. *Probability of yield* based on likelihood that geologic strata at the site are fossiliferous. This factor may be evaluated by direct reconnaissance or by consulting the pertinent literature; preferably both methods will be employed.
3. *Values* of an educational, interpretive, or recreational nature.

Public education, interpretive, and recreational values are those that utilize the power of fossil resources to provoke insight into ancient life ways and ancient ecology, and to reveal their connections to the present and future. Educational values also enhance a stewardship ethic towards legacy resources, and stress the importance of environmental and scientific literacy.

4. *Risk* of resource degradation at the site.

Risk factors include:

- Biotic agents: Vandalism, theft, destruction; grazing impact; trail-use impact.
- Abiotic agents: Chemical and mechanical destruction of fossils exposed by erosion; landslides; inundation; fluvial transport; etc.

Each factor above should be ranked individually on a scale of 1 to 5, where 1 is the lowest sensitivity ranking and 5 the highest. The composite ranking of sensitivity for a locality or site is the arithmetic mean of the individual rankings.

Example 1

A "category: vertebrate" site is identified in rocks of the Orellan Land Mammal "Age" on the Pawnee National Grassland.

Scientific significance ranking = 5.

See Scientific significance criteria below. Specimen-based criterion 3 is met. Criteria 1, 2, and 3 are likely to be met by many specimens in this geologic formation. Context-based criterion 2 is met--the mammalian fauna of the Pawnee NG is critically important for constraining age correlations in the Orellan.

Probability of yield ranking = 4.

The formation is known to be fossiliferous. Mammal fossils are likely to be found following erosional events.

Values ranking = 4.

The mammalian fauna of the Orellan in the Western Interior is informative to questions of paleoecology and biogeography. Interpretive materials that utilize this paleontological resource would be good examples of the way scientists interpret ancient ecosystems, and how that information can be applied to modern-day problems of global change.

Risk factor ranking = 5.

Biotic agents: Significant and sensitive sites are located near or on trails. These trails are advertised in area guides as "good places to pick up fossils."

Abiotic agents: Sites are located in geologic strata that erode very easily and rapidly, especially during the spring and early summer. Fossils may be easily washed out of their informative context, or removed altogether and re-buried downstream by ephemeral flows.

Composite ranking: $5 + 4 + 4 + 5 = 18$; divide by 4 = 4.5 sensitivity ranking for this site.

Appropriate management strategies for this site would include designation as a Research Natural Area. Allowable activities on an opportunity spectrum would include research by qualified investigators, technical educational field work by non-specialists overseen by qualified technicians, guided interpretive tours for the public.

Example 2

A "category vertebrate site" is identified in Cretaceous marine rocks on the Buffalo Gap National Grasslands.

Scientific significance ranking = 1.

The only identified fossils at and near the site are shark teeth and an occasional fish vertebra.

Probability of yield ranking = 5.

Shark teeth are exceedingly abundant, and in places form a deflation surface.

Values ranking = 2.

The recreational public is likely to enjoy picking up shark teeth in this area, and to consider the past environment in which they were deposited – without interpretive aids. The area does not lend itself to formal interpretive displays or activities.

Risk factor ranking = 2.

Biotic agents: The likelihood that sufficient collecting by the general public will deplete the supply of shark teeth is low for the foreseeable future; however, the possibility that other, more significant fossils will be found and carried away exists and cannot be easily monitored. The area is heavily grazed, but the fossils are fairly evenly distributed on the landscape, so areas where cattle do not congregate are fairly free of impact.

Abiotic agents: The outcrop area is low, flat-lying, and heavily vegetated, so the chances that erosion, landslides, floods, or flash floods will threaten the fossil resource is low.

Composite ranking = $1 + 5 + 3 + 2 = 10$; divide by 4 = 2.5 sensitivity ranking for this site.

Appropriate management strategies for this site would be: No permit required for picking up shark teeth; mention in a Forest/district brochure on paleontological resources as an educational and interpretive tool to promote understanding of represented ancient environment; request that the public report any unusual fossil finds; occasional reconnaissance to determine if collecting of shark teeth is threatening other resources in the area or affecting the scenic and aesthetic values of the site.

SCIENTIFIC SIGNIFICANCE CRITERIA FOR FOSSIL RESOURCES

(drafted by the Paleontology Advisory Group July 2000)

Scientific significance may be attributed to a fossil specimen or trace, and/or to its context (e.g., location in time and space; association with other relevant evidence; or association with cultural resources).

The scientific significance of a paleontological specimen or trace, and/or its context is determined by meeting any one of the following criteria:

- **Specimen-based criteria:**
 - Represents an unknown or undescribed/unnamed taxon.
 - Represents a rare taxon, or rare morphological/ anatomical element or feature. The "rareness" criterion comprises either absolute rareness in the fossil record, or relative or contextual rareness as described below.
 - Represents a vertebrate taxon.
 - Exhibits an exceptional type and/or quality of preservation.
 - Exhibits remarkable or anomalous morphological/anatomical character(s) or taphonomic alteration.
 - Represents "soft tissue" preservation or presence.
 - Exhibits cultural affiliation, e.g., alteration or use by ancient man.
- **Context-based criteria:**
 - Is associated in a relevant way with other evidence of scientific interest, providing taphonomic, ecologic, environmental, behavioral, cultural or evolutionary information.
 - Is evidence that extends and/or constrains the stratigraphic, chronologic and/or geographic range of a taxon or functional paraphyletic group.

PALEONTOLOGICAL SURVEY PROCESS

Once a ground-disturbing project is identified to take place and during the NEPA process, a series of steps is taken to determine if paleontological resources will be impacted and what process will be needed for mitigation:

Step 1. Determine if the area to be disturbed will impact paleontological resources:

- Each unit will determine if the project area contains fossils by consulting the maps delineating the geologic formation classifications.
- If the formation is Class 1, fossils are not likely to be discovered; document in NEPA project file.
- If the formation is Class 2, significant fossils are not likely to be discovered; notify the Forest Service Paleontologist and proceed with Step 2.
- If the formation is Class 3-5, significant fossils will likely be discovered; notify the Forest Service paleontologist and proceed with Steps 2-5.

Step 2. The Forest Service paleontologist will conduct a literature search of paleontological information for the project area, including material that may be contained in permitting documents, scientific literature, geological maps, libraries, and museums. This information will become part of the NEPA project file. Surveying will not be required when no scientifically important specimens or sites are discovered in the literature. Go to Step 3 if the literature review indicates scientifically important fossils may be impacted.

Step 3. Forest Service paleontologist and/or qualified consultant will conduct a pedestrian survey of proposed project area and document findings. If paleontological sites are discovered then go to Step 4. If survey reveals no surface indication of fossils, then document in the NEPA project file.

Step 4. The Forest Service paleontologist or qualified consultant will determine the sensitivity ranking for the sites to be impacted. (A Class 5 geologic formation may contain sites of low sensitivity.) The paleontologist on site will have to make this determination based on professional judgement and according to the process outlined in the sensitivity ranking.

Step 5. In sites with Class 3, 4, or 5 and a high sensitivity ranking, a Forest Service paleontologist shall develop a protection and mitigation plan prior to project initiation and periodically monitor for compliance with the mitigation plan throughout the project

Note: Units with formations ranked as Classes 3-5 should have repository agreements in place with agencies or institutions collecting fossils as part of mitigation in order for the fossils to be cared for in perpetuity.