

APPENDIX J PALEONTOLOGY

Probable Fossil Yield Classification - (PFYC)

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. The classes are described below, with some examples of corresponding management considerations or actions. Useful references are the Paleoresources 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 (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: 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 paleoresources on Class 1 acres is negligible. Ground-disturbing activities will not require mitigation except in rare circumstances. 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 or 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 paleoresources 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 paleoresources 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 paleoresources 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 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 Morrison Formation.

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
 - 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 paleoresources on Class 4 acres is toward management and away from unregulated access. Ground-disturbing activities will require mitigation to determine whether significant paleoresources 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 paleoresources.

Class 5

Description: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant nonvertebrate (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.
- 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 (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
 - 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 paleoresources 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 paleoresources must be recognized and addressed in planning for such use.

Predictive Modeling and the Designation of Paleo Classes

The Rocky Mountain Region of the Forest Service is currently experimenting with the PFYC in partnership with the University of Wyoming and Bureau of Land Management. The model that develops out of this experiment will predict where paleoresource management and dollars should be concentrated in the Northern Great Plains. Paleo classes are assigned to geologic units in the Northern Great Plains Planning area on the basis of empirical data gathered through on-line searches of the GeoRef Geological Database. Classes are recommended by the investigator based on the number of "hits" produced by search strings optimized to capture most references to

vertebrate fossils in the key unit being investigated. Calibration of the parameters employed will be preliminary and probably subject to continuous refinement as designated classes are validated through actual paleoresource management. This method does not allow designation of Class 4 Paleo acres, because in most cases the physical characteristics of the surficial outcrop will not be known from the literature alone. Therefore, these units will by default be designated as Class 5, until other methods allow separation of Class 4 units or areas on units. Other methods would include aerial reconnaissance, interpretation of remote-sensed data, and on-the-ground field reconnaissance.

The Fossil Yield Potential Classification is a tool developed for the Forest Service by the Paleontology Center of Excellence and funded by the Paleo Initiative, as is paleontological assessment of the Northern Great Plains Planning area which will be the first test of the FYPC.

The management examples and narrative recommendations are not to be considered directives, or standards and guidelines for planning purposes. They are informal guidelines to supplement policies, regulations, and directions in draft for the national paleontology program. These guidelines are not exhaustive; many other factors are considered in management decisions.

The criteria given as the basis for classification are not exhaustive either. They are designed to guide the outside expert who may be recommending classification as part of a partnership, contract, or permit. Final designations will be made by the reviewing Forest Service paleontologist or one of our qualified colleagues from another Federal agency. Designations are not final and are expected to change as we gain understanding about the paleoresources of National Forests and Grasslands.

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 lifeways 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.

1. 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.

2. Probability of Yield ranking = **4**.

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

3. 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.

4. 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 NG.

1. Scientific Significance ranking = **1**.

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

2. Probability of Yield ranking = **5**.

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

3. 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.

4. 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.

5. 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.

Significance Criteria for Paleontological Resources -- Vertebrate, Invertebrate, and Plant Fossils, including Ichnofossils

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 are 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 that may be contained in permitting documents, scientific literature, geological maps, libraries, and museums. This information will become 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 judgment 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.