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Partners in Paleontology
Proceedings of the Fourth Conference on Fossil Resources

Margaret Johnston and James McChristal, Editors

Natural Resources Report NPS/NRFLFO/NRR-97/01

United States Department of the Interior ● National Park Service
Florissant Fossil Beds National Monument

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Cover art from a poster by Charles Harper

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May 23, 1997

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Memorandum

To: Director, Technical Information Center, Denver Service Center

From: Writer-Editor, Natural Resource Information Division, Natural Resource Program Center

Subject: Announcement of New Technical Report and Instructions for Placing Additional Orders

Enclosed are three copies of the 249-page Natural Resources Report entitled *Partners in Paleontology: Proceedings of the Fourth Conference on Fossil Resources* for your collection.

Enclosures

Partners in Paleontology
Proceedings of the Fourth Conference on Fossil Resources

OCTOBER 31 - NOVEMBER 4, 1994
COLORADO SPRINGS, COLORADO

Compiled and edited by

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Natural Resources Report NPS/NRFLFO/NRR-97/01
March 1997

United States Department of the Interior
National Park Service
Natural Resource Program Center
Natural Resource Information Division
Denver, Colorado

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INTRODUCTION

About the conference

The wealth of fossil resources on public lands is matched by the wealth of creative people working with those resources. The Partners in Paleontology conference brought together public agencies and private organizations on issues related to the management, research, and protection of fossil resources. Almost 200 participants at the week long conference included managers, researchers and scientists, educators and interpreters, law enforcement and resource management specialists, museum professionals, and paraprofessional volunteers. The common thread uniting this diverse group was the recognition that issues concerning fossil resources on public lands extend beyond the boundaries of any specific agency or institution.

The 1994 conference was the fourth in a series initiated by the National Park Service. Florissant Fossil Beds National Monument hosted the meeting in Colorado Springs, Colorado, as part of its twenty-fifth anniversary celebration. Two other Department of Interior agencies, the Canon City District of the Bureau of Land Management and the US Geological Survey in Denver, joined the National Park Service as conference sponsors. The volunteer organizations, Friends of Florissant Fossil Beds and Garden Park Paleontology Society, were significant contributors. The Department of Agriculture US Forest Service, the Colorado State Natural Areas Program, and the City of Colorado Springs Parks and Recreation Department rounded out the conference sponsors.

Previous National Park Service fossil conferences were held at Dinosaur National Monument in 1986; Petrified Forest National Park in 1988; and Fossil Butte National Monument in 1992.

The theme of partnerships underscored the importance of cooperation in preserving America's fossil heritage through expanding scientific knowledge and developing strategies for protection. Presentations illustrated the depth and scope of work being done in the areas of research, education, curation, law enforcement, and information management. Viewpoints were debated on the different levels of protection needed for vertebrate fossils as compared with those of invertebrates and paleoflora. Compelling interpretive and educational programs suggested creative ways to make science accessible and relevant to the public. Computerized approaches to collection management and paleontological data bases demonstrated how paleontology can travel the "information superhighway." A nuts and bolts discussion of partnerships emphasized how public and private organizations can work together to accomplish mutual goals. Field trips to the Picketwire Dinosaur Trackway (USFS); Dinosaur Ridge/Denver Museum of Natural History; and Florissant Fossil Beds (NPS)/Garden Park Fossil Area (BLM) provided a first hand look at management issues affecting fossil resources in southeast Colorado.

Speakers at the plenary sessions repeated the themes of resource protection, partnerships, and research. Dr. Richard Stucky, Denver Museum of Natural History, spoke on the significance of conducting research on public land. Elizabeth Estill, US Forest Service, stressed the need to garner public support for fossil resources. At the conference banquet, John Wesley Powell, reincarnated by actor Earll Kingston, thrilled the audience with his adventures and challenged them with his vision of the role of government in managing national resources in the West.

Aknowlegements
To organize the Fourth Conference on Fossil Resources, real partnerships were created between government agencies, private organizations, and individuals. Members of the planning committee included: Dale Ditmanson, Margaret Johnston, and Herb Meyer at Florissant Fossil Beds National Monument; Harley Armstrong and Dan Grenard with the Bureau of Land Management; Thomas Woody Henry with the US Geological Survey; Marsha Kearney of the Pike & San Isabel National Forests; Jim Von Loh from the Colorado Natural Areas Program; Pat Monoco and Donna Engard with the Garden Park Paleontology Society; and Emmett Evanoff of the University of Colorado Museum. Help with conference logistics and registration from Ronnie Walls, Dave Dunatchik, Sheryl Sether, Vickie McCullough, Paula Evans, Jane Claudfelter, and Eadie Gorsline was invaluable. Finally, it would not have been possible to pull off this multi-agency effort without the cooperation of the Rocky Mountain Nature Association.

About the publication
Conference speakers were invited to submit papers for a post conference publication, which might be said to represent the state of paleontology on public lands at that time. Much has changed since the 1994 conference. Landmark court decisions have been reached, significant research concluded, and several agencies have undergone major reorganization due to government streamlining efforts. At the end of the 1994 conference, enthusiasm for future multi-agency meetings was high. We hope this publication will serve to remind readers of the value of sharing ideas, resources, and knowlege.

Where papers were not available, abstracts of the presentations were taken from the conference schedule. Field trip handouts can be found in the appendix. Some papers, such as those from the USGS, were subject to in-house review. We appreciate the efforts of Herb Meyer and Thomas Woody Henry to review the entire publication. Many people were involved in getting this document ready for printing. We would like to thank Leona Bowersox, Emmett Evanoff, Doris Kneuer, Donna O'Leary, Laurie Robinson, Sheryl Sether and Jeff Selleck for their help.

Addendum to USGS Papers
After the Partners in Paleontology conference, the Geologic Division of the US Geological Survey (USGS) underwent significant reorganization. All of the Branches within that Division were abolished and incorporated into new organizational groups called "Teams." Effective October 1995, most of the personal of the former Branch of Paleontology and Stratigraphy were reassigned to three Teams: National Geologic Mapping, Paleoclimate, and Energy Resources. Many of the professional paleontologists from the former Branch of Paleontology and Stratigraphy who retired have remained at the USGS as scientists emeritus or science volunteers and are available to assist with questions about fossils.

USGS fossil collections remain the jurisdiction of the USGS and are under the supervision of the Chief Paleontologist (see below). With the exception of the remaining macro plant and vertebrate collections, which were accessioned to the Smithsonian in the summer of 1996, the other USGS fossil collections remain in the regional centers described in the papers by Thomas W. Henry and John Pojeta, Jr., in this volume. Ultimate control of these collections is in the domain of the National Museum of Natural History, Smithsonian Institution. Questions regarding the disposition of, databases for, and access to these collections should be directed to:

Bruce R. Wardlaw, Chief Paleontologist
US Geological Survey
National Center, Mail Stop 959
12201 Sunrise Valley Drive
Reston, VA 22092

PAPERS

Assessing and Documenting Earthquake Damage to the Museum Collection of Fossil Butte National Monument with Suggestions for Preventative Measures

Peter D. Ambrose, Park Paleontologist, National Park Service, Fossil Butte National Monument, PO Box 592, Kemmerer, WY 83101

No state in the U.S. is immune to the effects of earthquakes within its borders or those of nearby states (Hensley, 1987). Such events, even of moderate or minor magnitude, can have devastating effects on fossil collections. At 0205 on 3 February 1994, an earthquake measuring 5.8 on the Richter Scale occurred approximately 90 miles northeast of Fossil Butte National Monument, 10 miles west of Afton, Wyoming.

Fossil Butte National Monument is in the state of Wyoming, county of Lincoln, about 10 miles west of Kemmerer on Highway 30 at an elevation of 7000 to 8000 feet. The general landscape is characterized as high, cold desert. The monument itself is located within an intermontane basin in which considerable deposits of the Green River Formation are located.

Recognizing the scientific importance of this area, Fossil Butte National Monument was established "to preserve for the benefit and enjoyment of present and future generations outstanding paleontological sites and related geological phenomena, and to provide for the display and interpretation of scientific specimens..." (Public Law 92-537).

A total of 1409 natural history and 1841 cultural items (mostly photographs) are currently under the curation of Fossil Butte National Monument personnel. The bulk of the natural history items comprise an extensive collection of Eocene Fossil Lake vertebrate, invertebrate, and plant fossils, including portions of the historic McGrew collection on loan from the University of Wyoming.

Sixty-three of the natural history items are on display in the visitor center, 308 are on loan to other institutions or elsewhere, and the remaining 1038 are stored in the museum collection. Six of the cultural items are on display in the Monument's visitor center; nine are on loan to other institutions; the remainder are stored in the museum collection. The storage area for the collection is a 3 x 4 meter room within the maintenance building of the Monument, approximately 2.4 kilometers southwest of the visitor center. Within the storage area, eight single door "Lane"-style cabinets are stacked two high along the west wall. Two double door cabinets are stacked on the east wall between a 2.5 meter high wooden storage shelf (for heavy, bulky or large items unable to fit in the storage cabinets) and a wardrobe-style cabinet used as an herbarium and storage for photographic cultural resources. The storage room and cabinets within are locked when not in use.

Following the 3 February quake the Monument Interpreter inspected the curatorial storage room for damage to the collection. She noted that 30 fossils were cracked or broken. She also noted that pieces had also moved around within the cabinet drawers. No damage was noted to specimens on display in the visitor center, or to any cultural resources, or non-fossil natural resources such as natural history specimens.

Of the 30 damaged fossils, only three were within appropriately sized specimen trays, cavity-packed with plastic foam cut to conform to the shape of the fossil. Twelve of the damaged specimens were located in the single door, double stacked specimen cabinets; seven in upper cabinets, five in lower cabinets. A total of seven different single door cabinets contained damaged fossils. The remainder of the damaged material was located in the lower of the two double door storage cabinets. That no damage was sustained in the upper of these cabinets appears to be more a function of the nature of the specimens stored within each rather than any difference in storage between the two.

The lower cabinet contains large (up to 0.75 x 0.5 meter) thin (less than one centimeter) limestone slabs containing fish fossils in degrees of preparation ranging from good to unprepared. This material was collected by P. O. McGrew in the region prior to the establishment of the Monument, and is curated at Fossil Butte National Monument at the pleasure of the University of Wyoming. A number of these slabs are mounted on 3/4 inch plywood sheets roughly conforming to the shape of the specimen itself. Although the specimens were not cavity-packed, the drawers were lined with foam pads.

Photographs were made of the damage in order to have adequate documentation, determine how the damage was sustained, and assist in developing measures to safeguard the collection during future seismic events. In the course of photodocumentation, an examination was made of each specimen, as well as the drawer in which it was located. Based upon these observations, it is apparent that the specimens shifted about within the cabinets during the seismic event. Small pieces of sediment were crumbled or powdered against drawer sides, suggesting the specimen was moved with sufficient force to not only come in contact with the drawer side, but to break off some of the material. One specimen, although cavity-packed within a specimen tray, sustained damage when the tray itself slid about within the drawer.

In the double wide cabinets, some damage from sliding was observed, but other damage was apparently the result of the nature of the specimens and the design of the cabinet itself. In testing the flexibility/rigidity of the cabinet drawers, it was found that by shaking a drawer in one of the double wide cabinets, a wave could be sent across the thin sheet metal bottom, bouncing the object placed in the drawer. Although no specimens were subjected to shaking sufficient to damage them, it is reasonable to conclude that the shaking attendant to an earthquake could damage fossils, particularly thin, rigid slabs of limestone mounted on more flexible pieces of plywood.

During the 17 January 1994 Northridge earthquake, a small number of specimens were damaged within storage cabinets in the vertebrate fossil collection of the Los Angeles County Museum of Natural History. This damage was sustained when some larger pieces shifted in the drawers and broke. These pieces were not cavity-packed. Cavity-packed items apparently sustained no damage, although stacked storage cabinets did shift about, creating "S"-shaped vertical stacks. When the Southern California Lander quake struck on 27 June 1992, a large section of the storage racks of the George C. Page Museum (La Brea Tar Pits) ossuary collapsed, burying thousands of fossils in metal drawers and shelving. Remarkably only a handful of fossils were damaged. In both cases, a strong argument can be made for permanently fixing storage cabinets and shelving to walls and flooring. Such remedial action was taken at both facilities subsequent to the seismic events described.

Although the storage cabinets at Fossil Butte National Monument apparently underwent little or no observable shifting (quake magnitude was significantly smaller than either recent California quake), it is strongly recommended that shelving and storage cabinets be affixed to walls with screws (Reitherman, 1984). One must ensure that screws are affixed to wall studs or that expansion bolts are used in concrete and masonry. If not adjacent to a wall, attach the storage item to the floor. It is important to note that vibration will still occur within these fixed objects, but they will not be jolted about and will flex with building walls and floors.

Within the cabinets themselves, cavity-packing and minimizing any lateral or vertical movement of fossil specimens appear to be the best defense against the type of earthquake damage noted at Fossil Butte National Monument. All fossil specimens should be cavity-packed in a specimen tray (when possible) to minimize movement. If the specimen is too large for a tray, the item can be cavity-packed within the drawer itself, stacking pads of foam one atop the other, or securing foam of adequate thickness to encase the fossil specimen. If cavity packing fails to minimize possible vertical movement of the fossil (bouncing out of the cavity), additional layers of foam can be sandwiched over the specimen - provided it will not damage protruding surfaces or details - and loosely secured with bias tape. As an additional precaution, foam may be laid over the entire drawer contents, effectively "bedding" the specimens. It is important to note that if fossils are sandwiched, identification of the fossil and its location within the "sandwich" should be noted on the outer layer of foam, e.g., FOBU 1081 - 2 LAYERS IN.

Specimen trays should be packed as tightly as possible within a drawer to minimize lateral and vertical movement. Empty trays can be employed upside down as filler, as well as remnants of foam not used in cavity-packing. **All** drawers should be lined with foam padding. Snugly packing drawers, particularly double wides, will reduce the range of vibration through the bottom of the drawer itself.

Although California is regarded as the most earthquake-prone of all the contiguous 48 states, seismic events can take place virtually anywhere in the U.S. Some areas are less likely than others to suffer significant damage from quakes, but all organizations having responsibility for the display and storage of scientific or cultural collections should provide for such eventualities in order to prevent damage to irreplaceable items. The suggestions outlined herein are modest, both in cost and person-hours when measured against the damage even a small, rare earthquake can inflict on an unprotected fossil collection, and the hours required for repair of damaged specimens.

References

Grande, L. 1984, Paleontology of the Green River Formation, with a review of the fish fauna, The Geological Survey of Wyoming, Laramie, Wyoming.

Hensley, J. R. 1987, Safeguarding museum collections from the effects of earthquakes, Curator 30:199-205.

Reitherman, R. 1984, Protection of museum contents from earthquakes, The J. Paul Getty Museum Symposium on Protection of Art Objects From Damage By Earthquakes: What Can Be Done? Santa Monica, California.

The Power of Partnerships

Arden Anderson, Bureau of Land Management, Gunnison Resource Area, 216 N. Colorado St., Gunnison, CO 81230

As our budgets shrink and our workloads increase, public resource management agencies are relying more and more on partnerships to get the job done. The purpose of this presentation is to discuss the essential principles for developing and maintaining successful partnerships.

What is a Partnership?

1. For our purposes, a **Partnership** is a cooperative venture between two or more parties with goals that lead them in a common direction. These partners combine complementary resources to carry out appropriate actions on a mutually beneficial project.

2. They can be simple or complex. Anyone in the organization can initiate them. They need to be win-win situations. They are not new; we are just expanding their role.

Why Develop Them? The Advantages of Partnerships

For the Agency
- Expand our capabilities, money, resources and staffing.
- Help create or reinforce a positive image of the agency.
- Increase public understanding and involvement with the agency.
- Increase the public's sense of ownership and stewardship.
- Helps identify issues important to the public.
- Helps us achieve education and outreach.
- Helps with conflict resolution.
- Helps us tap into funds that are otherwise unavailable.

For Our Partners
- Makes them feel more involved with their public lands.
- Gives them more visibility and a positive public image.
- Provides tax deductions for some partners.
- Offers an opportunity to learn about and enjoy public lands.

The Dark Side - Obstacles to Partnerships

- Requires us to step out of traditional mind set - not always easy.
- Time and effort are required to make partnerships work.
- The administrative process is not always clear.
- There is a lack of clear guidelines on what we can and can't do.
- We sometimes encounter unrealistic expectations in our partners.
- There is the potential for conflict of interest or ethics problems.
- Playing fast and loose can result in more restrictions, which hurts us all.

By recognizing these obstacles we are more likely to avoid them.

Building and Maintaining Successful Partnerships

Planning
Define your goals and objectives. This important first step helps you be proactive by thinking through exactly what it is you need to get done. This helps keep you from wasting your time on partnerships that meet other's needs but not your own. It also helps focus on high priority projects rather than low priority ones. Be sure you are consistent with your agency's land use plans and policy.

Identify your possible partners. Be creative and think of all the people, groups, businesses and agencies who might have an interest in the project you have in mind. Focus particularly on groups that have worked with you in the past, but don't be afraid to expand your horizons. Review existing Cooperative Agreements and MOU's. Assess the political and public image risk. Talk to these folks and see if they are willing to work with you on mutually beneficial goals.

Coordination
Select and involve your partners. After your preliminary inquiries to potential partners you need to sit down and discuss the project in detail. Deal with

the appropriate level of the group; preferably the one closest to the ground. Understand what their motivations are, what they have to offer and what they hope to get out of the partnership. Come up with a work group that can help you get the job done with the least amount of effort.

Develop a common mission. Make sure everyone understands what the goals, objectives, tasks, and products are. As you come to understand your partners, your goals and objectives may evolve to accommodate them. Be flexible, but not so flexible that you lose sight of your priorities. Make sure your common mission is realistic and rewarding.

Recognize and discuss your constraints. This is necessary for defining the scope of your project, even if it causes some partners to back out. It is better to know these things up front rather than half way through a project. Make sure everyone's expectations are clear.

Operations and Implementation
Establish an action plan that includes time frames and a budget. This gives everyone a view of the **big picture**. Break the project down into bite sized pieces. Set realistic time frames based on each partner's constraints. Figure your budget with a bit of leeway. Things always cost more than you think.

Clearly define roles and responsibilities for all involved. What is needed for the project and who will provide it? Consider the limits identified earlier and make sure the roles you assign are realistic.

Obtain your funding. If you rely on agency funding, be sure you allow enough time to program funding in your budget system. Explore creative funding opportunities such as cost share agreements, grants, and donations. If you are getting funds from others, be sure to understand what strings are attached. Maintain your integrity in this process. Few things in the government will get you into trouble quicker than playing fast and loose with tax dollars.

- Use the Appropriate Administrative Tool.

- No Money Changing Hands. Memorandum of Understanding.

- Money or Services Go From One Federal Agency to Another: Interagency Agreement/Intraagency Agreement

- Money Goes From the Government to an Outside Entity: Cooperative Agreement, Challenge Cost Share Agreement, Grants, Procurement Contract, Requisition.

- Money Goes From an Outside Entity to the Government: Donation or Contribution -Form 41200-9; Reimbursable Work Authorization - Form 1681-3 Note: Be aware of the 18% Administrative Charge for these tools.

- Money May or May Not Change Hands: Volunteer Agreement; Temporary Use Permit

- Complete other supporting documentation. This will include NEPA documentation, archeological clearances, threatened & endangered species clearances, internal and external review, procurement documentation, etc.

Do it!!!

Keeping the Partnership Alive

Communication
This is essential throughout all phases of the partnership. It gives your partners a feeling of really being involved in the project and keeps everyone informed on what is going on.

Follow Up and Evaluation
Once the project has been completed, check back with your partners to see what they thought. What went well? What could have been improved? Is there any interest in working together on future projects? Be sure the lessons learned here are carried over into the next effort.

Consistent and Appropriate Recognition
This will change for each partner. For some a handshake and a thank you will be enough. Others may require something else. Consider what you discovered earlier about the motivations of your partners and try to tailor your recognition to those needs. In almost all cases get the media involved so everyone can see the good work you and your partners are doing together.

Comparison of Various Paleontology Teaching Kits

Harley J. Armstrong, Paleontologist, Bureau of Land Management, Grand Junction District Office, 2815 H Road, Grand Junction, CO 81506

One good way to teach paleontology is through the use of hands-on teaching kits. Land managers, both individually and through partnerships, are increasingly making use of teaching kits for educating the public about paleontological resources management.

The United States Geological Survey for years has demonstrated the science of paleontology through several teaching kits originally developed by **Tom Hanley** and **Bob O'Donnell. Suzanne Powers** of the USGS is also currently making use of teaching kits in paleontological education.

Gennie Mast and **Marsha Barber** of the Colorado School of Mines Museum, and various other museums have used teaching kits developed for trained docent and school programs. It is hoped that some of these teaching kits will be brought for comparison with teaching kits developed by the USGS and by other agencies managing paleontological resources.

Laurie Bryant and **Harley Armstrong** of the Bureau of Land Management are developing paleontological teaching kits that can be checked out by the public for use in schools and with various groups with interests in paleontology and the BLM Paleontological Resources Management Program. These kits will have a BLM paleontological resources management theme and include slides, brochures, and various hands-on types of objects such as fossils, casts, maps, charts, and models.

"Tree Trunks," kits with various land management program themes, have been successfully developed by **Frogard Ryan** and **Wendy Ahrendsen** of the US Forest Service, and have been used in partnership with other agencies and groups. Thoughts for a paleontological theme trunk are in the works.

Gwen Pratt, with the Beidleman Environmental Center in Colorado Springs, has developed successful teaching kits. Her kits teach children and other groups about dinosaurs and other fossils.

Teaching kits brought to the conference will be explained by an agency representative, and participants will be able to compare the kits by close examination. It is hoped this paleo kit rendezvous will spark ideas for more partnerships and the sharing of ideas in our common educational goals.

Conducting Research on Public Lands: Working With Agencies

Moderator
Harley J. Armstrong, Paleontologist, Bureau of Land Management, Grand Junction District Office, 2815 H Road, Grand Junction, CO 81506

Panel Members
Invertebrates: Emmett Evanoff, Research Associate and Instructor, University of Colorado Museum, Campus Box 315, Boulder, CO 80309

Plants: Kirk Johnson, Curator of Paleontology, Denver Museum of Natural History, 2001 Colorado Blvd., Denver, CO 80205

Vertebrates: Hannan E. LaGarry, Division of Vertebrate Paleontology, University of Nebraska State Museum, W436 Nebraska Hall, Lincoln, NE 68588-0549

Paleontologists conducting research within the United States of America must often work directly with landowners and/or public land management agencies. Prior to beginning work, legal requirements aside, common courtesy should demand that paleontologists seek permission from land owners, public or private. Permission for legally collecting vertebrate, and scientifically important invertebrate and plant fossils, usually entails obtaining a permit for federal, state, and local government managed lands.

The panel has experience in conducting paleontological research on lands managed by various agencies in many states. Observations on their experiences with different agency permitting systems ranges from positive and useful to negative, with a perception of needless paperwork.

Vertebrate fossils are considered rare, and permits for their collection are required by most agencies. In order to obtain a permit, an applicant must demonstrate or show evidence of having the proper knowledge, skills, and experience to conduct the research, and must have an agency approved repository at which to curate the collected fossils and associated data. In some cases, and in some agencies, collecting of vertebrate fossils may entail even further considerations if located on lands with special management status, such as in a Wilderness Study Area. A proposed research project may have to fit an overall resource management plan, and/or a special quarry plan or research design.

Invertebrate fossils on some agency managed lands may be collected by hobbyists and the general public. In some cases, invertebrate fossils considered of special scientific importance, and/or invertebrate fossils located on lands with special management designations may be collected by permit only. Again, collection of such specially protected invertebrate fossils may be subject to research applicability to an overall resource management plan, and/or a special quarry plan or research design.

Paleobotanical (plant) fossils are treated much like invertebrate fossils. Some agencies protect all plant fossils from private collecting, allowing such work to be done only scientifically and under permit. Agencies such as the USDA Forest Service and the DOI Bureau of Land Management currently allow the limited collection of fossil wood.

Under the current system, with all the differing agency approaches occurring over the years, what should the objectives of paleontological resource management be? Are the needs of both land managers and researchers being met? What is needed to meet these objectives?

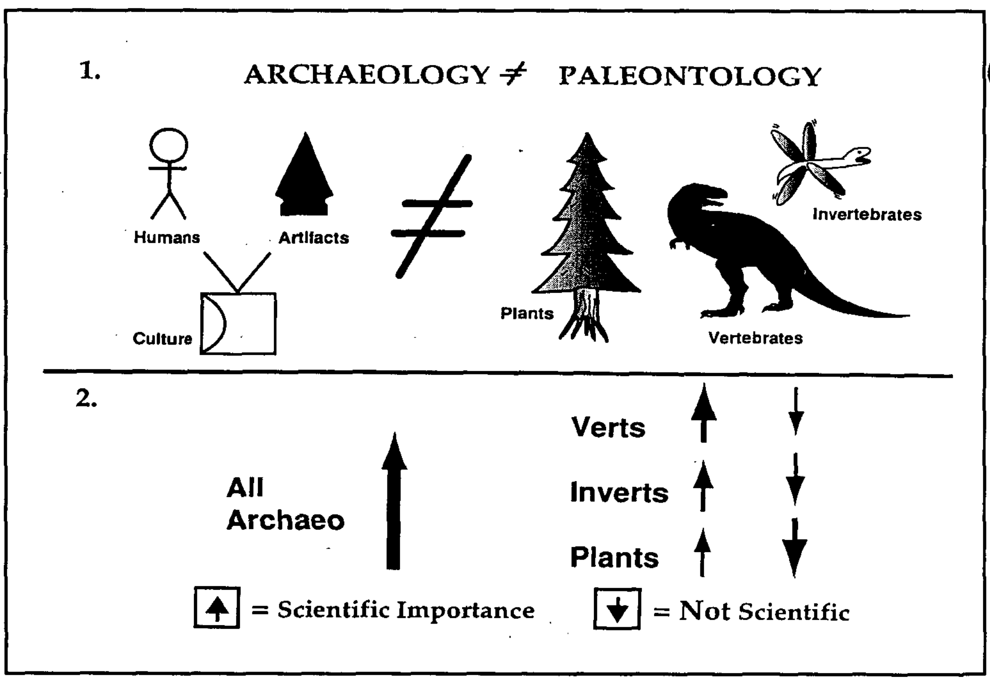
How Paleontology is Not Archaeology

Harley J. Armstrong, Paleontologist, Bureau of Land Management, Grand Junction District Office, 2815 H Road, Grand Junction, CO 81506

Garth Portillo, Archaeologist, Bureau of Land Management, Utah State Office, PO Box 45115, Salt Lake City, UT 84145-0155

1. **Archaeology and Paleontology are different disciplines.**
Archaeological (cultural) resources contain evidence of humans interacting with the environment through their culture. Paleontological resources contain physical evidence of past animal and/or plant life forms. Cultural resources are intrusive into the natural substrate, while paleontological resources are naturally deposited as part of the substrate.

2. **Vertebrate and certain other fossils are educational and scientifically important.**
All archaeological materials are considered important, and collections are curated in BLM approved repositories for the public good. Vertebrate fossils by definition are rare and/or scientific. Non-common invertebrate fossils and some fossil plants are also of scientific value. Their use is educational. Collected scientific fossils are housed in BLM approved repositories, and are available to the public through exhibits, research, and other educational endeavors.



3. **Paleontology is important.**
Observations of life forms in past ecosystems gives society a perspective on conditions that form the present ecosystem. The study of paleontology gives us depth in understanding extinction events as well as the hardiness of some species under adverse conditions. Humans adapt culturally to environmental stresses, while other life forms either deal with survival in terms of evolutionary change, or face extinction. Artifacts and associated remains are the material culture used to study archaeology. Fossils are the physical evidence of past life and are used to study paleontology. The fossil record entails fossils and evidence of their paleoenvironments as preserved in geologic layers. Through erosion, new fossils are constantly being exposed, but this may be a slow hit-and-miss process at any one location, and thus fossils are nonrenewable resources.

4. **Why vertebrate and other fossils of scientific value are important.**
Vertebrate and other scientifically important fossils are studied for their unique features. Scientifically important fossils include type specimen representative of species new to science, all vertebrates, fossils of rare or unusual preservation, and those

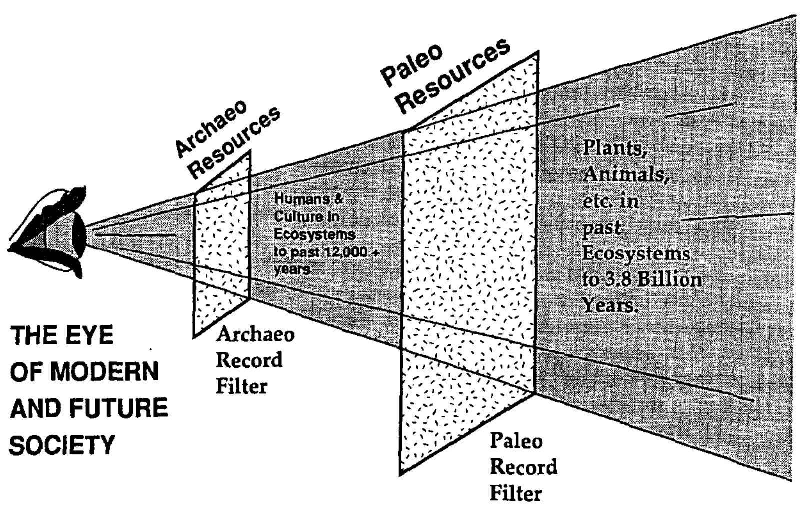
fossils needed for population and/or other scientific studies. These paleontological resources illustrate the body of paleontological science, and collected fossils of scientific importance are housed in BLM-approved public repositories such as museums and universities.

5. **Paleontology is relevant to Ecosystem Management.**
Fossils and associated data often reflect moderate to drastic fluctuations in differing ecosystems at any one location over the past 3.8 billion years, and especially for the last 600 million years. Archaeology reflects human interactions with the environment and the use of the land through differing ecosystems for at least the past 12,000 years.

Reference

Armstrong, H. J., 1982, Differences and similarities between archaeology and vertebrate paleontology, Unpublished Master's Report, M.B.S. Studies, University of Colorado/Boulder.

3. ARCHAEOLOGY ≠ PALEONTOLOGY



Twelve Reasons Why Archaeology is Not Paleontology

Archaeology

1. **Goals**
Describe humans and cultures through archaeological remains and associated environmental data.

2. **Resource Management Objectives**
Managing archaeological resources according to professional archaeological standards.

3. **Resources - Where Found and Why**
Intrusive into the ground or substrate.

3. **Research Strategies**
Research questions apply to humans, culture, and their environment.

5. **Survey Methods**
Conducted in transects as sites can be located in all topographies, soils, and vegetation.

6. **Mitigation of Resources**
Surface collecting, testing, and partial to total excavation.

7. **Significance**
Site is eligible for inclusion in the National Register of Historic Places.

8. **Excavation Methods**
Always uses grid units with horizontal and vertical positions of features, artifacts, and associated data.

9. **Preparation Techniques**
Few needed.

10. **Storage**
By state, county, and site number in an environmentally stable repository according to 36 CFR 79.

11. **Specimen Analysis**
Analysis of dating samples, paleoenvironmental samples, and artifact analysis.

12. **Ecosystem Management**
Archaeology reflects human interactions with the environment and use of the land through differing ecosystems for at least the past 12,000 years.

Paleontology

1. **Goals**
Describe all past life through fossils and their environment of deposition.

2. **Resource Management Objectives**
Managing paleontological resources according to professional paleontological standards.

3. **Resources - Where Found and Why**
Deposited as original part of the ground or substrate.

4. **Research Strategies**
Research applies to evolution and diversity of all past life.

5. **Survey Methods**
Prospecting stratigraphic sequences, and then only exposures, basically, and usually on or at base or sides of hill slopes - fossils are not commonly found in areas of dense vegetation and well developed soils.

6. **Mitigation of Resources**
Surface collect and test rock matrix - may entail collection of several tons of fossiliferous rock matrix for washing/screening, or for other types of preparation, and collection may include partial to total (rare) excavation, when safe, of a specimen or fossiliferous deposit.

7. **Significance**
Locality produces specimens of scientific importance - this includes all fossil vertebrates, non-common fossil invertebrates, and some fossil plants.

8. **Excavation Methods**
Tied into strata, but grid systems are not always used if characteristics of fossil deposit does not require it.

9. **Preparation Techniques**
Commonly needed to see and study fossils, as they are encased in rock.

10. **Storage**
By time, formation, phylogenetic relationship, and locality number in a stable and secure repository (but has no standards like 36 CFR 79).

11. **Specimen Analysis**
Actually dating samples is rarely done, paleoenvironmental samples are sometimes done, and fossils are analyzed.

12. **Ecosystem Management**
Fossils and associated data often reflect moderate to drastic fluctuations in differing ecosystems at any one location over the past 3.8 billion years, and especially for the last 600 million years.

The Use of Plant Fossils for Interpretation of Paleoclimates: Petrified Forest National Park, Arizona

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Plant megafossils and palynomorphs in the Chinle Formation in Petrified Forest National Park indicate the paleoclimate became notably drier during the deposition of the formation, in Late Triassic time.

The many plant fossils that occur in the Upper Triassic Chinle Formation in Petrified Forest National Park and vicinity provide information on the relative age, paleovegetation, and paleoclimate of the southwestern U.S. approximately 220 million years ago. The Chinle Formation was deposited as river, stream, and lake sediments on the Colorado Plateau during the early stages of dinosaur evolution. These remains vary in size from gigantic tree trunks over 120 feet long to fossil pollen so small it would take five of them end-to-end to span across a single human hair. The presence or absence of key age-diagnostic species of plant megafossils and palynomorphs (pollen and spores) through the formation established the age span of the Chinle Formation as Late Carnian to Early Norian (Late Triassic)(Litwin et al., 1992). The abundance and distribution of collective groups of fossil plants (for example, ferns, cycads, and conifers) vertically through the Chinle Formation provide separate information on relative changes in paleoenvironment, and on a larger scale, paleoclimate.

Silicified ("petrified") logs that were preserved as bedload in fossil stream channels, as floodplain overwash, and as in-place stumps (Ash and Creber, 1992), provide some evidence of relative paleoforestation patterns and general indications of paleoclimate by their fossilized cellular arrangement. Relatively more paleoenvironmental and paleoclimatic evidence has been discovered through the analysis of leafy plant megafossils (Ash, 1972; Ash, 1987) and analysis of fossil pollen and spores preserved in these same rocks (Stone, 1978; Litwin et al., 1992).

The fossilized leaves, pollen, and spores recovered from rock exposures in Petrified Forest National Park demonstrate that nearly all of the major modern plant groups had evolved by Late Triassic time. Arthrophytes (horsetails), lycopods (clubmosses), pteridophytes (ferns and tree ferns), pteridosperms (seed ferns), cycadophytes (cycads and cycadeiods), and conifers (evergreens) are commonly represented fossils in the lower, Late Carnian part of the formation (Ash, 1980; Figure 1). Their presence indicates that the environment of deposition was wet enough for them to thrive and reproduce (Ash, 1972; Litwin, 1985; Litwin et al. 1992). Fossil plant evidence from the upper, Early Norian part of the formation shows a lower abundance and diversity of plants that require persistent moisture, suggesting that the paleo climate generally became dryer during the course of Chinle deposition. However, no unequivocal cellular evidence of annual (or seasonal) tree rings has yet been found in thin sections of these fossil woods, which might substantiate a xeric (dry) or at least markedly seasonal environment (Ash and Creber, 1992). This lack of annual growth rings remains enigmatic in part because paleomagnetic evidence does suggest that the southwestern U.S. was located in the paleotropics during Late Triassic time (10-15^0 N latitude), where strongly seasonal precipitation might be expected (Dubiel et al., 1991).

Fossil palynomorph (pollen and spores) evidence also suggests a similar pattern of environmental change through the formation. Palynomorph assemblages, in particular the abundance and diversity of spores from ferns, clubmosses, horsetails, and other lower vascular plants, indicate that wetter and more equable conditions were prevalent during deposition of the lower, Late Carnian part of the formation. Lower vascular plants (ferns, tree ferns, clubmosses,

FIGURE 1. Major plant groups and fossil plant species identified from the Chinle Formation (southwestern U.S.A.)

Lower vascular plants

Horsetails
Equisitites bradyi
Equisitites spp.
Neocalamities virginiensis
Neocalamites sp.
Schizoneura harrisii

Ferms amd Fern-like foliage
Cladophlebis daughertyi
Cladophlebis subfalcata (Brown)
Cladophlebis yazzia
Cladophlebis spp.
Clathropteris walkeri
Cynepteris lasiophora
Sphenopteris arizonica
Todites fragilis
Wingatea plumosa

Higher vascular plants

Cycads
Charmorgia dijolli
Ctenophyllum braunianum
Lyssoxylon grigsbyii
Aricycas pauli

Cycadeoids
Eoginkgoites davidsonii
Eoginkgoites sp.
Nilssoniopteris ciniza
Otozamites macombii
Pterophyllum brownii
Pterophyllum sp.
Williamsonia nizhonii
Zamites occidentalis
Zamites powelli
Zamites spp.

Ginkgoes
Baiera arizonica
Ginkgophytic leaf (unnamed)

Higher vascular plants (cont'd)

Cordaites
Dadoxylon chaneyi
Pelouridia poleoensis
Samaropsis puerca
Samaropsis sp.

Conifers
Araucariorhiza joae
Araucarioxylon arizonicum
Brachyphyllum hegewaldia
Brachyphyllum spp.
Cephalotaxopsis sp.
Pagiophyllum duttonia
Pagiophyllum navajoensis
Pagiophyllum readiana
Pagiophyllum simpsonii
Pagiophyllum zuniana
Pagiophyllum spp.
Palissya spp.diffusa
Palissya sphenolepsis
Palissya spp.
Podozamites arizonicus
Podozamites emmonsi
Podozamites lanceolatus
Podozamites? sp.
Protocupressinoxylon dockumense
Woodworthia arizonica

Uncertain botanical affinity
Axelrodia burgeri
Carpolithus chinleana
Dechellyia gormani
Dinophyton spinosus
Macrotaeniopteris magnifolia
Marcouia neuropteroides
Masculostrobus clathratus
Nemecheckigone flabaforma
Sanmiguelia lewisi
Schilderia adamanica
Synangispadixis tidwellii

seed ferns, and horsetails) averaged approximately 10% of the total palynological assemblage in this (lower) part of the formation (below the Sonsela Sandstone Bed). Above this stratigraphic interval, in the upper (Early Norian) part of the Chinle Formation, lower vascular plants contributed approximately 2.8% of the palynomorphs to the total assemblage on average. This major decrease in the lower vascular plant component indicates some decrease in available precipitation and/or groundwater. This interpretation is supported by a small increase in the frequency of cycadophyte pollen (from cycads and cycadeoids) and a greater increase in the frequency of monosaccate gymnosperm pollen (Figure 2A). A second, common type of conifer pollen (bisaccate) does not show the same anticipated increase upsection. Although bisaccate pollen comprises approximately 45-50% of each fossil pollen assemblage, whether from the lower or the upper part of the formation, it actually decreases slightly in relative abundance upsection (Figure 2B).

The general stability in the abundance of this major floral component (the gymnospermous conifers) through the formation, and the persistent lack of environmentally controlled growth rings in the abundant fossil conifer wood suggests that climatic conditions in the depositional area also must have remained relatively stable through much of Chinle time. On the basis of most other fossil plant evidence, however (especially that recorded in the palynological record), the Chinle paleoflora does show an early response to an increasingly desertified climate that culminated in the deposition of the eolian (wind-deposited) Wingate, Navajo and Entrada Formations over the Chinle Formation later in the Mesozoic.

References

Ash, S.R., 1972, Plant megafossils of the Chinle Formation, In: Breed, W.J., and Breed, C.S. (eds.), Investigations in the Triassic Chinle Formation, Museum of Northern Arizona Bulletin, 47, pp. 23-43.

Ash, S.R., 1980, Upper Triassic floral zones in North America: Dilcher, D.L., and T.N. Taylor (eds.), Biostratigraphy of Fossil Plants, Dowden, Hutchinson and Ross, Inc. Stroudsburg, PA, pp. 153-170.

Ash, S.R., 1987, Growth habit and systematics of the Upper Triassic plant Pelourdea poleoensis, southwestern U.S.A., Review of Palaeobotany and Palynology, 51:37-49.

Ash, S.R., 1989, A catalog of Upper Triassic Plant megafossils of the western United States through 1988: Lucas, S.G., and A.P. Hunt (eds.), Dawn of the Age of Dinosaurs in the American Southwest, New Mexico Museum of Natural History, Albuquerque, pp. 189-222.

Ash, S.R., and G.T. Creber, 1992, Palaeoclimatic interpretation of the wood structures of the trees in the Chinle Formation (Upper Triassic), Petrified Forest National Park, Arizona, USA., Palaeogeography, Palaeoclimatology, Plaeoecology, 96:299-317.

Dubiel, R.F., J.T. Parrish, J.M. Parrish, and S.C. Good, 1991, The Pangaean megamonsoon - evidence from the Upper Triassic Chinle Formation, Colorado Plateau, Palaios, 6:347-370.

Litwin, R.J., 1985, Fertile organs and in situ spores of ferns from the Late Triassic Chinle Formation of Arizona and New Mexico, with discussion of the associated dispersed spores, Review of Palaeobotany and Palynology, 44:101-146.

Litwin, R.J., A. Traverse, and S.R. Ash, 1991, Preliminary palynological zonation of the Chinle Formation, southwestern U.S.A., and its correlation to the Newark supergroup (eastern U.S.A.), Review of Palaeobotany and Palynology, 68:269-287.

Stone, J.F., 1978, Pollen and Spores: S.R. Ash (ed.), Geology, paleontology, and paleoecology of a Late Triassic lake, western New Mexico, Brigham Young University Geological Studies, Part 2, 25:45-59.

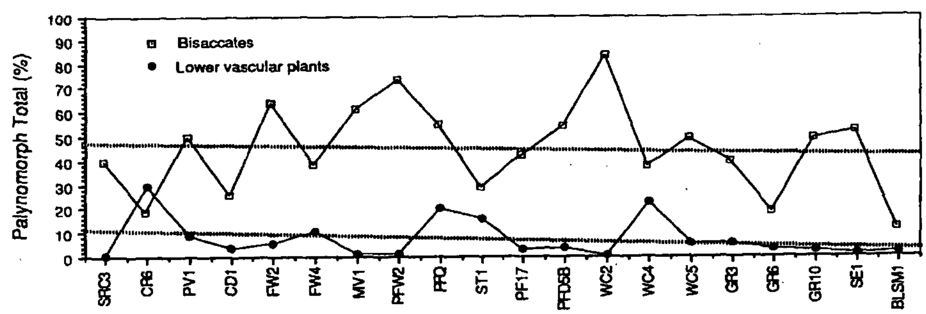

FIGURE 2A. Paleovegetational elements that decreased during Chinle deposition

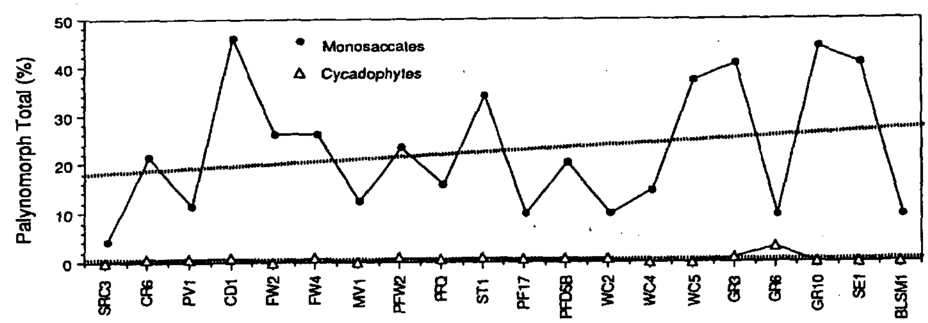

FIGURE 2B. Paleovegetational elements that increased or stayed the same during Chinle deposition

Paleontology and Dinosaurs (A K-12 Curriculum Project Developed with Colorado Partners)

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The Denver Earth Science Project is a K-12 curriculum development effort coordinated by the Colorado School of Mines (CSM). In partnership with corporations, federal agencies, school districts, and professional organizations, a series of educational "modules" addressing a range of earth science topics is being developed. The modules deal with topical earth science issues and are prepared by trained curriculum development teams composed of experienced earth science teachers and practicing scientists. The key to the success of the Project is the involvement of teachers in the design and writing of the materials along with the technical expertise of the geoscience professionals.

Three curriculum modules have been developed and field tested with local teachers and students 1. Paleontology and Dinosaurs (grades 7-10); 2. Oil and Gas Exploration (grades 7-12); 3. Ground Water Studies (grades 7-9). A fourth module, "Energy - A Closer Look at Oil and Gas" (grades 4-6), will be field tested in the Fall of 1994.

The Paleontology and Dinosaurs Module
The innovative approach being developed by the Denver Earth Science Project centers around modules which stress a topical issue related to the study of the earth. The "Paleontology and Dinosaurs" module teaches students basic paleontology concepts through the study of dinosaurs. The "hands-on" student activities use real data collected in the field, model dinosaurs, and fossils to allow students to look at the earth's past by using a problem-solving approach. In addition, the module integrates science, mathematics, and geography into a high interest topic.

Teacher Training
Teachers are able to obtain the teacher resource kit and notebook for the "Paleontology and Dinosaurs" module by attending a teacher training workshop. The workshop provides teachers an opportunity to actively participate in the module activities while attending special lectures by paleontologists and geologists. In addition, a field trip shows teachers local fossil resources in their community. The workshop provides the necessary scientific background for the teachers to successfully teach the module to their students. The teacher resource kit, which includes dinosaur models, fossils, audiovisual materials, owl pellets, and the teacher/student notebook, provides the "hands-on" materials needed for the students to actively learn how fossil evidence gives paleontologists clues to the past history of the earth.

Partnering Opportunities
Through a number of partnership programs in the Denver area, the Denver Earth Science Project has been able to create relevant earth science curricula to enhance existing school programs. The following partnering opportunities give interested individuals, state and federal agencies, local business and industry, and school districts the chance to make exciting dinosaur activities from the "Paleontology and Dinosaurs" module available to teachers throughout Colorado.
1. As a professional geologist or paleontologist, give a special lecture at a teacher training course.
2. Visit a K-12 classroom when students are studying paleontology and/or dinosaurs.
3. Fund teacher resource kits for educators who have completed a training program.

Initial Sponsors of the "Paleontology and Dinosaurs" Module
- CSM, Office of Special Programs and Continuing Education, Golden, Colorado.
- Denver Museum of Natural History.
- Marathon Oil Company, Petroleum Technology Center, Littleton, Colorado.
- National Science Foundation, Wash. D.C.
- Texaco Exploration and Production, Inc., Denver, Colorado.
- The Denver Foundation, Denver, Colorado
- Woodward-Clyde, Denver, Colorado.

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Proactive Paleontological Resources Management on the Nebraska and Samuel R. McKelvie National Forests, Buffalo Gap, Ft. Pierre, and Oglala National Grasslands

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Management of paleontological resources on lands administered by the Nebraska National Forest (NNF) is very challenging in a multiple-use agency setting. Many other resources, such as threatened and endangered species and heritage resources must be addressed when any ground disturbing activity, such as paleontological excavations, take place. The NNF is the first national forest to conduct forest-wide paleontological resource inventories. The area administered by the NNF is highly fossiliferous and many people in the local communities are interested in fossils, be it for a hobby or for extra income. The land managers of the NNF realized that they did not know what fossil resources existed on lands under their responsibility, compromising their ability to effectively manage them.

The following three pronged approach was initiated to help land managers and the public better understand fossil resources:

1. Coordinate an open forum for the multiple interest groups and land managers to discuss paleontological resources on federally administered lands.

2. Conduct paleontological resource inventories with local universities.

3. Establish a paleontological initiative by the US Forest Service (USFS) focusing on education, interpretation, partnerships, and policy development.

The USFS, in partnership with South Dakota School of Mines and Technology (SDSM&T), Badlands National Park, University of Nebraska/Lincoln (UN/L), and the South Dakota State Historical Society, organized a two day "Fossils for the Future" Conference in 1992. The purpose of the conference was to raise awareness of issues and concerns regarding fossil management and to discuss possible solutions. Unfortunately, due to unforeseen events beyond anyone's control, the second day of the conference was cancelled.

The second phase was to implement paleontological resource inventories on the Oglala and Buffalo Gap National Grasslands. The purpose of the fossil inventories was to answer the following questions:

- What and where are the fossil resources?

- What is the significance of the fossil resources?

- Is theft a serious threat to fossil resources?

- If fossil theft is evident, what fossils are being impacted?

The goal of these inventories is to provide land managers of the NNF the information needed to evaluate fossil resources in all management decisions and to know the importance and location of the resources. Since 1991, SDSM&T has been conducting paleontological inventories on the Buffalo Gap National Grassland and the UN/L has been conducting paleontological inventories on the Oglala National Grassland and the Nebraska, and Samuel R. McKelvie National Forests.

The Rocky Mountain Region (RMR) established a 5 year paleontological initiative which is the third phase for the management of paleontological resources. A few strategies include the following:

- To conduct internal education programs regarding the significance of this nonrenewable resource which has historically been ignored by the USFS.

- To demonstrate effective education and interpretation at significant fossil areas to promote public understanding and appreciation.

- To build a model for a USFS Paleontological Program.

Unique Fossil Discoveries
As a result of the inventories, many significant fossils have been recorded and preserved that might have been lost to the paleontological community. Paleontologists from SDSM&T have been concentrating their portion of the inventory in the late Mesozoic marine section of the Buffalo Gap National Grassland, which includes the Belle Fourche, Carlisle, Niobrara, and Pierre formations. Some of the interesting fossils SDSM&T has found include a baby plesiosaur which may have been preserved near its mother (this assumption will remain unconfirmed because of the unauthorized collection adjacent to the specimen). Other fossil finds include pterosaurs (winged reptiles), hesperornids (diving birds), and at least two previously unreported fish. UN/L has been documenting the longest known Oligocene mammalian and avian trackway exposed in Toadstool Geologic Park, Sioux County, Nebraska. This trackway records an approximate 2 week southward migration of at least 2 species of birds and 9 species of mammals, including oreodonts (extinct sheep-like mammals), entelodonts (extinct pig-like mammals), camels, rhinoceroses, and possibly carnivores, that traveled along the stream bank approximately 30 million years ago. Many of the trackway bearing sandstone slabs are located along the present one mile visitor trail that winds through the park. Some trackway slabs are continually being worn by foot traffic and natural erosion. One slab containing avian tracks has already been completely worn away. Fortunately, Dave Nixon, Superintendent of the Nebraska State Trailside Museum, realized the inevitable and made a plaster cast of the slab. Currently, geologists and paleontologists at UN/L and the NNF are working with an interpretive contractor to move the current visitor trail and to do other interpretive enhancement projects in the park.

Vandalism and Fossil Theft
Results of the paleontological inventories indicate approximately 25% to 30% of all inventoried fossil locations have been impacted by vandalism or unauthorized collecting. Most of the vandalism occurs in Toadstool Park where visitors carve names, initials, or colloquialisms into the sandstone blocks that contain tracks or break or dislodge trackway bearing slabs. Theft of fossils also occurs in the park. Within a half hour walk (a 1.23 mile radius), 32 sites have been identified as having fossil material removed illegally. Of course, some vandalism and theft occur through ignorance, but much of the fossil theft is fueled by the high market value of fossils. Paleontologists conducting the inventories in remote areas of the grasslands have discovered vandalism and theft impacting fossil resources. A few examples of the destructive activities impacting fossils:

- Skeletons left to erode after the highly valued skull was taken;
- Flagging or cairns used to identify fossils for future collection;
- A complete tortoise, measuring a meter wide, exhumed, but left on its back because it was too heavy to carry;
- Titanothere skulls with the teeth removed for possible future sale;
- Fossil skeletons hammered to bits so competitors could not benefit.

Final Statements
The NNF has a lot to offer the scientific and local communities with the rich paleontological resources on lands that it administers. Professional paleontologists and land managers have an uphill climb to create viable working relationships with each other, with amateur collectors, hobbyists, commercial collectors, and with the public. The implementation of educational and interactive programs are needed to enlighten the public to the methods and practices of land management, how fossil resources are integrated into management plans, and how the concerned public can contribute to management of the resource. Forests of the RMR are taking a proactive stance regarding paleontological resources. Cooperation and partnerships between federal and state agencies, professional and academic paleontologists, amateur collectors, and commercial entities are a must if fossil resources are to be preserved for future generations.

Learning from Fossils: The Role of Museums in Understanding and Preserving our Paleontological Heritage.

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Fossils mean many different things to different people, but if there is one common denominator, it is the belief that we can learn something new from them that is interesting and, sometimes, quite exciting. Such learning experiences can enrich the lives of people of all ages, and the value of fossils as objects for learning is a primary theme of this paper. The ways that fossils can teach are many and varied, from the spectacular skeleton on public display to a treasured trilobite in a 5-year-old's pocket. All of these ways need to be taken into account as we plan for the future preservation of fossils and their uses to satisfy human curiosity and to expand our knowledge of the past.

When a fossil erodes or is quarried from its surrounding rock, it leaves the safety of millions of years of burial for exposure to the elements, which will quickly destroy it unless reburial occurs. Many fossils are unstable in surface environments and begin to "self-destruct" as soon as they reach the atmosphere. When we collect a fossil and decide to preserve it, we take on a large challenge and responsibility; not only must we hold back the natural processes of destruction, we must keep the fossil safe from human-generated damage, and preserve the information (where it was found, its age and identity) that makes up a large part of its value.

A fossil newly discovered and collected can be a source of awe and media attention as well as admiration for its lucky finder. A fossil kept for years often becomes once again a hidden treasure - stored in a museum cabinet or lost in a dusty attic - unless its existence and location are properly documented. The initial period of discovery and collection is the time when the fossil can mean the most as a source of new information, at least from the public point-of-view. But a well preserved and well documented fossil can remain valuable to science, and, through scientific understanding, to the society at large, for hundreds of years or more. Particular fossils, such as the Cambrian Burgess Shale fauna or the dinosaur skeletons of the American West, recapture the imaginations of new generations of professional and amateur fossil enthusiasts, thus providing a source of fresh ideas about the history of life on Earth. Imagine every generation having to start from scratch to explore the fossil record, and it is easy to understand the value of preserving the collected specimens as well as all that is known about them for future generations.

Museums, traditionally, are the places where fossils and other objects of value to society are kept, cared for, and made available to the public. In the rapidly changing world of today, however, we are re-examining the roles of museums and other caretaker institutions in light of expanding national, state, and local involvement with fossils and other objects caught at the intersection of scientific, public, personal, and commercial interests.

The National Museum of Natural History (NMNH) has served as one of the nation's leading institutions for the preservation, study and exhibition of fossils since early in this century. Before NMNH was built, the parent Smithsonian Institution held in trust large natural history collections including fossils. NMNH today has 7 departments, including the Department of Paleobiology, which is primarily responsible for Smithsonian fossil collections. (Some collections also reside in other departments, such as Anthropology and Invertebrate Zoology.) Over the years, NMNH also has been responsible for housing fossil collections of other government organizations, such as the US Geological Survey (USGS), and, recently, it has taken in important "orphaned" collections from universities or other organizations that no longer were willing or able to care for them. At present, the Department of Paleobiology curates and studies one of the largest fossil collections in the world, amounting to approximately 40 million specimens. The museum has a complex of 5 large exhibition halls for fossil organisms, which was renovated in the 1960's-80's.

The Department of Paleobiology at NMNH is a research and collections organization with 17 active curators/scientists, 2 emeritus curators, 55 research, collections, and administrative support staff, 10 USGS emeritus scientists, 30-50 volunteers, fellows, associates, collaborators, and interns, and many professional and lay public visitors each year. Activities range from investigating the evolution and paleoecology of marine and terrestrial plants and animals to assisting teachers with school curricula and identifying fossils that individuals bring to the museum's Naturalist's Center. Funding for personnel comes through a federal appropriation to the Smithsonian Institution and support for operations (e.g., field expeditions, laboratory analysis, and collections maintenance) includes both federal and trust (private) sources.

The mission of the Department of Paleobiology echos that of the museum as a whole, which is to discover, preserve, and understand objects that are part of our natural and cultural heritage, and to communicate this information to the public in order to educate and inspire present and future generations. The NMNH holds in trust collections of fossils for the benefit of all people, and provides access to these through exhibits, publications, interaction with the museum's staff, and exchange of specimens for research and exhibition purposes. Increasingly, the museum is enhancing access to its collections through electronic media, including Internet and CD-ROM technology. Currently we have approximately 8 million visitors a year from all over the world. In the future anyone connected to the global electronic highway will have access to information and images from our collections and research holdings.

What should be the roles of large museums, such as NMNH, and smaller museums and other organizations interested in fossils, that wish to have access to the information they represent? Keeping in mind the principle that learning from fossils should be a top priority, large museums have an important role to play in providing expertise based on their research and exhibition programs. They also provide a central storage facility where specimens can be properly preserved, catalogued, and made available for a broad range of users. Smaller museums and educational organizations, including state and local facilities, have an important role to play in providing exhibits, information, and education to their communities. Museums of all sizes can enhance the learning that flows from fossils to the public through information exchange, such as will be increasingly available through Internet. This does not solve the issue, however, of which organizations should take responsibility for collecting and preserving the fossils themselves.

Large museums such as NMNH are set up to handle fossils of all kinds, and in the past have had the resources to see that these were properly preserved and documented. At present, both resources and storage space are being stretched by the increase of incoming collections and the reduction in the funds being allocated to collections care from federal and other sources. Although smaller organizations are usually even more limited in resources necessary for basic collections care and access, there is also strong local pressures for retaining fossils that are "native to" a particular state or region. In paleontological research, it often is essential for the paleontologist to compare the traits of as many specimens as possible in developing new information about the past. This is more difficult when specimens reside in many different, widely separated museums. Thus, even when storage and curation are provided by such organizations, fossil collections usually cannot live up to their potential for contributing to the general understanding of the history of life, or to the education of the public at large.

New opportunities for computer links between all organizations that maintain fossil collections should help to resolve such problems and to build a new framework for exchange of both specimens and information. However, we still need strategic planning so that the fossils, as well as supporting information, have permanent homes where they are properly preserved and maintained for the future. While large museums such as NMNH can provide such a home for fossils and access for the global community, state and local museums and other government organizations also serve their constituencies through exhibition of important local specimens, and through educational outreach based on collections.

Given the reality of limited resources, perhaps local and state organizations could make the best use of their fossils by planning a strategic set of exhibition, teaching, and research goals for specific collections, while the larger museums take responsibility for preserving the bulk of the research collections, plus exceptional specimens for broader exhibition and public outreach. The most spectacular specimens could be loaned between museums to enhance public access both locally and nationally. The larger museums could assist with up-to-date scientific information, as well advice on specimen replication and conservation. Specimens that are primarily of research rather than exhibit value should be where they can do the most good (i.e., in the larger museums that are equipped to care for and provide access to them). Specimens that are objects of special local or regional pride should likewise be available to serve their community (i.e., on display in their home territory). Curators of local or regional collections also should have access to information about their local specimens that are part of larger museum collections. In all cases, every effort should be made to retain and make available fossils from public land for the good of the public.

The future of paleontology, and the health of its rapidly expanding connections to other fields such as ecology, biodiversity research (including ancient DNA), global climatic research, archeology, and anthropology, depends on forging stronger links between collections and the individuals who can learn new things from them. Also important is the need to plan new collecting efforts to keep the broad goal of learning from fossils healthy and growing. It is critical that we balance the dual importance of fossils for public education and scientific research, and develop collection and preservation policies that will serve both goals as we forge new partnerships in paleontology for the 21st century.

Building a Paleontological Resource Management Program at Badlands National Park

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Badlands National Park has recently hired a paleontologist and is presently developing a Paleontological Resource Management Program. Rapid rates of erosion, the growing fossil trade and the sheer abundance of fossils contained within the Park provide unique challenges for park management.

Badlands National Park is in an exciting phase of its 55 year history. The basic groundwork for a Paleontological Resource Management Program is being developed. The purpose of this talk is to inform conference participants of on-going paleontological programs at Badlands and some of the challenges to be faced in the coming years.

Several unique paleontological management issues occur at the Badlands which are not encountered in other fossil parks. The fact that Badlands is a National Park implies that there are other resources which deserve equal protection status, including endangered wildlife, mixed grass prairie preservation, and Native American history and culture. All of these issues compete for employee time and research dollars.

The great size of the park and abundance of fossils forces the park paleontologist to set priorities in fossil collecting. Limited curatorial and preparation facilities also provide restraints. Sites of greatest paleontological significance and at greatest risk of theft and erosion are presently being documented for future cyclic prospecting programs. These sites, along with other significant factors, will be recorded through GIS for future management planning. The 1993 discovery of a unique fossil assemblage including *Archaeotherium*, *Mesohippus*, and *Subhyracodon*, provides evidence that aggressive collecting and prospecting will uncover many other significant fossil finds.

For many years the Paleontology Staff at Badlands National Park consisted of one seasonal paleointern, usually a graduate student with one to two years of graduate school. This year has brought many exciting changes with the addition of a full time paleontologist and a seasonal physical sciences technician.

The paleontological resource management issues at Badlands National Park are complex and, in many ways, unique from those of other paleontological parks. Since the discovery of a fossilized titanothere jaw by Dr. Hiram Prout in 1846, the White River Badlands of South Dakota have been considered a world class paleontological research area. Extensive studies not only in systematics but also sedimentation, paleosols, and geomorphology have been made in the last 150 years and continue today.

However, because the Badlands is also a National Park, other resources such as endangered species, mixed grass prairie, and Native American history and culture all deserve attention. It has only been in the last few years that paleontological resources protection has been established as a park priority.

Many significant factors come into play when managing fossil resources at Badlands National Park. The great size of the park and the abundance of fossils forces the park paleontologist to set priorities in fossil collecting. Limited curatorial and preparation facilities also provide restraints. The growing commercial value of fossils has shown an increase in vandalism and theft within the park area.

The majority of these challenges cannot be solved overnight. Before any major management changes can be made, careful documentation of the resource and collection of baseline data need to be completed. Badlands National Park is presently developing a GIS program. Important paleontological data including historic research areas, sites most vulnerable to vandalism, and erosion rates will be documented through GIS.

Once the most significant and vulnerable sites have been documented, regularly scheduled prospecting trips need to be developed. This type of program will not only help in the removal of fossils which are at risk but also will create a greater "presence" in the field to discourage vandalism and theft. Due to the varying abundance of fossils found in the Badlands, priorities must be set as to what is collected. This requires an understanding of what has been collected historically and at what stratigraphic levels. Plans are being made to complete extensive literature searches for all publications written on the White River Badlands, and a collections search for the materials collected in the park and surrounding areas.

The paleontology staff at Badlands National Park has increased, but not to the point of achieving the above mentioned goals in a reasonable time period. The park has historically granted research permits for large numbers of museums and universities to collect and do research. Our hope is to continue building these relationships with associated institutions and coordinate their efforts in developing active monitoring and research programs within the park. Badlands National Park presently has a cooperative agreement with the South Dakota School of Mines and Technology to assist in the excavation of a large scale fossil assemblage found in 1993. The site not only provides important information about taphonomic assemblages but also is a source of visitor interpretation within the park.

Long range goals for the park include expansion of the Cedar Pass Visitor Center to include a larger curatorial area and a preparation lab. There are also plans to expand the paleontology staff to include a collections manager and preparator. With these additional assets, long term paleontological resource management goals will be easier to achieve.

Paleontological Resource Management through Project Evaluation, Monitoring, Mitigation, Resource Evaluation, and Curation

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Consequent to more than five years of paleontological sensitivity, survey work, federal and state agency interaction, and museum curation activity, we compiled this research design for paleontological resource management as applied to survey work. It has proven to be effective in protecting the resource while optimizing company construction schedules. Examples will be given during the presentation about interactions with Northwest Pipeline Corporation, Questar Pipeline Corporation, and a variety of other organizations.

Project Evaluation

Literature Survey
The United States Department of the Interior, Bureau of Land Management (BLM), following the 1906 Antiquities Act, the National Environmental Policy Act of 1969 (NEPA), the Federal Land Policy and Management Act of 1976 (FLPMA), and subsequent BLM rulings and guidelines, along with the Federal Energy Regulation Commission (FERC), requests reviews of the paleontological sensitivity of formations to be impacted by a variety of construction projects (e.g. pipelines, well-site construction). Similar guidelines are also outlined by western state laws regarding paleontological collecting.

These reviews involve extensive literature search with a thorough review of the bibliographies regarding the formations to be impacted and their paleontological sensitivity. However, other unpublished sources also must be utilized. These include known fossil locality maps and paleontological survey reports in the hands of federal agencies such as BLM, US Geological Survey, US Forest Service (USFS), and Bureau of Indian Affairs, state geological surveys, university and museum personnel, as well as independent researchers.

These literature reviews should include a survey of previous work, geologic history and stratigraphy of the area, description of the geologic formations to be impacted, known faunal and floral paleontology lists, and a comprehensive bibliography of each formation. Recommendations should be made for field surveys contingent upon the deduced paleontological sensitivity.

Paleontological Field Survey
A classification system based on designated types is suggested by the BLM and modified from Raup (1987, p. 121-122) for defining the paleontological sensitivity of geological formations based on the known sites and discoveries of fossils of scientific value. The USFS and the BLM (Raup, 1987, p. 122 & 142) have attempted to define **fossils of scientific value** using the following criteria:

- Preservation of soft body parts.
- Preservation of uncommon invertebrate fossils.
- Close or intimate association of plants with animals.
- Preservation of the skull, whole isolated bones, or other diagnostic materials.
- A concentration and diversity of plants and animals of restricted geologic or geographic range.
- Fossils poorly known or new to science.
- Unique or significant geographic, stratigraphic, or paleontologic position such as type locality, only known occurrence, reptile-mammal transition, etc.
- Materials having the potential for clarifying the evolutionary position, morphology, development, behavior of the organism and/or its environment.

A 100% pedestrian field survey should be done through all Type 1 units (those containing significant fossils)(Raup, 1987, p. 121-122) excluding extremely steep slopes, areas of soil development, and vegetated areas. These excluded areas are either not safe to attempt fossil recovery or are not likely to be productive paleontologically. Alternatively, areas of good, safe, formational exposure should be carefully examined. Other, less productive units may be either spot checked (Type 2 - fossils, low to moderate scientific value) or not examined (Type 3 - few or no fossils).

Recommendations for paleontologic discoveries
If critical or significant vertebrate, invertebrate, plant, or trace fossil material (as defined by Raup, 1987, p. 174) is encountered during the field survey, appropriate recommendations should be determined by several criteria. These are:

Sampling: During the field survey or during construction (as defined in the monitoring and mitigation plan), fossil material should be sampled to facilitate further analyses to determine significance.

Salvage: Salvage is requested if the fossil discovery is of scientific interest and if the construction will destroy the site.

Rerouting: A request for a reroute is made if critical or significant fossil material is encountered directly on the route or site and the salvage cost or time factor is unacceptably high. A reroute also may be requested if the locality is scientifically very important and should be left undisturbed for subsequent scientific evaluation.

Monitoring: If critical or significant fossil material is likely to be encountered during the construction at the site, monitoring is recommended. The probability of this occurring is determined from the evaluation of the literature and of field survey discoveries.

A report for the Environmental Impact Statement (EIS) should be prepared upon completion of the field survey, identifying and describing significant fossil-bearing formations. Known fossil localities on or near the construction site or route should be identified and recommendations made regarding mitigation. All formations and fossil sites to be impacted should be clearly identified on maps. Tables should be compiled identifying the locations of all paleontologically sensitive formations.

Mitigation and Monitoring Procedures

Mitigation
If a geologic unit or fossil site is deemed to be of high sensitivity (as determined by a review of the literature and/or a field survey) for containing significant nonrenewable paleontologic resources, mitigation measures should be performed to protect that resource. All phases of mitigation should be supervised by a qualified, federally permitted, professional paleontologist.

- To prevent damage to a known paleontologically sensitive resource and to prevent construction delays, salvage or rerouting recommendations should be made prior to the beginning of construction.

- Specific boundaries of sensitive formations or fossil sites must be delineated so the company personnel, developers, and/or contractors are aware of areas with potential problems. Any special treatment should be specified prior to excavation.

- A fossil identification and procedures pamphlet should be prepared before construction begins for worker orientation. Responsibility for the protection of the resource should be clarified, as well as the definition and description of the fossils commonly found at the site or along the route.

Monitoring
During construction there must be adequate paleontological monitoring of significant units to salvage specimens. The monitoring program includes:

- Qualified paleontological monitors should be present during 100% of ground disturbing activity along the Type 1 sectors of the route and should perform spot checks along Type 2 portions of the route. Maps of specific areas to be monitored along each segment should be provided to the paleontological monitor, the operation chief for construction, and the environmental inspector prior to construction. The supervising paleontologist (primary investigator holding the federal permits), in cooperation with the environmental inspector and paleontological monitor, should determine what material is present, arrange for removal and/or sampling, and verify when work at that site may continue.

- Backup monitors should be available to assist in the removal of large or abundant fossils so that delays to continued construction can be avoided.

- Some significant vertebrate resources are small to microscopic in size and may not be readily apparent during construction activity. Close inspection of the fine grained rocks, sampling, and on-site screening may determine if fossils are present. An adequate sample size for further screening should be determined by the supervising paleontologist. To avoid construction delays, matrix samples may be removed from the path of the excavation for later processing.

- Sources of fill or mat material, usually unconsolidated gravel or sand, may contain vertebrate fossils. Frequently these sources are chosen after construction has begun. A paleontologist should evaluate the source, or at least the debris for fossils. If fossils are found, recommendations regarding their redistribution and future scientific impact around the countryside should be made.

Resource Evaluation
Preparation of small to medium size fossil material should be conducted under the direction of the primary investigators. If large vertebrate material is encountered, other arrangements might have to be made (e.g., cooperation with regional museum personnel). Under no circumstances should fossils be removed from private lands for any reason, including curation, without the written consent of the affected landowner.

Preparation of fossils involves cleaning, stabilizing, and identification. Numbering, boxing, and storage should be done as prescribed by the designated curation facility. Fossil localities on or near the construction site encountered in the field survey as well as during construction should be plotted on US Geological Survey 7.5' quadrangle maps and described in appropriate locality forms.

Curation facilities are chosen by their proximity to the site, by the professional curation staff, or by the federal or state agency which has authority over the site or portion of the pipeline or construction route. Generally these are facilities that have repository agreements with the appropriate federal agencies, and are complying with or are attempting to comply with Federal Regulation 36 CFR Part 79 for archaeological collections.

A complete set of records and photographs with an itemized specimen inventory should be compiled and filed at the curation facility. Some museums have adopted the Automated National Cataloging System (ANCS), an inexpensive system developed by the National Park Service for all its collections. Where appropriate, much of the cataloging data should be computerized and given to the curation facility. This step would eliminate costly curation time at that museum site. In addition, compliance with the standardization set up on ANCS eventually will allow nation wide computer access to collection information (a valuable asset to researchers).

Final Report
Upon completion of construction and evaluation of samples collected along the route, a final scientific project report should be done. Included in this report should be:

- Description of field work.

- Geologic history and stratigraphy of the formations along the route.

- Survey results and evaluation of the formations impacted, with a description of fossil sites by formation.

- Significance of recovered specimens with regard to other known localities.

- Bibliography of formations and paleontological resources.

- Appendix of Paleontology Locality Forms with maps.

- Appendix of an itemized specimen inventory of collected samples with curatorial facility.

- Appendix of Collection Permits, Curation Agreements, and other appropriate communications.

Significant scientific results should be published at least regionally, if not nationally. Appropriate manuscripts should be provided to all involved entities: the company, the federal and state agencies, land owners, and the curation facilities. All paleontological data should be compiled on a data base (like ANCS) which should allow for further study, definition, and protection of significant paleontological resources.

Reference

Raup, D. M. (Chairman), 1987, Paleontological collecting: committee on guidelines for paleontological collecting, National Academy of Sciences, National Academy Press, Washington, D. C.

Resource Protection Via Education: Getting the Word Out Through Public Programs in Museums

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Perhaps now more than ever before, the general public travels to museums to learn about the intriguing beasts of the past and the exciting wonders of our ancient world. They marvel at how our planet has evolved through its 4.5 billion year history and how the animals and plants have changed through time. One of the advantages of the popularity of dinosaurs in the 1990s is that people are thinking about paleontology, how it works, and how much there is still left to learn. Museums provide an important link between scientists and the public by translating the information provided by researchers into the interesting stories about the past.

In addition to telling the stories of past life, museums generally have in their mission statements a clause that mandates them to protect and preserve the scientific resources which they have in their collections. Museums have the additional responsibility of striving to ensure the protection of these resources by educating the public of their importance. That means discussing not only current scientific ideas related to specimens but also protection of this material from activities that could be detrimental to the progress of science and, thus, the exchange of information which eventually translates to museum exhibits. Although a variety of scientific specimens could be considered in the context of protection of geological resources, vertebrate fossils are focused upon because of their rarity and unique educational and scientific values.

Most people are woefully ignorant as to the ownership of fossils. They do not understand that fossils generally belong to the owner of the land on which they are found, be it private or public. On private lands this is a relatively simple issue, but on public lands these fossils belong to all of us. Therefore, management of these resources is the responsibility of the public as a whole. This cooperative protection philosophy is imperative for the care of the resource in the best interest of the general public, rather than for any one person's individual pleasure. It is the public's responsibility to make certain that vertebrate fossils are properly collected and cared for to maintain the integrity of the resource for future generations. Museums should educate the public on their role in the protection of this part of our natural heritage.

To realize the significance of vertebrate fossils and conserve them in perpetuity, the specimens must be properly curated in appropriate scientific institutions and made available for study by researchers. Because vertebrate fossils are such unique resources, the protection of this material is of critical concern. Fossils are the basis for our understanding of past life and environments, and provide valuable information about our ancient earth. The conservation of this knowledge is paramount and should take precedence over short-term economic goals. To this end, detailed locality data are critical and should be well documented, in addition to the proper collection and curation of the material. Paleontologists should be involved with the removal of vertebrate fossils from public lands. Once collected, this material should reside in a suitable, paleontological repository overseen by qualified individuals. Unfortunately, not all museums have the qualifications nor personnel to be considered as repositories. The responsibility of accepting material and acting as a steward of the public trust is an awesome one that should not be entered into lightly. Individual ownership (privatization) of these resources does not usually conserve the scientific integrity of the resource in the best interest of the general public. The most critical aspect of vertebrate fossil management is protection from information loss. Because fossils provide important information about our past world, they are in essence the "books" of the past. Information loss often occurs when fossils are irresponsibly collected and privatized.

If fossilized remains are the "books" of our past, then museums are the libraries. And, just as a library is responsible for the repair, preservation, cataloging, and storage of a book, so to must museums exercise the same care when dealing with fossilized remains. A fossil is more than an object which is aesthetically pleasing. It has a story. That story is what generations of the interested public go to museums to learn more about, and what the museum community is dedicated to preserve, interpret and present. The popularity of exhibit halls is not simply a matter of having "pretty" objects on display, but rather the exciting past history of our earth that is interpreted through this material. Only through the proper curation and research of these specimens can this story be told.

Museum professionals have a responsibility to ensure the safekeeping of vertebrate fossils found on public lands. In recent years there have been an alarming number of reports of illegal fossil collecting. As vertebrate fossils on federal public lands are naturally occurring, nonrenewable educational and scientific resources that belong to the people of the United States, adequate regulations and management procedures must be in place in order to protect this part of our natural heritage. Apparent violations of and noncompliance with existing regulations regarding vertebrate fossils on public lands indicate that stronger, clearer legislation must be put into effect, and that the general public be made aware of the rules and their role in resource protection.

Museums should work closely with land management agencies to get the word out through displays (both permanent and traveling), lectures, and distribution of literature. Museums should support the activities of professional, amateur, and hobbyist collectors that result in enhancing the educational and scientific value of these irreplaceable fossils. They should strive to ensure that these resources and the associated contextual data are preserved in trust for the people of the United States. Institutions should illustrate the need to protect fossil vertebrates found on federal lands from loss due to privatization by promoting the educational and scientific values of fossils.

Over a decade ago, congress enacted legislation similar to that currently being presented for the protection of vertebrate fossils (i.e., Vertebrate Paleontological Resources Protection Act) to protect archaeological material found on federal public lands, as a result of the escalating private demand for these resources. Current events indicate that vertebrate fossils are now in dire need of the same type of protection. However, whereas the need for protection of artifacts is generally understood and respected by the public, the need for protection of vertebrate fossils is not clear, either because of misinformation or lack of information regarding this issue. It is therefore imperative that museums utilize their public outreach capacities to educate individuals as to the problems and the needs for more effective management procedures. More people go to museums on an annual basis then go to sporting events. Museums should take the initiative to instruct the public on current events relating to the protection of fossil resources. Because of the number of visitors that enjoy museums every year, these facilities are the ideal public forums for the presentation of information of this sort. Museum displays are very effective educational tools.

Public facilities have a responsibility to educate people on matters of environmental concern. As part of their educational mission, museums should be the intermediary between the general public, scientists, and land managers, with regard to the exchange of information dealing with resource protection. Museums would not exist without specimens and the information derived from them. We would know little about our ancient world without these resources and, thus, their preservation and protection is vital. Scientists and land management agencies should work closely with their local museums to show how we can all work as partners in the protection of our fossil heritage.

Benefits Based Management Applied to Paleo Recreation-Tourism Attractions

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A new technology is being developed in response to the needs of recreation providers which states more clearly their management directions, provides better information about visitor choice options, and improves customer relations. There is considerable interest in the concept in Norway, Denmark, Finland, and New Zealand; and it is being taught and practiced widely in Canada. When applied to management, this benefits approach to leisure is called Benefits-Based Management (BBM). Five pilot implementation projects are presently underway here at home: one each in Colorado, Minnesota, Oregon, New Mexico, and Virginia.

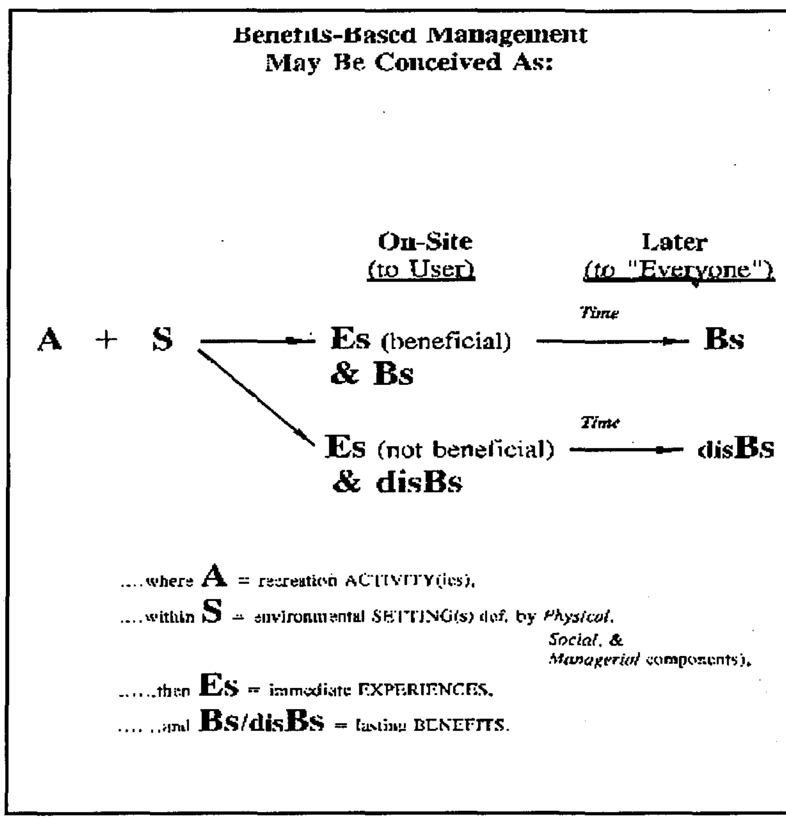
These efforts are beginning to demonstrate that BBM helps clarify visitor demands and needs as well as management outputs. It is also facilitating closer working relationships among a variety of recreation-tourism partners. In contrast with other earlier studies, the application of Benefits-Based Management is not restricted only to inventory and data gathering. The BBM framework is also being applied to the development of management objectives, marketing plans, and is being used to guide long-term monitoring and evaluation efforts.

Twenty years ago, outdoor recreation providers typically viewed the opportunities they provided for visitors to participate in recreation activities as the end products of their management efforts. Few managers then considered the kinds of settings within which those activities could occur any kind of broader framework. Few considered the profound effect which environmental settings have on the outcomes of recreation participation. Nonetheless, studies of recreation behavior have indicated for quite some time that visitors have as much, if not greater concern for the environmental settings of their recreation engagements as they do for the activities themselves. Moreover, recreation behaviorists discovered a connection between visitors' experiential outcomes and their activity-setting engagements. While not all experiences are as setting-dependent as others, the achievement of some experiences is directly dependent upon having the opportunity to engage in certain activities within certain other kinds of environmental settings.

Subsequently, these leisure scientists teamed up with outdoor recreation managers to apply this new knowledge to on-the-ground management situations. What resulted was an Experience-Based Management (EBM) framework wherein opportunities for visitors to participate in certain activities within highly valued settings are viewed as essential inputs to the production of satisfying experience outputs. These experiences are defined as psychological outcomes that are realized by individual recreationists on-site. For natural resource recreation providers this was all conceptualized in a recreation opportunity spectrum concept wherein all recreation opportunities could be arrayed on a spectrum from primitive to urban according to their physical, social and managerial setting characteristics.

Now Benefits-Based Management (BBM) is once more helping managers shift their product focus in two major ways. One is the outcome focus. Although EBM has been around for more than a decade, many managers have still not moved beyond simply describing activity and setting opportunities. Few have proceeded to write Experience-Based Management objectives and apply them. BBM goes beyond activity and setting inputs (primary outputs), and beyond intermediate experiences (secondary outputs), to improved conditions (final outputs) as a result of visitors' participation in the recreation activity and setting opportunities provided.

Secondly, like EBM, BBM helps managers expand their conceptual recreation management framework, continuing to consider both activity and setting inputs, but expanding the scope of outputs. It is within this expanded scope of desirable, improved-conditions outputs that the contributions of BBM are most profound. Like EBM, BBM builds on existing managerial frameworks, rather than replacing them. Therefore, in the same way that EBM helped us see that managing by activities (ABM) is necessary but insufficient in that it fails to consider other important inputs (settings) and outputs (experiences), BBM helps us see that managing for experiences (EBM) is also necessary but insufficient in that it does not consider other important outputs.



BBM defines a benefit as: "A change that is viewed to be advantageous or an improvement in condition (a gain) to an individual, to a group, to society, or even to another entity such as an endangered species - or the prevention of a worse condition...." (Driver et al.: 1991)

There are four primary differences between EBM and BBM:

1. More explicit Specification of Benefits
EBM must be recognized as an important, integral part of BBM; but BBM expands the EBM framework by **describing recreation outputs more explicitly**, whenever needed to clarify the value-added nature of benefits provided.

2. Psychological and Physiological
EBM defined visitor outcomes psychologically, but visitors also undergo physiological changes. **Benefits are defined by BBM to include both.**

3. On-Site and Long-Term
EBM looks at outcomes only as on-site phenomena, whereas **BBM traces outcomes over time.**

4. Individuals and Groups of Individuals
EBM considers only on-site, individual outcomes, but **BBM considers outcomes accruing to individuals as well as groups of individuals,** including those to Society and Culture (both households and communities), Local and Regional Economies, and the Environment.

Applied to on-the-ground management, the BBM concept has much to offer paleo resource managers, especially in terms of identifying and targeting for delivery a wider range of user benefits. Over 90 benefits have been identified to date. These targeted outcomes may be addressed in terms of explicitly-stated Benefits Based Management objectives. BBM can also facilitate the development of appropriate marketing messages to ensure that they promote more informed choices among visitors about the exact nature and location of various paleo adventure travel products.

The present educational focus of most paleontological visitor center facilities does not explicitly add as much value to visitors lives as it could. By way of contrast, and to maximize the value which paleo resources add to human lives, BBM research and its initial application to on-the-ground management suggests that the strategy for their management should be expanded beyond the dominant protection and education theme to target other benefits as well. In addition to paleo resources being managed to provide cognitive benefit opportunities, like nature learning, problem solving, and natural history awareness, they can be managed to provide other benefits as well.

These may include other benefit opportunities to individuals. Some are physiological in nature and could be targeted by implementing management actions which facilitate greater visitor interaction with the natural terrain, such as improved cardiovascular functioning, increased muscle strength, and reduced hypertension. Others are psychological in nature, and their delivery is to a large degree dependent upon the vision which land managers, communities and their tourism partners have for the paleo resource itself, the nature of visitor services to be delivered, and facilities needed to protect the resource and accommodate the visitor. Paleo managers may target opportunities for stress management, promoting a holistic sense of wellness, leadership development, creativity enhancement, spiritual growth, a greater sense of freedom, a sense of adventure and aesthetic appreciation.

Paleo managers may also target the delivery of socio-cultural benefit opportunities by structuring partnership management strategies with local communities to meet identified leisure needs of groups of individuals, either at the household level or for entire local communities. These may include opportunities for family bonding, reduced delinquency, community satisfaction, cultural or historical awareness and appreciation, cultural identity, and conflict resolution and harmony.

Stronger paleo partnerships with local communities also suggest that paleo resource managers consider targeting economic benefit opportunities. By formulating protection/maintenance and development/promotion strategies in close cooperation with local communities and the tourism industry, opportunities for increased job productivity among local residents or local and regional economic growth may be explicitly targeted. In the same way, paleo resource managers may explicitly target environmental benefit opportunities by promoting an improved environmental ethic, improved stewardship of fragile paleo resources, an improved understanding of human dependency upon natural resources and local communities, and greater political involvement in environmental issues among area visitors and residents.

IDENTIFIED BENEFITS

A. PERSONAL BENEFITS

Psychological

Better Physical Health and Health Maintenance
(mostly from habitual physical activity)
Cardiovascular benefits
Reduced or prevented hypertension
Reduced serum cholesterol and triglycerides
Improved control and prevention of diabetes
Reduced spinal problems
Decreased body fat/obesity
Improved neuropsychological functioning
Increaed bone mass and strength in children
Increased muscle strength and better connective tissue
Respiratory benefits (increased lung capacity)
Reduced incidence of disease

Mental health

Better Mental Health and Health Maintenance
Holistic sense of wellness
Stress management (meditation and restoration)
Catharsis
Reduced depression/anxiety
Positive changes in mood and emotion

Self concept/image

Personal Development and Growth
Self-confidence
Self-reliance
Self-competence
Self-assurance
Value clarification
Independence/autonomy
Humility
Leadership
Aesthetic enhancement
Creativity enhancement
Spiritual Growth
Adaptability

Cognitive

Cognitive efficiency
Problem solving
Nature learning
Culturing/history awareness/learning
Environmental awareness/understanding
Tolerance
Balanced competitiveness

Personal appreciation

Personal Appreciation/Satisfaction
Sense of freedom
Sense of control
Self-actualization
Flow/absorption
Exhilaration
Stimulation
Sense of advanture
Challenge
Nostalgia
Quality of life/life satisfaction
Creative expression
Aesthetic appreciation
Nature appreciation
Spirituality
Positive change in mood/emotion

B. SOCIO-CULTURAL BENEFITS

Community satisfaction
Pride in community/nation (pride in place/Patrioti
Cultural/historical awareness and appreciation
Reduced delinquency
Reduced social alienation
Community/political involvement
Ethnic identity
Social binding/cohesion
Conflict resolution/harmony
Social support
Support democratic ideal of freedom
Family bonding
Reciprocity/sharing
Social mobility
Community integration
Nurturance of others
Understanding and tolerance
Environmental awareness, sensitivity
Enhanced world view

Socialization/acculturation
Cultural identity
Cultural continuity

C. ECONOMIC BENEFITS

Reduced Health Costs
Increased productivity
Less work absenteeism
Reduced on-the-job accidents
Decreased job turn-over
International balance of payments (from tourism)
Local and regional economic growth
Contributions to net national econoic developmen

D. ENVIRONMENTAL BENEFITS
(at least partially influenced by leisure)
Stewardship/optional preservation
Husbandry
Understanding of human dependency
Environmental ethic
Political involvement in environmental issues
Environment protection
Ecosystems
Species diversity
Maintenance of natural scientific laboratories
Preservation of particular site

Paleo for People: Essential Recreation-Tourism Partnership Linkages

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Most of the nation's outstanding paleontological visitor centers are managed principally as museums. Preservation of their irreplaceable artifacts is primary, and the overwhelming focus of visitor management efforts centers on educating visitors about fossil resources themselves and related issues, including area geology and prehistoric ecology and climatology.

However, paleo resources also have a substantially broader appeal to leisure visitors including, but transcending, the educational motif. Managing paleo for people requires adopting real-world perspectives on visitor behavior, user desires, and the real tourism product. Several factors have contributed to this emerging perspective of managing paleo resources for the nature-based recreation and tourism experiences and benefits they offer.

Market research suggests that paleo resource partners should reconsider the rather specific recreation and tourism desires of their potential clients. Colorado Tourism Board research demonstrates that, even more significant than traditional forms of outdoor recreation activities, is the touring market. Though perhaps not as great as the outdoor market, Colorado's country resort visitor also has a substantial interest in natural resource related leisure products.

Service quality research has also furthered the notion of managing paleo resources to meet people's needs for satisfying experiences and more enduring leisure benefits. These research results have helped capture the elusive notion of quality. At least ten dimensions of service quality have been identified, along with at least four major obstacles to achieving it.

Our understanding of recreation and tourism products has broadened considerably. While a scientific perspective has tended to view actual fossil remains as the product, more recent behavioral recreation research suggests that there is a second-stage product of greater importance to both individual visitors and to affected and affecting local communities. This product consists of visitors' on-site recreation experiences and of the benefits that accrue to those same visitors and to local and regional communities. Analysis of potential benefits therefore must address both visitor desires and those of adjoining gateway and basecamp communities. Land managers, local paleontology support groups, and tourism industry officials must therefore be sensitive to a variety of issues.

One is the need to establish a better relationship between paleo resource, visitor, and facility management inputs and the resulting experience and benefit outputs. Indeed, the conservation of irreplaceable fossil resources and their study are of critical importance. So is the interpretation of those resources for public visitors, and all of the facilities needed both to conserve the resource and to promote its enjoyment. But, from a recreation and leisure perspective, all of these actions are simply inputs to the delivery of highly valued (we hope) on-site visitor experiences and of lasting off-site benefits individually to those same visitors, socio-culturally to households and communities, to local and regional economies, and to the environment.

All of this leads naturally to a second essential: involving all affecting and affected recreation-tourism providers as partners in the management of paleo attractions. Paleo resource proponents need also develop greater sensitivity to the kinds of management strategies that will be most responsive to visitor desires and to the needs of local communities. Paleo resource advocates should therefore consider building stronger alliances with their recreation-tourism partners to diversify paleo products beyond traditional on-site educational experiences. And recreation research increasingly suggests that emerging partnerships interested in delivering beneficial experiences to their visitors should also focus on outcomes that visitors take with them, rather than on managerial inputs such as buildings, exhibits, and programs.

This requires viewing paleo attractions more within a local-regional recreation-tourism context than from a site-based educational or scientific perspective. It thus compels cooperating providers to determine how paleo and other diverse regional attractions complementarily satisfy area visitors' experience and benefit preferences.

It also necessitates involving key recreation-tourism interests and affected communities early on in every visitor-oriented paleo partnership. At a minimum, local communities, including local governments and key interest groups, the tourism industry, and land managers, must be involved as equal partners. These partners must be cooperatively engaged in identifying both the kinds of benefits to be delivered to local and regional communities as well as strategies to ensure their actual delivery.

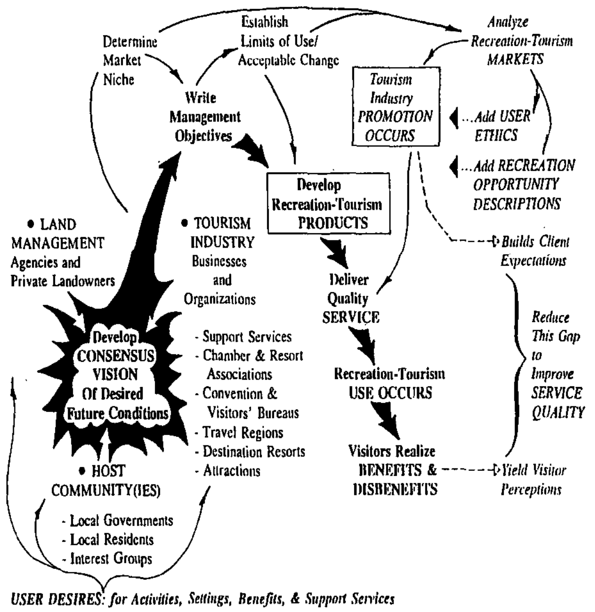
Adventure travel recreation-tourism has potential for delivering significant benefits to the lives of individual visitors, households and communities, to their economies, and to the environment. But it also has the potential for adversely impacting these same communities and visitors. The difference lies in the degree to which key sectors of the community are cooperatively involved in planning and managing their common future. Done right, adventure travel tourism can promote a community's sense of identity, maintain or strengthen its economy, improve residents' quality of life, and increase the satisfaction of its visitors and guests. Done wrong, it can split communities, foster social ills, destroy its distinctive market niche, and discourage its customers.

With proper understanding, involvement, planning, and management, adventure travel can ensure the sustained delivery of highly-valued recreation-tourism products as well as the community's significant market niche and its distinctive resources, cultures, aesthetics and lifestyles.

An essential ingredient for sustainable adventure travel is involving, appointing, and empowering a balanced recreation-tourism partnership organization, representing all affecting providers, to forge a consensus vision of their common future, develop objectives describing targeted adventure travel products, and develop implementing agreements that engage all affecting providers as cooperating partners in the delivery of targeted products on a sustainable basis.

A second non-negotiable is ensuring that the resulting plan design addresses all basic essentials. Beginning with a thorough assessment of community and resource assets and the statement of a definitive vision for the future, the following outline reflects these essential considerations.

THE ADVENTURE TRAVEL PRODUCTION PROCESS



Recreation-Tourism Adventure Travel Partnership Framework

1. Balanced Partnership Organization
• Form & Structure
• Types and Sources of Support

2. Community Attractions & Services
• Natural Resources
• Cultural Resources & Local Cultures

- Recreation Resources
- Hospitality Resources
- Attractions
- Adequacy of Lodging-Restaurant and Transportation Services

3. Visioning Process
- Community Values/Attitudes Inventory
- Desired Future Community: Lifestyles & Quality of Life Issues
- Identification of Product "Niche"
- Management Goals & Objectives

4. Product Development
- Resource Protection, Enhancement & Development
- Maintenance of Resource Quality
- Recreation Attractions
- Monitoring & Protection
- Infrastructure Protection, Enhancement & Development
- Accommodations/Restaurants
- Transportation/Traffic
- Medical/Police/Fire
- Visitor Services
- Interpretive Plan
- On-site Support Facilities

5. Marketing & Promotion
- Identify Markets
- Establish General Marketing Strategy & Techniques
- Establish a Promotion Program

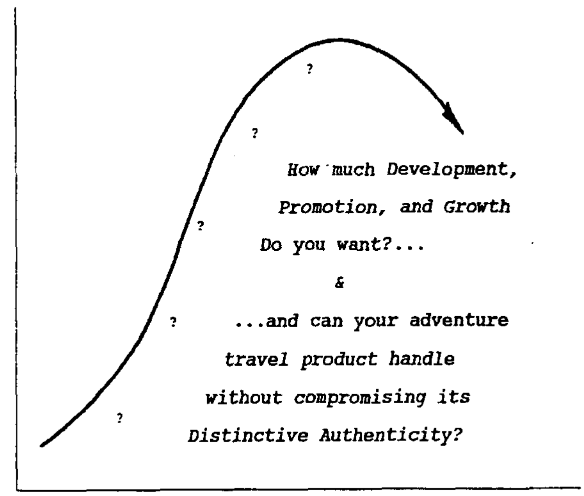
6. Funding & Financing
- Types & Sources of Funding /Revenue
- Budget/Funding Program
- Fund Leveraging
- Financial Projections

7. Implementation & Evaluation
- Partnership Management Roles
- Cooperative Management Agreement(s)

The Allocentrism-Psychocentrism Scale *
GROWTH AND DEVELOPMENT CURVE

GROWTH:

Size of Audience or Amount of Visitor Use



Authentic **Synthetic**

——With TIME, Development & Promotion Continue——>
Unless Planning Partners Build In Designed Limits!

Appealing to ALLOCENTRICS	Appealing to MID-CENTRICS	Appealing to PSYCHOCENTRICS

Note: ***All destinations move across this spectrum from left to right unless a carefully designed cooperative management strategy among all effecting partners has been developed to arrest this movement in order to ensure the sustained delivery of a specifically identified adventure travel product!***

* Adapted from Plog, Stanley C. 1991. **Leisure Travel: Making it a Growth Market...Again!** John Wiley and Sons, Inc., New York. Pp. 77-82.

BLM Paleontology "Stars" with "Jurassic Park"

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With the release of last summer's blockbuster "Jurassic Park," fossil fever hit a new high. Wyoming BLM anticipated a "bone rush" as movie viewers became prospectors. While amateur fossil collectors are welcome on public lands, vertebrate fossils, including dinosaur bones, are off limits. Fossils are, after all, not a renewable resource. Vertebrates, especially, are rare and fragile, and even fragments may be of scientific importance.

We wanted to reach fossil enthusiasts with a protection message, urging them to leave bones where they found them and to save them for future generations. To accomplish this, we decided Public Service Announcements (PSAs) would reach a wide audience and, if we could tie them in with the movie "Jurassic Park," we would create a lot more interest in them.

We began by contacting the author of the book, Michael Crichton. Working through his publicist, we negotiated with Mr. Crichton and eventually, he ended up writing the 30-second spot for us. Instead of telling people "Don't go pick up bones" the message stressed positive action "go see bones in a museum and leave fossils for professionals to collect."

At the same time, Wyoming BLM was negotiating with Steven Spielberg's company, Amblin Entertainment. They asked us to provide a proposal of what we wanted, so we asked for the works: the stars to voice the spots, music, and clips from the movie. Much to our surprise, Amblin agreed to everything and arranged for us to work with MCA Corporate to work out the details.

BLM staff went to Burbank, California for a press junket, which was held 3 weeks before the opening of the movie. Michael Crichton, Sam Neill, Laura Dern and Jeff Goldblum all agreed to voice the spots and MCA filmed them for us. With the help of BLM's Denver Service Center, spots were cut for both radio and television. We distributed the tapes to over 700 radio stations and 300 TV stations in 11 western states.

Did our message reach the public? Reports came in from all over Wyoming, Montana, and Colorado that they were being aired extensively throughout the summer months. The Fossil Fact Sheets that were prepared and distributed from each BLM office were also very popular.

What did we learn from our experience?

First: Don't be afraid to think big. When we first were brainstorming about doing PSAs for Wyoming using Michael Crichton, we had no idea it would snowball into such a big project. A project that started off as rather a joke ended up on the national media. We asked for help and ended up partnering with Amblin and MCA! They were interested in our project and eager to help.

Second: Keep your message positive. As Michael Crichton told us, "If you tell people DON'T PICK UP BONES, they will **NOT** hear the DON'T and will only hear PICK UP BONES." Tell people what they CAN do and where they CAN see fossils.

Our goal in starting was to let the public know the value of fossils; fossils need protecting and **you** can help us do that. With the help of a lot of BLM personnel and our partners in Hollywood, we got our message out.

Paleogeographic Analysis of Selected Sedimentary Units at Fossil Butte National Monument: A Case Study Providing Data Significant to Paleontologic Resource Management

H. Paul Buchheim, Professor of Geology, Department of Natural Sciences, Loma Linda University, Loma Linda, CA 92350

A paleogeographic study sponsored by a grant from the National Park Service (NPS) has provided detailed maps that reveal that most of the paleontologically important and richest beds actually lie outside the boundaries of Fossil Butte National Monument (FOBU). The paleogeographic maps indicate lake center, margin, and river inflow areas. Of the seven sedimentary units studied, five indicate a lake center 5 km south of the southern boundary of FOBU, and two show a lake center at the southern boundary. In addition to defining the lake center areas, the paleogeographic maps provide information concerning total organic carbon content, mineralogic composition, laminae thickness and quality, and sedimentary unit thickness. Figure 1 is an example of one of the data summary maps. Figure 2 is an example of a paleogeographic interpretations map based on the data in figure 1. Table 1 details the interpretations concerning various paleogeographic and environmental parameters.

The most abundant and well preserved fossil fish (for which FOBU was originally established) coincide with rocks rich in organic carbon, composed of calcite, and thinly laminated. All of these characters were mapped during the paleogeographic study and all point to the lake center areas (south of the monument boundaries) as having the highest potential for containing abundant and well preserved fossil fishes, reptiles, plants, insects, and other fossils. It is no surprise that the most valuable fossil fish quarries are located on private lands within these areas.

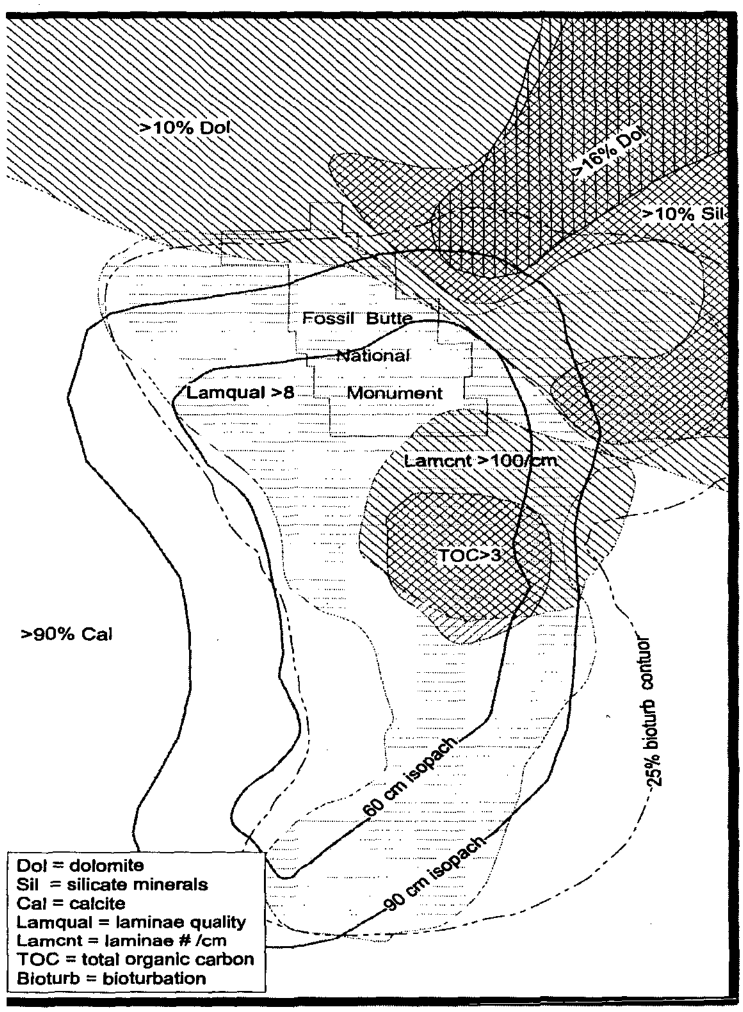


Figure 1. Unit 6 Summary Data Map.

The application of this primarily academic research to resource management is in the conclusion that the lake center where the most abundant fossil fishes are preserved is outside of the monument boundaries. The lake center area is composed of a mixture of Bureau of Land Management, state, and private properties. The NPS, whose interest centers on the preservation and scientific study of these fossil resources, needs to direct efforts towards some type of cooperative agreement with these other federal and state agencies to guarantee the preservation of these paleontological resources for future scientific study. In addition, it points out the need for continued scientific study of areas adjacent to NPS controlled lands by the NPS. In this case, the park boundaries of FOBU were determined without the advantage of more recent detailed scientific study, and I am sure the boundaries would have extended at least another ten kilometers south had this knowledge been available. Consequently, the value of academic research, and the need for cooperative efforts of paleontological resource management is demonstrated by this case study.

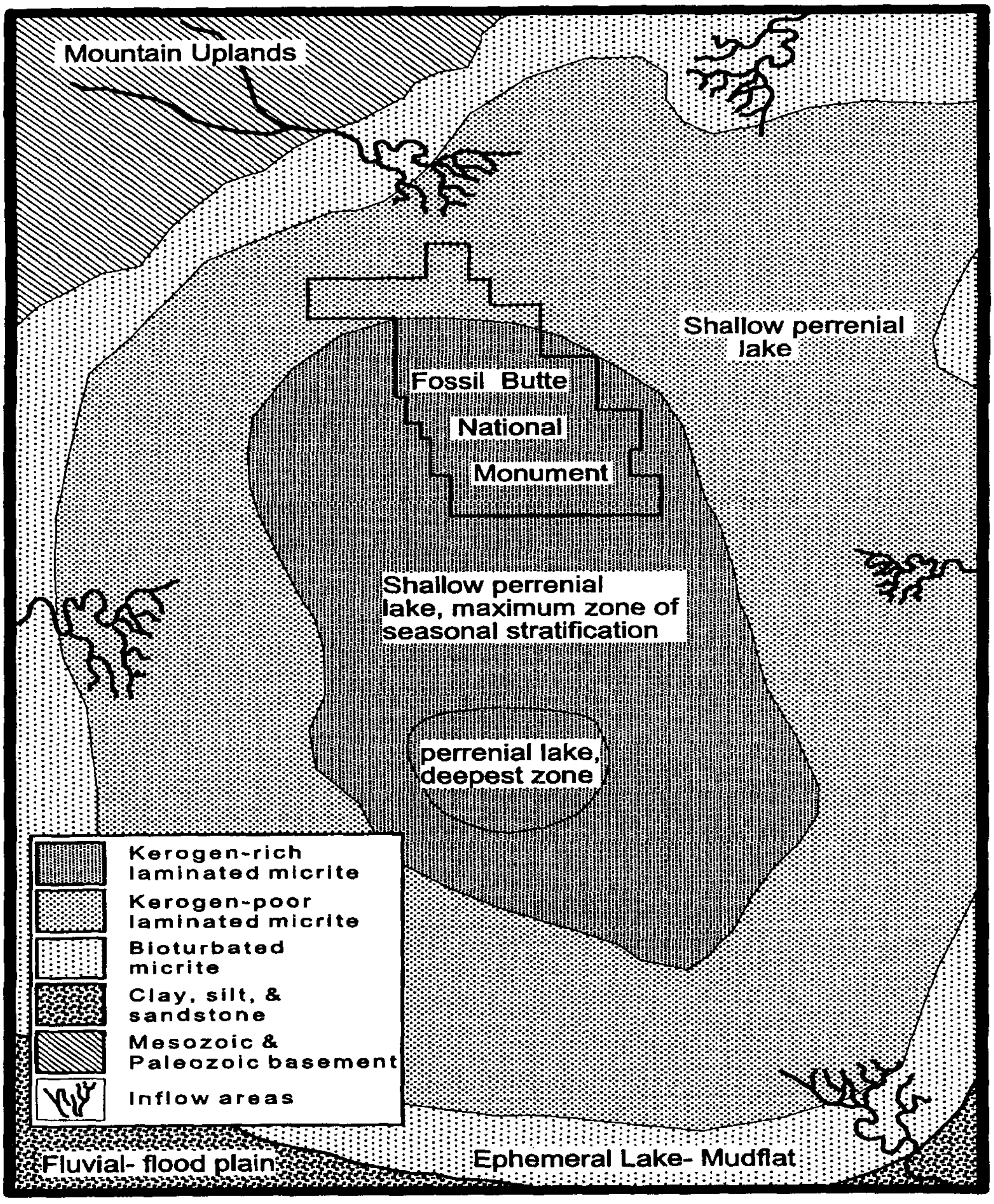


Figure 2. Paleogeographic Map

Table 1. Paleogeographic Interpretations

Lake center	Located about 6km south of Fossil Butte National Monument in the Clear Creek area. Lake center is estimated based on center of total organic carbon, laminae number, and laminae quality.
Aeolian (wind blown) siliciclastics:	Near the lake center is an area of higher silicate percentage (>3%). Generally a higher amount of silicate minerals would be expected nearer the margins of the lake. In this case, the relatively slower rates of calcite deposition at the lake center allows minor wind blown siliciclastics to show up. Nearer the margins higher rates of calcite production generally dilute out both siliciclastics and organic carbon.
Lake depth:	Lake depths were not great, generally around 8-20 meters.
Lake size:	Fossil Lake was near its maximum size (about 750 sq. km.) during unit 5b time. It had only regressed slightly from its maximum size during unit 4 time. Although the lake bottom gradient was low over most of the basin (see below), the lake bottom probably was steep in the northwest corner of the basin where it butted up against highlands.
Perennial Lake:	During unit 5b time Fossil Lake underwent only minor fluctuations, as indicated by a relatively narrow mudflat band. However, it should be pointed out that a marginal mudflat (1-3km wide) did band Fossil Lake during this time. A significant amount of dolomite (amount>6%) was generated on these mudflats, as indicated by the restriction of dolomite to the margins of the lake.
Inflow areas:	Inflow areas were generally broad fluvial-flood plain areas surrounding the lake. Fossil lake was clear during this period of time because the low gradient and broad flood plains served as sediment catchment areas. The very low percent of siliciclastic content supports this conclusion. The concentration of siliciclastics at lake center were derived as eolian dust (see above). Large volumes of clear, calcium-rich water reached the lake.
Geochemistry and Hydrographic characteristics:	Fossil Lake was a closed hydrographic system during most of its existence as indicated by marginal mudflats, dolomite, and zeolitized tuff beds. During periods of maximum expansion, including unit 5b, Fossil Lake may have had an outlet. No evidence of an outlet has been found, however this research concentrated on the lake deposits rather than surrounding fluvial deposits. Isotope data indicates fresher water conditions towards the margins of the lake. More negative numbers indicate fresher water conditions. Numbers less than -10 indicate very fresh waters while numbers more positive than -4 indicate saline waters.(*Janaway and Parnell, fig. 14,p.104,1989) This finding is consistent with data from calcite-dolomite ratios and associated tuff bed mineralogies that indicate a similar lake-ward trend from fresh to saline.

*Janaway,Timothy M. and John Parnell. 1989. Carbonate Productions within the Orcadian Basin, Northern Scotland: a Petrographic and Geochemical Study. Paleogeography, Paleoclimatology, Paloecology, v.70,p.89-195

Managing Extinct Ecosystems: The Program at Dinosaur National Monument

Daniel J. Chure, Park Paleontologist, National Park Service, Dinosaur National Monument, Box 128, Jensen, UT 84035

"This world is hell, and yet there are elements of heaven here. I do not at all like the way things go and the suffering we have to endure, yet when the success is won I can see that the tribulation has done me good. I have determined to do all I can myself and then when I can do no more I will have to leave it to the powers which are higher than I..."

Earl Douglass, discoverer of the Carnegie Quarry that became Dinosaur National Monument, 13 January 1926.

The history of managing fossil resources within the National Park Service (NPS) has a long and difficult history. Fossils were often ignored or, worse still, not even considered a resource to be managed. Natural resource managers felt they were cultural resources, and cultural resource managers felt they were natural resources. As a result, they often simply fell through the cracks. Thus, the above quote from Earl Douglass might, in some way, reflect how paleontologists felt about working for the NPS. However, the last decade has seen a sea change for fossils. They now receive the attention they deserve and are a player at the resource management table. This change in fossil resource management has been spectacular and beyond the wildest dreams of many. With this bright present and even better future, park paleontologists are moving beyond the management of fossils as objects to a more comprehensive view of them as parts of a larger whole - extinct ecosystems.

A Little History
The story of the discovery and historical collecting at the Carnegie Quarry and the establishment of DINO has been told several times and need not be recounted here. (McIntosh 1976, West and Chure 1984, Chure and McIntosh 1990.) For the purpose of this discussion we need only be concerned with the paleontology program at DINO over the last 40 years.

The long term NPS management objective for the Carnegie Quarry has been to expose the main bone-bearing horizon and to leave the bones in situ, just as they were deposited in a river channel some 145 million years ago. This objective has produced one of the most spectacular exhibits anywhere - some 1600 dinosaur bones from theropods, sauropods, stegosaurs, and ornithopods scattered across a 150 foot by 50 foot sandstone layer that is enclosed within a Visitor Center. This phase of the paleontological program was quite successful with both the visiting public and the paleontological community and has been adopted at several other areas.

Nevertheless, while this development was appropriate, it was at a cost. With all the emphasis and energies of the program being directed at the Carnegie Quarry excavations, little knowledge was gained about other fossil resources in DINO. By the mid-1980's it was clear that we needed to begin addressing those other resources in order to meet our mission. By the late 1980's we had shifted most of our energies to "backcountry" excavations. The dividends have been immense and have greatly improved our interpretive, science, and resource management programs.

Managing the Extinct Morrison Ecosystem
The rock formations of DINO Monument contain more than just fossils. Within these sediments there are extinct ecosystems, the remnants of worlds that are gone, but not totally lost. As DINO moved to a broader approach to managing this resource we realized that it was necessary to take a multidisciplinary approach to the resource. We needed not only a vertebrate paleontologist, but a wide range of paleontologists and geologists in order to understand, reconstruct, and protect the past.

For a variety of reasons we started by concentrating on the Morrison Formation. This is the rock unit containing the Carnegie Quarry and the one most likely to have abundant scientifically valuable fossils. First, we began excavations at several promising sites and they quickly produced important fossils of mammals, frogs, salamanders, lizards, and other organisms. This was followed by monies from the Natural Resources Preservation Program to fund two projects related to the Morrison within the Monument. The first was a paleontological inventory in order to determine the distribution, extent, and significance of its fossil resources. The second was a geological study to identify the environments present in the Morrison and how they changed through some 10 million years of deposition. This provided the geological framework in which to place the results of the paleontological inventory.

However, the geological study also addressed issues larger than simply the Morrison within DINO. We wanted to understand the significance of the Monument's exposures in the broader context of the Morrison as a whole, a formation with dozens of major dinosaur quarries and exposures of over 1 million square kilometers in the western US. In addition, we wanted to know how the exposures in DINO related to other Jurassic terrestrial deposits around the world. The decision to look at the Morrison in this broader context had profound positive impacts on the results of these studies.

What Was Learned

As a result of this work, the exposures within DINO are some of the most intensively studied pieces of Morrison real estate and will remain a critical reference area for all future Morrison studies.

Some 400 localities were discovered and documented by the paleontological inventory. A number of these sites became high priority for excavation and one produced a spectacular, nearly complete dinosaur skeleton belonging to a new genus and species of meat eater. This is one of the best skeletons of this kind of dinosaur found anywhere in world.

The geological study produced the needed framework for the fossils but also answered a number of fundamental problems about the Morrison, problems that have plagued paleontologists for over a hundred years. Among these are:

- Age of the Morrison: The discovery of datable volcanic ashes both low and high in the formation provided the first good solid dates on the beginning and end of Morrison deposition and the length of time represented by Morrison sediments.
- Position of Quarries: Nearly 100 quarries scattered across the Morrison have their stratigraphic positions determined and we now know how these quarries relate to one another temporally. This will allow paleontologists to study how the Morrison fauna evolved through time and has shown that some recent speculations about Morrison dinosaurs are incorrect.
- Morrison Flora: Many localities were sampled for pollen and spores, with spectacular results. Previous palynological work in the Morrison has produced very little material. However, new techniques developed specifically for this study have produced abundant material and is providing details of plant communities, food sources for the herbivorous dinosaurs, and a new ability to correlate the Morrison with Jurassic rocks elsewhere.
- Biozonation: Several groups of fossils, such as charophytes (freshwater algae), ostracods (freshwater crustaceans), pollen, and spores, have stratigraphic distributions that can be used to subdivide the Morrison into a number of zones. No such accurate and detailed biozonation has been previously available for the Morrison. These zones not only will help to correlate the Morrison at widely separated localities, but will test some current schemes which subdivide the Morrison on the basis of its dinosaur faunas.
- Environments: We now have good, detailed information on the mosaic of terrestrial environments in the Morrison within the monument and how they changed through time. Depositional environments identified include rivers, streams, proximal and distal floodplain, ponds, lakes, dune fields, etc. This provides an environmental context in which to place our fossil resources.

While I undertook the study of dinosaur fossils from our excavations, other specimens were sent to experts in those groups. Many new species have been identified and this has added considerably to our knowledge of Morrison biodiversity. It also has provided interesting data about distribution of vertebrate faunas within the Morrison as well as data about the variation in the composition of the faunas at different localities.

We did not forget about the Carnegie Quarry either. The National Science Foundation provided funding for a team to work on improving our understanding of the quarry. The current quarry face was photogrammetrically documented and digitized. Older quarry maps from the historical excavations were also digitized and combined to produce a single, complete map of all the thousands of bones which had been discovered at the site. A comprehensive database is being compiled for the collections as well as a CD-ROM library of scientific publications, photos, diary entries, etc. related to the excavations. This will allow for historical and scientific studies to be done which are currently difficult to do because of the scattered nature of the collections.

It is important that the results of our projects and studies are transmitted to the public. We provided briefings and training for interpretive staff to keep them abreast of what activities were going on in the park, what discoveries had been made, and what was the significance of those discoveries. This information was then incorporated into programs that the paleontology staff gave to visitors and the general pubic. I worked with regional newspaper reporters with an interest in paleontology and periodically received coverage for our work. We also wrote stories for the park newspaper, a copy of which is given to each visitor. Finally, all this new knowledge will be an important component when the museum exhibits are redone sometime in the future.

We are also interested in getting the information out to the scientific community. Researchers are encouraged to publish papers and present talks at professional meetings whenever possible. In 1994 an Interdisciplinary Symposium on Morrison Geology and Paleontology was held at the Denver Museum of Natural History and I served as one of the co-conveners. Many of the presentations included data from studies in Dinosaur. The proceedings of this symposium will be published by the Geological Society of America and will clearly show the importance of Dinosaur to understanding the Morrison.

The Future

The products of these studies showed us that our interdisciplinary approach had provided big benefits for our science, resource management, and interpretive programs. However, it was clear that much more could be learned about the Morrison ecosystem. Substantial funding has been obtained from the NPS Natural Resources Preservation Program to expand and extend the research. We are now embarking on a three year program to look at the Morrison ecosystem throughout the Rocky Mountain Region. This study will involve ten parks as well as critical areas between those parks. Our objective will be to understand the broad scale environmental, climatological, and biotic evolution of the entire Morrison ecosystem. Once again, the approach will be interdisciplinary, but the size of the team has been considerably expanded and we will apply innovative techniques (such as carbonate and nitrogen isotope studies) in an attempt to better delineate environment and clarify food web relationships. This is the largest such study ever undertaken in the Morrison and shows that NPS fossil parks have an important role to play in the international paleontological community.

References

Chure, D.J. & J.S. McIntosh, 1990, Stranger in a strange land: a brief history of the paleontological operations at Dinosaur National Monument, Earth Sciences History, 9(1), pp. 34-40.

McIntosh, J.S., 1977, Dinosaur National Monument, Constellation Press, Phoenix.

West, L. & D.J. Chure, 1984, Dinosaur: The Dinosaur National Monument Quarry, Dinosaur Nature Association, Jensen, Utah.

Bibliography

A bibliographical listing of paleontological and geological publications on DINO since the mid-1980s is available. Most of the papers relate directly to the Morrison Ecosystem Program. The bibliogaphy indicates the scope of scientific, resource management, and interpretive contributions being made at DINO and shows the advantages of having a robust and active research and resource management program. For a copy, write to Dinosaur National Monument, Box 128, Jensen, UT 84035.

Clones, Bones, and Interpretive Groans: Interpreting Dinosaurs in the Face of and Entertainment Megahit

Daniel J. Chure, Park Paleontologist, and Herm H. Hoops, Green River District Naturalist, National Park Service, Dinosaur National Monument, Box 128, Jensen, UT 84025

The astounding success of Ken Burn's PBS series, "The Civil War," undoubtedly had a major impact on visitation to Civil War National Park Service (NPS) units. The series certainly brought the tale of this titanic struggle to many citizens who previously may have had little interest in the Civil War. This publicity can help us in preserving our precious historical heritage from this tragic era.

Unfortunately, there is nothing on television about NPS natural history units which is even remotely comparable to The Civil War. Of course, the PBS series, "Nature," has had a number of excellent programs about individual parks, their resources, and their problems. As good as these may be, none has matched the critical acclaim of Ken Burn's documentary. There is, of course, "Close Encounters Of The Third Kind," which certainly increased visitation to Devil's Tower. However, we suspect that this surge in visitation had little to do with increased interest in the geological resources of the park, but was sparked by the curiosity to see the landing zone. Later (and probably in no small part due to the movie) Devil's Tower was elevated to the status of a Vortex Point for one of the nonsensical "Harmonic Convergences"!

Paleontological resources in the NPS have fared even more poorly. As far as television is concerned, NPS fossil units are usually relegated to occasional bit parts in larger productions, except for a few locally produced documentaries. Fossils have not fared much better in the cinema. The only NPS fossil movie we know of is "The Crater Lake Monster," A 1977 Crown International production which has been generously described by Michael Weldon (1983) as:

"For animation fans only. A low-budget, badly acted independent feature starring a briefly seen animated dinosaur. A meteor reactivates the dormant creature; its final battle is with a snowplow. It was animated in "Fantamation" by David Allen, who has done good work on other low budget films such as Equinox and Flesh Gordon and does great TV ads with Poppin Fresh, the Swiss Miss, and Mrs. Butterworth."

It is ironic that with such a history, dinosaurs would end up as the focus of the greatest money-making movie in cinema history - the colossal "Jurassic Park" - which was released just in time for the vacation season and dominated the popular culture for the entire summer.

The implications for the interpretive program at Dinosaur National Monument were clear well before the movie was released. Like the proverbial silent screen heroine we were tied to the railroad tracks and the steam locomotive was speeding our way. However, no square-jawed hero was waiting in the wings to run out, untie us, and sweep us to safety far from the tracks. We knew there was no escape. Our only question was, "How can we survive the impact?"

The Plan

In reality, we had several advantages. "Jurassic Park" is at least about dinosaurs and was therefore relevant to our resources (even though most of those shown in the movie, i.e. *Tyrannosaurus, Parasaurolophus, Triceratops*, and the villainous *Velociraptor*, are Cretaceous, not Jurassic, dinosaurs). Other fossil parks, such as John Day and Hagermann Fossil Beds, contain the remains of animals and plants that lived long after the dinosaurs, but would nonetheless have to cope with dinosaur-crazed visitors with eyes still glazed over from Spielberg's special effects extravaganza.

Our fundamental interpretive decision was that we were **not** going to interpret "Jurassic Park." Nor would we be doing campfire programs built around the movie. On the other hand, we were not going to ignore it either. Visitors were going to come here hopped up on dinosaurs and we decided early on that we would use the popularity of the movie to get the message out about our fossil management and science program. "Jurassic Park" would be our tool, not our focus.

Every visitor entering the Monument gets a free copy of the park newspaper "Echoes." In 1993 the entire front page was given over to dinosaurs. Greg Paul, a well known dinosaur artist, was kind enough to let us use one of his sketches - a particularly dramatic confrontation between Jurassic dinosaurs - as a cover illustration. This drawing caught the readers eye and naturally led to reading the text, which was about our work reconstructing the dinosaur ecosystem buried within the park (Figure 1).

FIGURE 1: The cover of the 1993 edition of ECHOES, the newspaper of Dinosaur National Monument. Our objective was to combine striking artwork with hopefully interesting text in order to attune the visitor to what the Monument's paleontology program is about.

ECHOES Special Edition • A Guide to Dinosaur National Monument • 1993-94 • FREE

A *Real* Jurassic Park!

By Dan Chure, Park Paleontologist,
Dinosaur National Monument

The film *Jurassic Park* tells the story of how a group of genetic engineers are able to clone several species of dinosaurs and ultimately bring them back to life for a most unusual amusement park. The idea is exciting — even if not scientifically possible. Any paleontologist would certainly give his or her eye teeth for a five minute look at a living *Tyrannosaurus rex.*

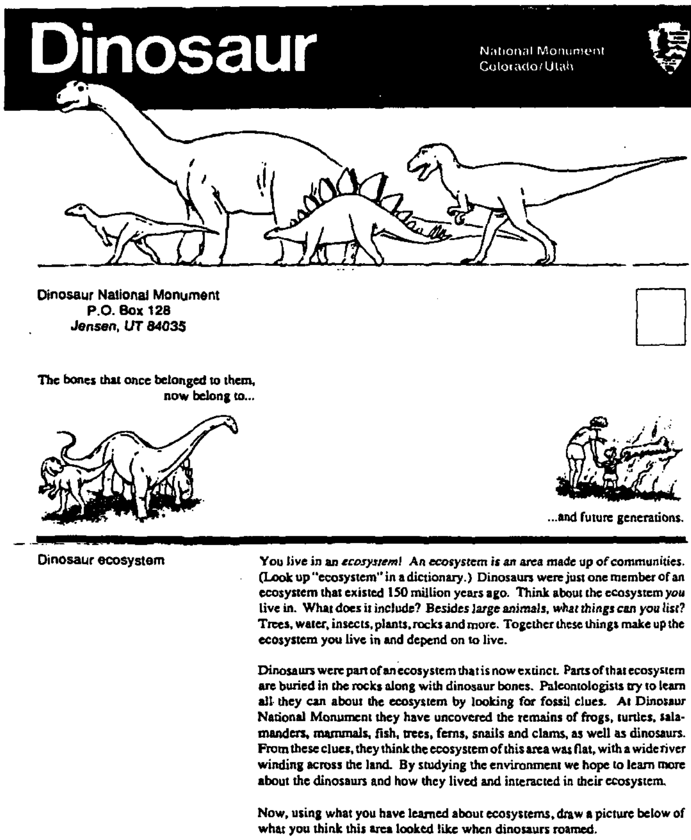
Here at Dinosaur National Monument we too are reconstructing dinosaurs. Unlike novelists and movie makers, we are constrained by the rules of the science of paleontology. Our tools are hammers and chisels, shovels and sandbags, geological maps and field notebooks, microscopes and cameras. These tools are used for research in the field and laboratory to better understand the extinct ecosystems buried in the Jurassic age rocks of the Morrison Formation in Dinosaur National Monument.

Visitors are often surprised to learn that not all of our fossils are dinosaurs. Many other kinds of ancient life forms have been found here — snails, crustaceans, fish, salamanders, frogs, turtles, mammals, footprints, algae, horsetail rushes, ferns, conifers and cycads. Using special techniques, even fossil pollen and spores have been extracted from the rock! What we have uncovered is a rich and complex plant and animal community, ranging from microscopic pollen to gigantic brontosaurs, that lived during the Jurassic Period, some 150 million years ago.

The fossils are found through careful field work, excavated from the site, and brought back to the laboratory in the Quarry Visitor Center where they are freed from the rock, studied and ultimately described in scientific publications. While some specimens are studied here, others are loaned to specialists, some as far away as Russia.

Geologists working in the Monument also contribute to our reconstruction. Some study the rocks to determine the types of environments which existed here. At some sites geologists and paleontologists work together to determine how a fossil deposit came to exist while others use volcanic ash to determine the rock's age.

The information gathered from these studies is used in reconstructing our long lost Jurassic ecosystem. Thus, in a very real sense, the work at Dinosaur is not done in isolation, but rather as part of a worldwide scientific endeavor to learn more about the past and to reconstruct the dinosaurs and the world they lived in. That is the difference between the *reel* Jurassic Park and Dinosaur National Monument — a REAL Jurassic park.



Dinosaur

National Monument
Colorado/Utah

Dinosaur National Monument
P.O. Box 128
Jensen, UT 84035

The bones that once belonged to them,
now belong to...

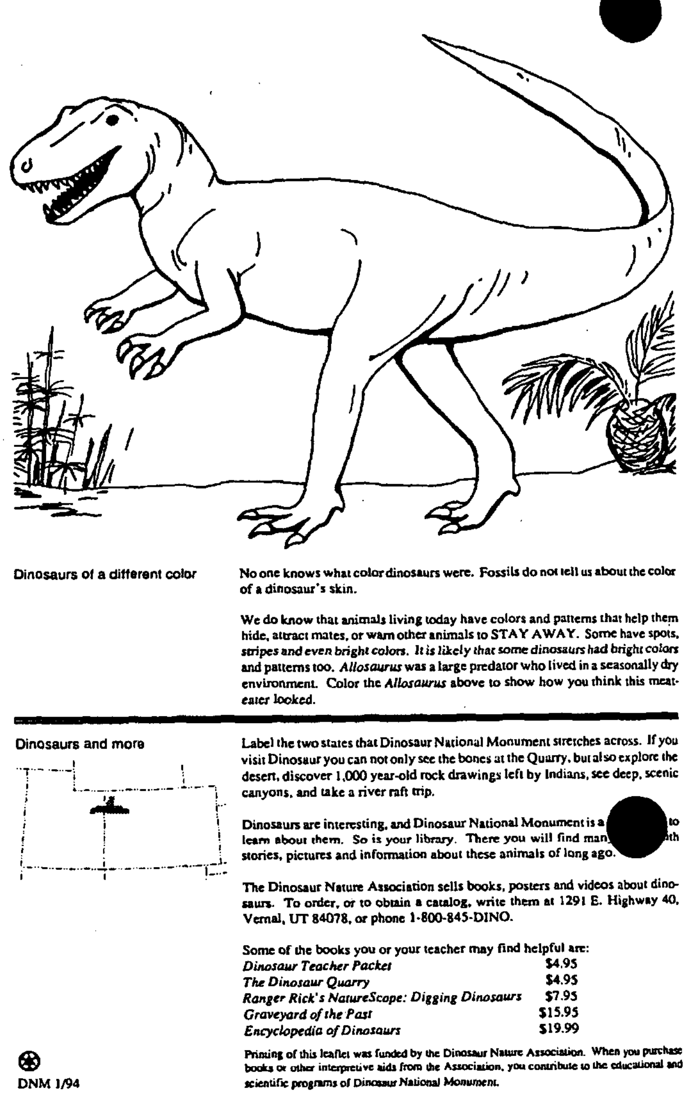
...and future generations.

Dinosaur ecosystem

You live in an *ecosystem! An ecosystem is an area made up of communities.* (Look up "ecosystem" in a dictionary.) Dinosaurs were just one member of an ecosystem that existed 150 million years ago. Think about the ecosystem *you* live in. What does it include? Besides large animals, *what things can you list?* Trees, water, insects, plants, rocks and more. Together these things make up the ecosystem you live in and depend on to live.

Dinosaurs were part of an ecosystem that is now extinct. Parts of that ecosystem are buried in the rocks along with dinosaur bones. Paleontologists try to learn all they can about the ecosystem by looking for fossil clues. At Dinosaur National Monument they have uncovered the remains of frogs, turtles, salamanders, mammals, fish, trees, ferns, snails and clams, as well as dinosaurs. From these clues, they think the ecosystem of this area was flat, with a wide river winding across the land. By studying the environment we hope to learn more about the dinosaurs and how they lived and interacted in their ecosystem.

Now, using what you have learned about ecosystems, draw a picture below of what you think this area looked like when dinosaurs roamed.



Dinosaurs of a different color

No one knows what color dinosaurs were. Fossils do not tell us about the color of a dinosaur's skin.

We do know that animals living today have colors and patterns that help them hide, attract mates, or warn other animals to STAY AWAY. Some have spots, *stripes and even bright colors. It is likely that some dinosaurs had bright colors* and patterns too. *Allosaurus* was a large predator who lived in a seasonally dry environment. Color the *Allosaurus* above to show how you think this meat-eater looked.

Dinosaurs and more

Label the two states that Dinosaur National Monument stretches across. If you visit Dinosaur you can not only see the bones at the Quarry, but also explore the desert, discover 1,000 year-old rock drawings left by Indians, see deep, scenic canyons, and take a river raft trip.

Dinosaurs are interesting, and Dinosaur National Monument is a ... to learn about them. So is your library. There you will find man... th stories, pictures and information about these animals of long ago.

The Dinosaur Nature Association sells books, posters and videos about dinosaurs. To order, or to obtain a catalog, write them at 1291 E. Highway 40, Vernal, UT 84078, or phone 1-800-845-DINO.

Some of the books you or your teacher may find helpful are:

Dinosaur Teacher Packet	$4.95
The Dinosaur Quarry	$4.95
Ranger Rick's NatureScope: Digging Dinosaurs	$7.95
Graveyard of the Past	$15.95
Encyclopedia of Dinosaurs	$19.99

Printing of this leaflet was funded by the Dinosaur Nature Association. When you purchase books or other interpretive aids from the Association, you contribute to the educational and scientific programs of Dinosaur National Monument.

DNM 1/94

FIGURE 2: The two sided, free mail handout developed to stimulate questions in young minds already saturated with leaping, slashing, and drooling dinosaurs. Note the arrangement of the address block which indicates that the fossils at Dinosaur National Monument belong to them. Thus, they have a direct interest in the protection and preservation of the bones.

Because visitors get to the Monument's Quarry Visitor Center via a free shuttlebus which runs every 15 minutes, we hoped that many of them would use that time to read the cover story and become attuned to what the park was all about.

Training of our seasonal and permanent interpretive staff also took the movie into account. We knew that the story's central gimmick - the use of fossil DNA to clone dinosaurs - was sure to generate questions about whether or not any DNA was preserved in our dinosaur bones. We made the limitations and problems of this technology clear to the staff so that they could responsibly answer that question. But once they answered it and had the visitor engaged, it was their responsibility to exploit that opening to tell visitors about some part of our program, such as mineralogical studies on the bones designed to elucidate the fossilizatio process in the Monument.

We encouraged interpreters to be creative, to use any opportunity to respond to a "Jurassic Park" question with a Dinosaur National Monument answer. For example, the opening scene of "Jurassic Park" shows a quite fanciful use of seismic techniques to locate dinosaur skeletons with resultant imagery almost as crisp and clear as a 35mm photograph. Ah, if only it were so! Although there has been some experimentation with this technology, the results have been equivocal. However, during the summer of 1993 we were completing a three year excavation of a spectacularly complete and totally new carnivorous dinosaur skeleton. Visitor questions about the use of ground penetrating technology for hunting dinosaurs could be turned into a discussion about how difficult excavations actually can be - hot, noisy, butt and back breaking work, followed by lots of lab preparation and study. The reality of science is a far cry from film fantasy!

Additions were made to the Quarry Visitor Center fossil exhibits to take advantage of the rampant dinomania to publicize our program. These new exhibits focused on recent research in Dinosaur and one of them, the discovery of an embryo of the herbivorous dinosaur *Camptosaurus*, had something in common with the movie.

We anticipated an increase in children's letters and that correspondence actually doubled during 1993. In addition to sending them the standard park information about dinosaurs, we developed a free mail handout which, rather than feeding them information, challenged them to think and search for answers (Figure 2).

Everyone wanted to get on the "Jurassic Park" bandwagon. Thus, we had a record number of requests from the press, television stations, and independent documentary film makers to shoot in the park. Most amounted to only a few minutes of broadcast time, but several were considerably longer and some were almost exclusively about Dinosaur National Monument. This was a great opportunity for us to get coverage for many of our discoveries, fossil frogs, salamanders, mammals, dinosaurs; a veritable ecosystem buried within the mudstones and sandstones known as the Morrison Formation. The resultant productions were of mixed quality, but several were quite good and gave us quality coverage about the direction and importance of our paleontology program.

The Results

All in all, we feel rather good about the summer of "Jurassic Park." We managed to ride the tiger without getting tossed, and used this great surge of dinomania to get our message out to a wide and diverse audience. This was because we carefully thought ahead about the possible impacts of what was clearly going to be a blockbuster movie and developed strategies to try to use this opportunity to get our message across. That's not to say that our staff did not get bombarded with questions about "Jurassic Park," or that some did not weary of answering for the thousandth time the question about whether there's any DNA in these bones. However, without forethought and planning we might have easily become bogged down in the minutiae of the movie and issues which do not relate to the mission of Dinosaur National Monument. Finally, our success is the direct result of close cooperation between the science and interpretive programs at Dinosaur. Both programs, as well as the visitor, benefited from that joint effort.

So, the good news is that, unlike a silent screen heroine, it is possible to survive being hit by the train. The bad news is that production on "Jurassic Park II" is due to begin in early 1995! Does anyone know if Post-Jurassic Park Interpretive Stress Disorder will be covered under the new health care plan?

Reference

Weldon, M., 1983, The Psychotronic Encyclopedia of Film, Ballantine Books, N.Y.

Vegetational History and Climatic Transition in an Eocene Inter-Montane Basin: Plant Microfossil Evidence from Fossil Butte National Monument, Wyoming

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Fossil Lake was one of three major Eocene lakes whose sediments now comprise the Green River Formation. Fossil Lake was located in southwestern Wyoming, adjacent to the western flank of the much larger Lake Gosiute. Lake Gosiute covered much of southern Wyoming and part of Colorado in the Green River, Great Divide, Washakie, and Sand Wash basins. The third lake, Lake Uinta, spanned parts of Colorado and Utah in the Piceance Creek and Uinta basins. The Green River Formation forms a series of large lenses of lacustrine sediments that intertongue with the fluvial Bridger and Wasatch Formations.

The rocks and fossils of the Green River Formation have attracted the interests of geologists and paleontologists since the mid-1800's. Most of the previous research has focused on the rich oil shales and fossil fish of the Green River Formation. In contrast, relatively little work has been published on the fossil flora of the Green River Formation. Studies by Brown (1929, 1934) and MacGinitie (1969) of the macroflora, and by Bradley (1931), Wodehouse (1933), Leopold and MacGinitie (1972), and Newman (1974, 1980) of the palynoflora have provided the most information about the Green River Formation fossil flora. However, none of the previous studies have examined the Green River Formation palynoflora in Fossil Basin. Consequently, this study is focused on the palynoflora of the Green River Formation deposited in ancient Fossil Lake.

The advantages of studying the palynoflora are:

- Pollen and spores are more resistant to degradation than most other plant parts.
- Also, because of their small size (usually < 150 µm) they are more easily transported and deposited as sedimentary particles.
- Because they are produced in large quantities, they are often preserved in statistically significant numbers.

The objectives of this study are:

- To document the palynoflora assemblage and the vegetation of the area in and around Fossil Lake during deposition of the Fossil Butte Member.
- To examine the stratigraphic distribution of significant taxa from the palynoflora to aid in determining any climatic fluctuations that might have occurred during deposition of the Fossil Butte Member of the Green River Formation.
- To compare the palynological data with available sedimentological and some other paleontological data to aid in our understanding of the depositional environment of the Green River Formation in Fossil Basin.

In previous studies of the Green River Formation outside of Fossil Basin, Brown (1929, 1934) interpreted the Green River Flora as an assemblage of plants from warm, wet lowlands combined with plants transported from surrounding cool, dry uplands. In the Uinta Basin, MacGinitie (1969) interpreted the flora to be representative of warm temperate to tropical floras similar to those that now exist in Mexico and some parts of Central and South America. In contrast, based primarily on his study of the palynoflora, Wodehouse (1933) believed that Lake Uinta existed in a hot, desert valley and was fed by streams originating in surrounding highlands where there was greater precipitation. He also suggested that the lake was shallow and muddy with extensive marshy areas along the margins. In addition, the presence of conifer pollen provided evidence for the existence of a flourishing "mesophytic forest" in the neighboring highlands (Wodehouse, 1933).

In a recent sedimentological study of the Green River Formation in the Greater Green River Basin, Roehler (1993) concluded that Eocene climates ranged from cool temperate to tropical. He also concluded that the climates were affected by terrestrial factors such as latitude, altitude, regional geography, tectonism, and volcanism; and by astronomical factors such as seasonal changes, a 21,000 year precession of equinox cycles, and 100,000 year eccentricity cycles.

The purpose of the current study is to focus on the palynoflora and the information it can provide about the terrestrial factors that affected the paleoclimate in Fossil Basin. Outcrop samples collected from three measured sections representing the center, the margin, and intermediate areas of Fossil Lake yielded well preserved plant microfossil assemblages. These assemblages that occur within the Fossil Butte Member of the Eocene Green River Formation indicate that the vegetational history was dynamic during the life of Fossil Lake.

The depositional and vegetational history of Fossil Lake is divided into three stages or phases. These are equivalent to the lower, middle, and upper units described by Buchheim (1994). During the early phase of Fossil Lake, upland vegetation is dominant in the palynoflora record.
The predominance of *Pinus* (pine), *Picea* (spruce), *Carya* (hickory or pecan), *Platycarya*, and *Corylus* (hazel) suggests that the area near the lake was heavily wooded. However, the pollen of *Pinus*, *Picea*, *Alnus* (alder), *Carpinus* (hornbeam), and *Tilia* basswood) represent vegetation similar to that which MacGinitie (1969) interpreted to occur 3,000 feet above Lake Uinta. Therefore, pollen from the surrounding highland floras must have been carried into Fossil Lake by streams. At the lower elevations, vegetation composed of *Alnus*, *Carya*, *Corylus*, *Platycarya*, *Podocarpus*, *Tilia*, and *Ulmus* (elm) grew. Surrounding Fossil Lake itself, forests of *Populus* (poplar), *Pterocarya* (wingnut), and *Salix* (willow) grew on the floodplains and along the streams, while in the moist lowlands, cattails, ferns, and horsetails thrived. Important climatic indicator taxa, such as *Abies* (fir), *Picea*, *Alnus*, *Corylus*, and *Pterocarya*, are all elements of warm temperate or cooler climates. The other dominant taxa during this time have wider climatic ranges.

As Fossil Lake developed during the middle phase, moist lowland and hardwood vegetation continued to develop on the surrounding lowlands and floodplains. *Salix* and other riparian vegetation, such as *Platanus* (sycamore) and *Populus*, thrived along the streams that emptied into the lake. Pollen of *Ulmus*, *Carya*, and *Chenopodiaceae* were dominant. The vegetation at the lower elevation appears to have become better developed and taxonomically more diverse perhaps due to increased rainfall. During this time, the upland vegetation of spruce, pine, alder, etc. may have been partially displaced upward by elements from the warmer, lowland vegetation. Sedimentological evidence (Buchheim, 1994) suggests that Fossil Lake reached its broadest extent during this time. The majority of the palynomorphs deposited during this time have broad climatic ranges. However, pollen of the family Bombacaceae, which ranges from tropical to subtropical, was present in low quantity. Based on the presence of Bombacaceae and the scarcity of forms found in cooler climates (i.e., *Abies*, *Picea*, *Alnus*, *Corylus*, and *Pterocarya*) suggest that the climate during this time was more subtropical.

As regional uplift occurred during the late phase, Fossil Lake began to diminish in size. Conifers and other upland vegetation became more dominant and eventually were the major constituent of the plant microfossil assemblages. Pollen of the lowland floras such as *Carya*, *Platycarya*, *Populus*, *Quercus* (oak), *Tilia*, and *Ulmus* are still well represented. However, rainfall was probably more restricted to the highlands where *Abies*, *Picea*, *Pinus*, *Podocarpus*, and a variety of ferns flourished. Shallowing of Fossil Lake is indicated by the increased abundance of *Taxodium* pollen during the late phase. Pollen of cool temperate taxa, such as *Picea*, *Tsuga* (hemlock), *Castanea* (chestnut), and *Pterocarya* indicate that the climate may have become cooler during the decline of Fossil Lake. However, the continued presence of Bombacaceae indicates that the transition was gradual. Floral elements indicative of arid or semiarid environmental conditions are conspicuously absent from the plant microfossil record.

Overall, the mixture of floral elements from subtropical to warm temperate climates indicates that the climate may have fluctuated from the warm temperate climate of the early phase to a more subtropical climate in the middle phase followed by a return to a warm temperate climate during the late phase. As a whole, the palynoflora is well represented by subtropical (83%) and warm temperate taxa (93%). The presence of *Platycarya* during all three phases also suggests that the climate was one of high humidity and abundant summer rainfall, typical of modern China and Japan where *Platycarya* grows today (Leopold and MacGinitie, 1972).

In contrast, the sedimentological record (Buchheim, 1994) during the late phase of Fossil Lake suggests that the area was becoming cooler and drier during this time. Consequently, the apparent contradiction between the sedimentological and plant microfossil records during the late regressive phases of Fossil Lake must be resolved by invoking local and tectonic controls on lake deposition rather than climatic controls. The apparent contradiction suggests that the intermontane setting and accompanying rain shadow effect masked the overall climatic controls on the vegetation around ancient Fossil Lake.

References

Bradley, W.H., 1931, Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah: U. S. Geological Survey Professional Paper 168.

Brown, R.W., 1929 [1930], Additions to the flora of the Green River Formation: U. S. Geological Survey Professional Paper 154-J, pp. 279-292.

_____ 1934 [1935], The Recognizable Species of the Green River Flora: U. S. Geological Survey Professional Paper 185-C, pp. 45-77.

Buchheim, H.P., 1994, Eocene Fossil Lake: a history of fluctuating salinity, in Renaut, R., and Last, W., eds., Sedimentology and Geochemistry of Modern and Ancient Saline Lakes: Society for Sedimentary Geology, Special Publication #50.

Leopold, E.B., and H.D. MacGinitie, 1972, Development and affinities of Tertiary floras in the Rocky Mountains, in Graham, A., ed., Floristics and paleofloristics of Asia and eastern North America: Amsterdam, Elsevier Publishing Co., pp. 147-200.

MacGinitie, H.D., 1969, The Eocene Green River flora of northwestern Colorado and northeastern Utah: California University Publications in Geological Science, v. 83.

Newman, K.R., 1974, Palynomorph zones in Early Tertiary formations of the Piceance Creek and Uinta Basins, Colorado and Utah, in Guidebook to the Energy Resources of the Piceance Creek Basin, Colorado: Rocky Mountain Association of Geologists, 25th Annual Field Conference, pp. 47-55.

_____ 1980, Geology of oil shale in Piceance Creek Basin, Colorado, in Colorado Geology: Denver, Colorado, Rocky Mountain Association of Geologists, pp. 199-203.

Roehler, H.W., 1993, Geology of the Eocene Wasatch, Green River, and Bridger (Washakie) Formations, greater Green River Basin, Wyoming, Utah, and Colorado: U. S. Geological Survey Professional Paper 1506-F.

Wodehouse, R.P., 1933, Tertiary pollen - II, The oil shales of the Eocene Gree[illegible] River Formation: Torrey Botanical Cl[illegible] Bulletin, v. 60, no. 7, pp. 479-524.

Extinct Faunas in Northern Rockies and Plains Archaeological Contexts

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Archaeological and paleontological faunas from the late Pleistocene are lightly documented in Montana when compared to contiguous Northern Plains (Graham et al. 1987), Wyoming Basin and Bighorn Mountains (Anderson 1974; Walker 1982, 1987; Gilbert and Martin 1984; Chomko and Gilbert 1987), and Plateau areas (various). However, a number of research developments during the last 15 years in Montana, especially since the mid-1980s, suggest that a rich fossil legacy awaits research.

The First Montanans Search Program operated by the Museum of the Rockies investigates in situ late Pleistocene/early Holocene faunal assemblages as one of several Paleoindian (11,500-7,500 B.P.) site prospection strategies. Stratified, multicomponent Paleoindian campsites underlain by fossil-bearing deposits are primary targets for evaluation and research. Multidisciplinary archaeological investigations in the Montana Rockies have, for instance, recovered utilized fossil species from several buried living surfaces (Folsom, 10,980 B.P. *Bison* sp. at Indian Creek [24BW636], Davis 1984; Davis et al. 1987; Davis and Greiser 1992: and Folsom, 9740 B.P. *Bison* sp. at MacHaffie [24JF4], Forbis and Sperry 1952; Davis et al. 1991) at stratified Paleoindian campsites in the Elkhorn Mountains in west-central Montana.

Excavation of Paleoindian cultural deposits elsewhere in the southwestern Montana Rockies has exposed still earlier natural fossil assemblages extant in the same sedimentary column (*Camelops* sp., *Acinoynx trumani*, *Equus* sp., and *Ovis canadensis catclawensis* at Sheep Rock Spring [24JF292] on Bull Mountain (Wilson and Davis 1994). The initial occupation is dated to 9380 B.P. In the Centennial Valley, a late Pleistocene (ca. 32,000-25,000 B.P.) bonebed (*Bison* sp., *Ursus americanus*, *Homotherium serum*, *Ondatra zibethicus*, *Castor canadensis*, *Equus* sp., *Camelops* sp., *Antilocapra americana*, and *Mammuthus* sp.) exposed by erosion at the Merrell site [24BE1659] on Bureau of Land Management property underlies a prehistoric cultural debris (Dundas 1990, 1992).

Only rarely thus far have buried fossil finds presented a possible Paleoindian association, as was the case with a *Mammuthus imperator* discovery at the 11,300 B.P. Lindsay Mammoth site [24DW559] on the plains of eastern Montana (Davis and Wilson 1985). The archaeological recovery of mammoth elements amidst bonebeds of more numerous species has occurred at Mill Iron (Goshen, [24CT30], *Bison* sp.) in southeastern Montana (Frison 1987, 1991) and Mammoth Meadow at the South Everson Creek site [24BE550] (Bonnichsen at al. 1992).

Tantalizing indications of possible human association with *Symbos cavifrons*, the woodland musk-ox, and with *Ursus arctos middendorfi*, the big brown bear, and *Bison occidentalis* and projectile points at Blacktail Cave (Melton 1978; Napton 1988) in west-central Montana, Plainview (or Goshen) and Metzal (Davis et al. 1988) in type, remain to be tested. A less promising co-occurrence of late Pleistocene species is known from Point-of-Rocks Cave [24MA305] (Davis and Johnson 1988) along the west facing slope of the north end of the Tobacco Root Mountains in southwestern Montana, overlooking the Jefferson River: *Equus* and *Machairodus*. Only a single projectile point (Agate Basin?) recovered outside the cave in the 1930s-1950s period is conceivably associated with a late Pleistocene archaeological complex.

The location and study of in situ extinct late Pleistocene and early Holocene faunas is basic to the quest for evidence of the First Montanans. Those numerous and diverse megaherbivores and possibly dependent carnivores would become prey to hunter-gatherers who entered and initially peopled prehistoric Montana and the region. The increased research costs and curational and facility loads imposed by incorporating a productive paleontological component into a dedicated multidisciplinary archaeological research program require due consideration. However, the technical benefits of the resulting baseline paleoecological and paleobiological data cannot be underestimated for their value in characterizing the natural arenas within which the First Americans rapidly assumed inordinate importance. Important also is the addition of late Quaternary vertebrate fossils to what has been an essentially Mesozoic dinosaur focused paleontological research program at the Museum of the Rockies. Interdisciplinary cooperation in both research and public interpretation will enhance the Museum's ability to meet the public expectations associated with the theme "One Place Through All of Time." This expanded emphasis also holds promise for both protecting and preserving a richly diverse, largely extinct biota that has heretofore been unappreciated.

References

Anderson, E., 1974, A survey of the Late Pleistocene and Holocene mammal faunas of Wyoming, in Applied Geology and Archaeology: The Holocene History of Wyoming, edited by M. Wilson, pp. 78-87. Geological Survey of Wyoming, Report of Investigations 10.

Bonnichsen, R., M. Beatty, M.D. Turner, J.C. Turner, and D. Douglas, 1992, Paleoindian lithic procurement at the South Fork of Everson Creek, Southwestern Montana: a preliminary statement, in Ice Age Hunters of the Rockies, edited by D.J. Stanford and J.S. Day, pp. 285-321. Denver Museum of Natural History and University Press of Colorado.

Chomko, S.A., and B.M. Gilbert, 1987, The Late Pleistocene/Holocene faunal record in the northern Bighorn Mountains, Wyoming, in Quaternary Mammalian Biogeography of the Great Plains and Prairies, edited by R.W. Graham, H. Semken, Jr., and M. A. Graham, pp. 394-408. Illinois State Museum, Reports of Investigations, Vol. 22. Springfield.

Davis, L.B., 1984, Late Pleistocene to Mid-Holocene adaptations at Indian Creek, west-central Montana Rockies. Current Research in the Pleistocene 1:9-10.

Davis, L.B., S.A. Aaberg, and S.T. Greiser, 1988, Paleoindians in transmontane southwestern Montana: The Barton Gulch occupations, Ruby River drainage. Current Research in the Pleistocene 5:9-11.

Davis, L.B., J.P. Albanese, L.S. Cummings, and J.W. Fisher, Jr., 1991, Reappraisal of the MacHaffie site paleoindian occupational sequence. Current Research in the Pleistocene 8:17-18,19-20.

Davis, L.B., and S.T. Greiser, 1991, Indian Creek paleoindians: early occupation of the Elkhorn Mountains' southeast flank, west-central Montana. In: Ice Age Hunters of the Rockies, edited by D.J. Stanford and J.S. Day, pp. 225-283. Denver Museum of Natural History and University of Colorado Press.

Davis, L.B., S.T. Greiser, and T.W. Greiser, 1987, Spring cleanup at a Folsom campsite in the Montana Rockies. Current Research in the Pleistocene 4:5-6.

Davis, L.B., and A.M. Johnson, 1988, Fossils, folly and fantasy: incidents at Point-of-Rocks Cave, in An Appreciation of Professor Carling I. Malouf, Montana Anthropologist. Archaeology in Montana 29(2):47-96.

Davis, L.B., and M.C. Wilson, 1985, The Late Pleistocene Lindsay Mammoth [24DW501]: a possible man-Mammoth association. Current Research in the Pleistocene 2:97-98.

Dundas, R.G., 1990, The Merrell locality: A Late Pleistocene fauna from southwestern Montana. Geological Society of America Abstracts with Programs 22(6):8-9.

___ 1992, A Scimitar cat (*Homotherium serum*) from the Late Pleistocene Merrell locality, southwestern Montana. PaleoBios 14(1):9-12.

Forbis, R.G., and J.D. Sperry, 1952, An early man site in Montana. American Antiquity 18:127-133.

Frison, G.C., 1987, Paleoindian subsistence and settlement during post-Clovis times on the northwestern plains, the adjacent mountain ranges, and intermontane basins, in Americans Before Columbus: Ice Age Origins, edited by R.C. Carlisle, pp. 83-106. Ethnology Monograph No. 2. Department of Anthropology, University of Pittsburgh.

___ 1991, Prehistoric Hunters of the High Plains. Second Edition. Academic Press, Inc., New York.

Gilbert, B.M., and L.D. Martin, 1984, Late Pleistocene fossils of Natural Trap, Wyoming, and the climatic model of extinction, in Quaternary Extinctions: A Prehistoric Revolution, edited by P.S. Martin and R.G. Klein,

pp. 138-147. University of Arizona Press.
Graham, M.A., M. Wilson, and R.W. Graham, 1987, Paleoenvironments and mammalian faunas of Montana, southern Alberta and southern Saskatchewan, in Late Quaternary Biogeography and Environments of the Great Plains and Prairies, edited by R.W. Graham, H.A. Semken, Jr., and M.A. Graham, pp. 410-459. Illinois State Museum, Scientific Papers, Vol. 22. Springfield.
Melton, W.G., Jr., 1978, Late Pleistocene mammals and artifacts recovered from Blacktail Cave, Lewis and Clark County, Montana. National Geographic Society Research Reports, 1978 Projects, pp. 415-421. Washington, D.C.
Napton, L. Kyle, 1988, Blacktail Cave, Montana: archaeological excavations in the Alcove Locality, in An Appreciation of Professor Carling I. Malouf, Montana Anthropologist. Archaeology in Montana 29(2):25-46.
Walker, D.N., 1982, Early Holocene vertebrate fauna, in The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains, edited by G.C. Frison and D.J. Stanford, pp. 274-308. Academic Press, Inc. New York.
___ 1987, Late Pleistocene/Holocene environmental change in Wyoming: the mammalian record, in Late Quaternary Mammalian Biogeography and Environments of the Great Plains and Prairies, edited by R.W. Graham, H.A. Semken, Jr., and M.A. Graham, pp. 334-392. Illinois State Museum Scientific Papers, Vol. 22.
Wilson, M.C., and L.B. Davis, 1994, Late quaternary stratigraphy, paleontology and archaeology of the Sheep Rock Spring Site [24JF292], Jefferson County, Montana. Current Research in the Pleistocene 11.

What's Interpretation Got To Do With Paleontology?

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Interpretation is an important tool that site managers, scientists, and others can use in managing natural and cultural resources, including paleontological sites. To make the best use of limited funds, an interpretive planning process should be utilized so that the best types of interpretative media are determined for each individual site. The process can be utilized at new or existing sites, and is a collaborative process between interpretive specialists, scientists, site managers and potential partners, all of whom should be brought in early on. Each step in the planning process is based upon the previous steps so that the final recommendations are site specific.

What is interpretation? Making scientific information understandable, exciting, relevant and meaningful to visitors. Interpretation should strive to excite curiosity, encourage self-discovery and make people want to learn more.

Freeman Tilden's six principles of interpretation should be followed:

1. Interpretation must **relate** what is being displayed or described to something within the personality or experience of the individual.

2. Interpretation is not the presentation of information: It is revelation **based** on information.

3. Interpretation is an art, combining many arts. An art can be taught and successfully learned.

4. Interpretation's primary purpose is **provocation**, not instruction.

5. Interpretation must present the complete story and should relate to the whole person.

6. Interpretation for children should be specifically prepared and not be a dilution of the adult version.

The Interpretive Planning Process

The Agency
The agency section should describe how interpretive services relate to the overall mission and goals of the agency.

- What is the agency mission? Guiding principles?

- Is there specific legislation regarding the site?

- Why was the area set aside?

The Plan
"Well written and achievable objectives help you demonstrate that your program provides a valuable service to the agency." John Veverka.

Goals identify what you hope to accomplish.
Objectives are the intended results.

- Goals are general statements of things you would like to have happen.

- Objectives are specific, measurable statements which include:

1. Learning Objectives - What do you want visitors to **learn?**

2. Behavioral Objectives - What do you want visitors to **do**? (Most important, action-oriented.)

3. Emotional Objectives - How do you want the visitor to **feel**?

Management Concerns
What are the specific management concerns at the site that interpretation might be able to address?

Visitor Analysis
"The more you learn about who your visitors are (including potential visitors), where they're coming from, and their motives and expectations for their visit, the better you can design programs or services to relate to their interests and needs." (John Veverka)

- Visitor characteristics and trends.
- Visitor demographics.
- Visitor expectations, values, common questions.
- Carrying capacities.
- Other regional attractions.
- Potential target markets.

Site Analysis
Includes a resource inventory (what's there) and development of significance statements which capture the essence of the site. What makes it unique?

- Resource inventory. (cultural, biological, geological, archaeological, paleontological, etc.)
- Based on the inventory, what is significant? (scientific, scenic, recreational, natural, cultural and/or other values.)

Primary Interpretive Themes
You cannot interpret **everything**! Interpretive themes **focus** the interpretive services. These are the **main** ideas crucial to the area's significance that every visitor should understand and remember.

- Based on significance statements.
- Stated as short, simple and complete sentences, containing only one main idea.
- Visitors forget facts, but remember themes.

Media Prescription
Based on the agency, visitor analysis, and site analysis, these are the stories that should be told, where they will be told, and how to get the message across.

- Be creative!
- Potential interpretive sites identified.
- Best type of media for the site: brochures, exhibits, personal interpretive programs, audio, etc.
- Specific themes and objectives developed for each media. recommendation.
- Cost.
- Implementation Schedule.

Evaluation
How will the interpretive services be evaluated and monitored?

Yes Virginia, You Can Do Large Scale Excavation in a National Park, with Spectacular Results

Ann Elder, Museum Specialist, Scott K. Madsen, and Daniel J. Chure, Park Paleontologist, National Park Service, Dinosaur National Monument, Box 128, Jensen, UT 84035

THAR' SHE BLOWS! A blasting crew from Rocky Mountain NP makes a minor terrain modification by removing overburden in preparation for the excavation of a new dinosaur skeleton.

Introduction
The mission of the National Park Service (NPS) is to preserve and protect cultural and natural resources and to provide for the enjoyment of same by future generations. NPS lands are often considered the best preserved of all federal lands, with human impact strictly regulated and monitored. Outside researchers may believe that such strict regulations prohibit extensive excavation on NPS lands due to the amount of surface disturbance such excavations can create. They may also believe that obtaining a permit for conducting such activities is too cumbersome to be worthwhile. These beliefs sometimes keep researchers from pursuing paleontological questions within the boundaries of any of the more than 60 NPS units with significant fossil resources. In this paper we will describe a large and complex excavation which caused considerable surface disturbance. We hope that this example will remove many misconceptions among paleontologists about what can be done within a National Park.

Policy
Though human impact is strictly regulated on NPS lands, bona fide paleontological research is not prohibited, even when a large scale excavation is necessary. In fact, NPS managers may actually encourage outside researchers to work within park boundaries as a way of obtaining the scientific information necessary to manage the paleontological resources they are responsible for. This management strategy is supported by the Vail Agenda (National Parks for the 21st Century, 1993) Strategic Objective 5 which states that the NPS must engage in a sustained and integrated program of research and resource management aimed at acquiring and using the information

needed to manage and protect park resources.

In fact, NPS policy contains provisions which specifically allow for large scale paleontological excavations. NPS Management Policies (1988 p. 4:19) states that fossil resources will be protected, preserved, and developed for public enjoyment, interpretation and **scientific research** and that "paleontological research by the academic community will be encouraged and facilitated..." Furthermore, NPS management policies recognize that protection of fossils may include "**collection**, preparation, and placement of specimens in museum collections" (emphasis added). NPS-77 Natural Resources Management Guidelines (1991 pp. 2:156-2:175) provides guidance for managing fossil resources, including excavations. Thus, a proactive management program for fossil resources will often use excavations as a scientific and resource management tool.

Permitting

The permit process for obtaining permission to conduct paleontological research is not the same for all federal lands, though the process is fairly consistent throughout the NPS. Outside researchers should directly contact the park in which they would like to work. They will then be directed to a park paleontologist, resource management specialist, or other official, depending on the staffing of the unit. Generally the park will request that the researcher submit a scope of the work to be conducted and a completed Application of Permission to Collect Specimens of Plants, Rocks, Minerals, and Animals (Form 10-741). In most cases, permit decisions are made at the Superintendent level, with possible input from park staff, other parks, regional and Washington Office (WASO) personnel, and other outside researchers depending on the situation. If permission is granted, the researcher will be informed of any conditions affecting the permit, including curatorial requirements if specimens are to be collected.

Superintendents are entrusted with the protection of all cultural and natural resources within their unit. As with any research request, permission is only granted when the scientific or other information gathered through the study outweighs disturbances to the cultural and natural resources of the park. For that reason, paleontological studies that involve minimal ground disturbance are more likely to be approved. But the Superintendent of an area can grant permission for a large scale excavation if he/she feels it is warranted. Some considerations include:

- How significant is the research?
- Are the proposed research activities consistent with the unit's Resource Management Plan and Statement for Management?
- Does the proposed study identify and address new resource management issues?
- What type of lands will this work affect? (designated wilderness, inholdings, etc.)
- What land restrictions exist?
- What impact will the excavation have on surrounding resources such as threatened or endangered plants and animals, or cultural sites?
- Can the research be conducted on any other lands?
- How valuable is the research information to the visitors of the NPS area?
- According to 36 CFR 2.5, what curatorial issues need to be addressed?

The Dinosaur Experience

In 1990, a very promising fossil locality was discovered during a paleontological survey of Dinosaur National Monument (DINO). The articulated foot of a meat-eating dinosaur was found in the Salt Wash Member of the Morrison Formation. Dinosaurs are rare in the Salt Wash, making the prospect of an articulated meat-eater all the more significant. Further field work confirmed the significance and completeness of the specimen and it soon became obvious that a large excavation was necessary.

Though the work was conducted by the paleontology staff of Dinosaur National Monument, permission for the excavation still needed to be secured. The Superintendent of Dinosaur NM evaluated the situation, weighed appropriate factors, reviewed surface and subsurface disturbance clearance documents (which included an endangered plant and archeological survey), consulted with his paleontological, biological, and cultural resource managers, and approved the excavation, which included the use of explosives to remove some 300 tons of overburden.

Removing the meat-eater from it's burial site proved to be the most challenging excavation ever undertaken at Dinosaur NM. Because of the 70° dip of the bedding plane, and the complete neck to tail articulation of the skeleton, 95% of the specimen was removed in one 6700 lb block. Excavation was further complicated by the fact that the rarest, most fragile bones were located at the bottom of the large block. This made them especially vulnerable to damage during the moving of the block from the 70° bedding plane, to a vertical 90°, to a horizontal resting place on an adjacent ledge. An A-shaped, wooden palette, weighing 500 lbs was designed and constructed to protect the bones and also aid in transporting the block from the field site to the paleontology lab.

Because the excavation was on NPS land, there were special conditions with which the work had to comply. Due to land use restrictions, a road could not be built to the site. Therefore, all equipment and supplies had to be hand carried 1/2 mile from the closest established road and a helicopter was needed to remove the jacketed specimen. Foot travel was restricted to drainage bottoms and established trails whenever possible in order to avoid damage to the vegetation. A Rocky Mountain NP blasting crew familiar with "minimal impact blasting" was used to remove overburden. Though the location of the site was not publicized, visitors to the park that happened to stumble onto the excavation site were informed as to what was going on, and encouraged to view the operation from a safe distance. The excavation produced, in a timely and cost efficient way, a 6700 lb block, and a number of smaller associated blocks containing a nearly complete, articulated, meat-eating dinosaur - one of the most significant specimens ever quarried at Dinosaur. Complying with NPS land use restrictions did not adversely effect the success of the excavation. Rather, complying insured that the excavation would be completed with minimal impact to the surrounding resources, making permission for future large excavations more probable.

Results

The collection of this new dinosaur was one of the most complex resource management actions ever undertaken in the monument and the benefits of the excavation are many and complex. The most direct result was that we now possess one of the most complete Jurassic age carnivorous dinosaur skeletons found **anywhere** in the world. This specimen is currently under study but preliminary analysis indicates that it belongs to a previously unknown genus and species, possibly related to *Allosaurus*. This discovery will make important contributions to our knowledge of Upper Jurassic dinosaur faunas and the diversity and evolution of meat-eating dinosaurs.

However, the project also had a profound impact on the interpretive program activities in the Monument. For the three summers that the excavation was active, the interpretive staff was briefed frequently (at times even daily) about the progress of the dig. They, in turn, would incorporate this information into their paleontology programs. Many visitors found it exciting to be in a place where something of great scientific importance was being unearthed, especially when they were getting the "latest breaking news" about it. The fact that they could not go to the site did not diminish this excitement.

Interpretation prepared and distributed press packets, etc., in anticipation of the day of the great helicopter lift when the specimen would be flown to the Quarry Visitor Center. As a result, there was good television and press coverage. Video of the lift was even broadcast in New Guinea on the International News Network! An NPS volunteer assembled and edited all of the video shot during the excavation and lift and produced a 30 minute documentary - an important tool for use in training and public relations. In addition, the story of this "Dinosaur Roundup" was given the entire front page in the park newspaper.

Finally, because of the completeness of the specimen, it was decided to replicate the skeleton before it was taken apart for study. Molding was done by a professional molding and casting company under a contract with Dinosaur. The mold will allow for a lightweight cast to be made of the specimen. This cast will be incorporated into the Quarry Visitor Center exhibits when th[ey] are renovated and will allow visitors to see one of the most spectacular dinosaur fossils ever collected in the Morrison

Formation, just as it was buried 150 million years ago.

Conclusion

The NPS is mandated to preserve and protect the nation's resources which lie within it's boundaries. But that does not mean that paleontological research is locked out of national parks and monuments simply because of the disturbances it causes. The NPS recognizes the link between an in-depth scientific understanding of a resource and good resource management decisions, and encourages valid research within it's boundaries. Sometimes that means removing 300 tons of overburden.

Acknowledgements

Many people and agencies helped in the excavation and collection of the new dinosaur. First is DINO Superintendent Denny Huffman who saw the value of the excavation and approved our undertaking it. Dan Huff, Bob Schiller, and J.T. Reynolds of the NPS Rocky Mountain Regional Office provided funding for several stages of the project, including the blasting and the helicopter lift. Jim Leons and his ROMO blasting crew showed their outstanding skills by removing overburden in true "minimal impact" style. He also covered some of the costs for this activity. Superintendent Denny Huffman and Chief of Interpretation David Whitman supported the excavation and also provided funding for various aspects. Green River District Naturalist Herm Hoops and his staff kept the public informed of our progress throughout the years. The specimen was found during a NRPP funded Paleontological Inventory of the Morrison Formation of Dinosaur National Monument (Contract # CA-1463-5-0001). Funding for equipment and some helicopter time was funded by the RMR Resource Preservation, Restoration, and Mitigation Program. Partial funding for the helicopter was also made available through accounts at Dinosaur National Monument. Finally, volunteers Rod Joblove, Ron Hopwood, Sally Hopwood, Dale Gray, and Marilyn Sokolosky assisted in the excavation. Rod and Ron were particularly dedicated and each put in many, many months of volunteer time in hot and buggy conditions; and allowed us to retrieve the specimen years earlier than would otherwise have been possible.

THE PRIZE. Back at the lab the spectacular 20 foot skeleton is prepared and reveals its secrets of dinosaur evolution..

References

36 CFR (Code of Federal Regulations), Parks, Forests, and Public Property .

Management Policies. U.S. Department of the Interior, National Park Service 1988.

National Parks for the 21st Century: The Vail Agenda. NPS Document Number D-726, Chelsea Green Publishing Company, PO Box 130, Post Mills, VT 05058, 1993.

Natural Resources Management Guideline, NPS-77. U.S. Department of the Interior, National Park Service 1991.

Agency/Friends Partnerships: Different Perspectives

Moderator
Donna Engard, Past President, Garden Park Paleontology Society Route 1 Box 9A, Wetmore, CO, 81253

Panel
Harley J. Armstrong, Paleontologist, Bureau of Land Management, Grand Junction District Office, 2815 H Road, Grand Junction, CO 81506

Rick Otto, Superintendent, Ash Fall Fossil Beds State Park, P.O. Box 66, Royal, NE 68773

Willard Louden, Friends of the Purgatoire, Branson, CO 81027

A one hour panel discussion of different styles of partnerships which fit different situations. Each results in good management of resources with the bonus of public education and involvement.

Donna Engard

The Garden Park Paleontological Society (GPPS) is a non profit corporation which formed in 1988 after a request from the Bureau of Land Management (BLM) Royal Gorge Resource Area for citizen involvement in the management of the Garden Park Fossil Area (GPFA). Seven people answered the call and discussed with BLM staff the possible ways in which the fossil resources might be preserved for the future and rendered safe from random collecting. Together we made the decision that the best possible solution was to maximize use of the fossil area for positive purposes and thereby squeeze out the damage being done by uncontrolled use.

GPPS's first order of business was to formalize its own existence and identify its role in the goals of public education and scientific research that would result in good resource management. It achieved incorporation as a 501(c)(3) by mid 1990 while it grew to a membership organization of over 350 people. While developing its own identity and goals, GPPS evolved a partnership with the BLM and the Denver Museum of Natural History Earth Sciences Department which began the work toward proving the GPFA has a huge potential for modern research. New finds are a given when the museum comes with its volunteer crew of trained amateurs to do survey and excavation work. Five members of GPPS have been trained in the museum's certification program for amateurs and this, too, has been a valuable source of credibility for GPPS. We have also formed a Scientific Advisory Group of professionals in the earth sciences from across the United States and the services provided by these scientists to GPPS and the BLM has been invaluable. Together we have been able to provide support for and gained benefit from all the research being done in the GPFA by various entities.

The BLM has provided office space and services as well as staff support to GPPS as the relationship between the two entities has grown and strengthened. Our formal liaison to the agency, Dan Grenard, has cemented the bond and worked for support within the BLM for GPPS activities that benefit the GPFA. As of this past winter GPPS now has a formal Cooperative Management Agreement with the BLM which streamlines our ability to achieve common goals. We are often asked why we have gone so far in strengthening GPPS as a separate organization rather than being a simple volunteer group helping with limited activities. The answer lies in our ultimate goal of maximizing the education and research opportunities that the world class GPFA resource provides. We are building a multiple partnership which will put a major public education and scientific research facility in the fossil area before the turn of the century. To achieve this huge goal we need the ability to divide the work load into what the agency is able to do and what the citizens are able to do, which will result in a much better final facility.

Harley Armstrong
There are many opportunities for paleontological partnerships on BLM lands. In Colorado, BLM is working with numerous organizations and agencies with paleontological resource interests. Some of these partnerships are formalized with signed Cooperative Agreements (CA) or Memoranda of Understanding (MOU). Often a good, long-term working relationship has led to these formal partnerships, such as with the Garden Park Paleontology Society, Western Interior Paleontology Society, Colorado Department of Natural Areas, Denver Museum of Natural History, Museum of Western Colorado and others. The BLM also consults under an MOU with the USGS, USDA, USFS, and NPS on paleontological issues, and there is a proposal to blur the lines between agencies under Ecosystem Management for easier cooperation and standardization.

In particular, the recent MOU partnership with the Western Interior Paleontology Society (WIPS) has been a valuable addition to the BLM's ability to deal with special paleontological problems as they arise. The Society provides a trained cadre of volunteers to serve as the labor force when situations come up which require fast attention. They can provide immediate help to evaluate situations, or provide trained field assistants to a professional paleontologist who is doing salvage, mitigation or excavation on public land. WIPS is in fact an excellent example of how an existing amateur group can find a new meaningful activity for their members. They can find the extra satisfaction of being a part of the science of paleontology.

Other partnerships are just good working relationships that get together on a case by case basis. Temporary partnerships have formed with members of the public at large, adjoining private land owners, BOR CDOT, Colorado Historical Society, Colorado Geological Survey, various museums, colleges, universities and many others. Paleontological resources are not just being managed for the people of Colorado, but as a source of sustainable yield for the nation. Partnerships are critical in making sure the resources on any public lands are responsibly used and preserved.

Rick Otto
Ash Fall Fossil Beds opened in 1991 as a park managed by the University of Nebraska State Museum in Lincoln. The Fossil Beds however are located over 150 miles away and are open only in the summer. In order to have a formal structure for the volunteer program for this and other remote localities managed by the museum, we looked to the already established Friends of the Museum organization. The members of the Friends living in the region were contacted about their interest in becoming involved with the park. The respondents became a chapter of the Friends of the University of Nebraska State Museum which exists year round. The Ash Fall Chapter of the Friends now numbers over 200 members, of which approximately 40 are active volunteers. They pay their dues to the Friends and a portion of the funds fall to the Fossil Beds.

Most of the volunteers work as fee collectors or teach in public programs or as trail guides. The obvious benefits to the park are in budget assistance as we do not need to hire as many summer employees. A few volunteers however have taken a certification training of one week at the University of Nebraska Museum which qualifies them to work in the paleontology program in the lab and digging outside the "Barn". To date only staff and university students have qualified to work in the barn.

As this young program grows the staff and volunteers are looking for new avenues of involvement. This year they began an orientation program with the Paleontology Preparator so they can do a better job of interpreting the scientific work to the public. They have also added nature walks to give the public more to do and spread the visitors out a bit. Training courses are the key to each program with which the volunteers want to become involved. Mutual planning and involvement also keeps them happy so they keep coming back.

Willard Louden
The US Forest Service acquired nearly 17,000 acres of surplus land from Ft. Carson's Pinon Maneuver Area and it contains the extensive Purgatoire dinosaur trackway. Confronted with a multitude of problems concerning appropriate management of the property, Forest Service personnel recognized the

potential benefits of a volunteer assistance organization and sought the establishment of such a group. They contacted and assembled a number of knowledgeable and concerned citizens from the area, and with them hoped to establish some formally organized group with a 501(c)(3) tax exempt status with the IRS and contractual agreements with the Forest Service.

A number of joint meetings with the citizens and Forest Service personnel were held with the focus being the aims, objectives, bylaws and incorporation considerations. It was evident from the onset that some members of the volunteer group felt suspicious of and antagonistic toward the Forest Service. As those attitudes became more evident and the hostility more open, it essentially brought development to a halt. The Forest Service personnel understood the problem and stepped aside and let the group organize on their own.

At this point the Garden Park Paleontology Society was asked to make a presentation to our group and they graciously did so. Their presentations of the problems they experienced and the ways in which they resolved them proved to be of enormous assistance to our fledgling organization. From that point on our group, called the Friends of the Purgatoire, tempered their posture and the less assertive members of the group became the dominant element. Appropriate rapport was re-established with the Forest Service and the group chose to first establish their own organization and credibility before making any attempt to formalize a relationship with the Forest Service.

We are currently working constructively with the Forest Service and are optimistic about getting the Friends of the Purgatoire adequately organized and into a position where we can be of great help and have a significant, positive impact.

Paleontology, Conservation Leadership, Ecosystem Management and "Jurassic Park": How Does It All Fit?

Elizabeth Estill, Regional Forester, U.S. Forest Service, PO Box 25127, Golden, CO 80401

Paleontology has captured the interest of the nation. Never before has the opportunity been greater to garner public support for fossil resources. We possess one of those precious "teachable" moments - to move paleontology from a curiosity to an intrinsic component of public land management. By thoughtful planning and careful marketing of the resource, we can boost the current fad into a lasting institution of conservation and public enjoyment.

"Jurassic Park" Syndrome

Movie productions like "Jurassic Park" have captured the hearts and imaginations of the American people. Even before the movie release, young children could recite the multisyllabic species names of many dinosaurs, like some of us could recite Mother Goose nursery rhymes during an earlier generation. Dinosaur characters are on everything - lunch boxes, mugs, tee-shirts, sweat shirts, backpacks. The popularity of paleontology has been a huge success for the companies producing these items. Unfortunately, the actual dollars going to support paleontological research have not grown accordingly. Among the scientific disciplines, paleontology is at or near the bottom in terms of funding for research. Commercial successes, measured in many millions of dollars, have not spawned additional funds for research, nor have these successes resulted in better protection or interpretation.

Ecosystems Management

Popular paleontology and derivative commercial products have captured the hearts of the American People. We must build on that interest to capture their minds. One of the first challenges - how can we effectively fold paleontology into the US Forest Service? - is placing increased emphasis on responsible ecosystems management. Paleontological research, especially in the field of paleobotany, can contribute much to our understanding of modern ecosystems and how those ecosystems evolved. This understanding is vital to the Forest Service in adopting ecological approaches to achieve sustainable multiple use management and the best blending of the needs of people and their environment. Such research will contribute to a better and more comprehensive understanding of natural variability and scale. A rigorous analysis of sustainability requires us to think large scale and long term. Paleontological research will contribute to that ability.

The earth's biological systems are dynamic and mirror the larger forces that shaped the earth. The geologic record preserves the past events that lead to our understanding of the modern world. Fortunately, much of this record is preserved on public lands, including lands managed by the Forest Service and our sister agencies. Some of our Forests and Grasslands are especially rich in fossil resources of the Mesozoic Era, familiar to Americans as the Age of Dinosaurs. The Purgatory River Dinosaur Tracksite on the Comanche National Grassland and the Dry Mesa Quarry on the Uncompaghre National Forest are outstanding examples. The Tracksite, containing more than 1300 individual tracks of different dinosaurs including allosaurus and apatosaurus, continues to yield vital scientific information regarding dinosaur morphology and behavior. The Dry Mesa Quarry illustrates the rich variety of lifeforms in the Mesozoic. In a former riverine environment of stream banks and sand bars, large populations of dinosaurs including ultrasaurus, allosaurus and torvosaurus flourished among smaller reptiles such as turtles, crocodiles and pterosaurs. Forest Service lands also are rich in the paleontology of other periods. About 30 million years ago during the Oligocene period, the ecology of the Nebraska National Forest was similar to the African savannas. Picture shorebirds casually walking along a stream. They are followed by a group of rhino-like creatures moving south along the stream course, which in turn are stalked by an unknown predator. This scenario is preserved in the sandstones at Toadstool Park. The geologic record here is unique as the best evidence of extinct mammalian behavior for this period.

Ecological Literacy

There is a third critical element of ecosystem management, in addition to identifying the range of natural variability and gaining a better appreciation of scale; empowering an ecologically literate society. Ensuring ecological literacy in today's increasingly complex and diverse society is a challenging task. For several segments of today's population, the traditional values attributed to public lands are no longer shared. These segments have different values or no clear perception of public lands. Many managers see these changes as threatening, but we can, and must meet them. Ecosystem management will allow us to ensure sustainability, and sustainability will preserve options for future generations. In order to exercise those options, our descendants must understand what it is they own and what it means to them and their children. I've heard it said that the two biggest gifts we can give to future generations are "roots and wings". Ecological literacy is very much a part of our roots and the knowledge we impart will be very much a part of the wings we leave future generations to meet the coming difficult challenges.

Boundaryless Behavior

The challenges of ecological literacy and changing values will require increased involvement and cooperation among land managing agencies, institutions of learning, and the private sector. We must be knowledgeable about efforts to reform education in the natural sciences. It is more than having our professionals visiting classrooms as time permits, or efforts to train teachers in natural resources, although these are important and commendable activities. It is involvement in the current revision of the education system and helping make changes to meet the needs of the 21st century. Professional educators are willing to include scientists and public officials in this process and, in fact, the process is designed to include us. Children are interested in dinosaurs and popular paleontology in general. We need to stimulate their interest in paleontology as a science and in the larger contexts of the earth's history and its dynamic ecosystems.

That inclusion will be a challenging task for many reasons. Each of our agencies and institutions have difficult missions and limited resources in an era of flat or declined budgets. Working with non-traditional partners requires us to learn other languages and assume new roles. How do we do it? We must tear down the barriers that separate our sister agencies and organizations and adopt boundaryless behavior. We must focus on areas where we agree, where our missions are common and where we have common interests. It will be challenging, but the ultimate benefit will be greater natural resource sustainability for future generations. If we look at each other in a new way, strive for common goals and common ground, and solve differences as they arise with objectivity and leadership, we will have a stronger, more effective pool of human and financial capital to serve the future.

Social Values

The last important element in the puzzle is public values. It will be increasingly difficult to achieve public consensus using traditional techniques. We must learn the new public values and perceptions, and tie those back to resource sustainability. We must continue to keep our finger on the pulse of American society. All of us need skills in psychology, sociology, and anthropology. Paleontologists need to work closer with interpretive specialists: search them out, be involved in interpretive planning, and ensure that paleontological resources are reflected in interpretive plans and tied to environmental education initiatives. But our efforts to encourage ecological literacy must be more than environmental education or interpretation. Ecological literacy goes deeper to the values and thoughts of the people and how they see natural resources and their management. For us it means more than public involvement. It means actively listening and challenging ourselves to work with the public in a new way. In the coming months and years we will need to work better together to share limited resources and locate new sources. If we do these things, paleontology **will** capture the minds of the American people, and their hearts and imaginations. Paleontology is the study of life forms existing in former periods, but, in terms of ecosystem management, it is also about people now.

I hope I have challenged you, because what I have briefly touched on are indeed challenges which will require strong leadership.

"The great bulk of the people go with the moral tide of the moment. The leader must help create that tide."

Conservation leadership in paleontology requires that we be a part of creating a tide towards conservation and environmental ethics. We must create a tide that captures the **minds**, **hearts**, and **imaginations** of the American people. I know that we are up to that challenge, and I look forward to working with you to meet it.

Teaching Paleontology in the National Parks and Monuments

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Laine Weber, Park Ranger, National Park Service, Florissant Fossil Beds National Monument, P.O. Box 185, Florissant, CO 80816

The concepts of time, past life, and fossils are often difficult for children to comprehend. However, when an understanding is reached, these concepts become a fascination to children, leading to a motivation for additional learning and a deeper thought process.

Fossil Butte National Monument (FOBU) hosts a rapidly growing environmental education program, as do other parks with major fossil resources. Many programs have been developed over the years to accommodate school groups visiting the parks, but a curriculum dealing specifically with fossils has never been developed. Fossil Butte, Florissant, and Hagerman Fossil Beds National Monuments have developed such a program.

In 1993, FOBU received $10,000 through the Rocky Mountain Regional Office to develop part of a paleontologically based curriculum. Mike Leite, a geologist with the Department of Geology at the University of Wyoming, was contracted to develop a curriculum for 2nd and 3rd grade students. Assisted by Brent Breithaupt, Mike developed a program that includes five traveling kits and an accompanying slide show.

Organization and Philosophy

The curriculum includes four units. For 2nd graders, a unit on fossilization and human influences; for 3rd graders, units on adaptation, community and human influences. All units pertain to fossil park themes and complement science curriculums from Wyoming, Idaho and Utah.

Curriculum Themes for Each Unit

Unit 1: Fossilization

Theme: A very small percentage of organisms that lived in the geologic past have been preserved as fossils.

Goal: To explore and investigate the fossilization processes

Unit 2: Adaptations

Theme: Fossils tell the story of plants and animals that lived throughout our earth's history.

Goal: To explore and investigate the characteristics and habits of animal and plant species that lived millions of years ago and to compare them with modern relatives.

Unit 3: Community

Theme: Evidence for complex ecological communities is often found in the fossil record.

Goal: To compare complex ecological paleo communities with modern communities and discuss biological diversity.

Unit 4: Human Influences

Theme: Man has played a significant role in the discovery, preparation, collection, and protection of fossils.

Goal: To explore and investigate human influences as they relate to fossils.

Learning Skills

The curriculum addresses cognitive and affective learning skills and encourages problem solving and critical thinking. Activities are designed to be interdisciplinary which allows the teacher to go beyond teaching paleontology as a "science" and includes paleontology in other areas of study such as geography, math, and language arts. All activities are highly interactive or "hands-on," as children are naturally motivated by objects, particularly if they are allowed to "touch them."

What I hear, I forget.
What I see, I remember.
What I do, I understand.

Organization
Units are organized into grade specific lesson plans that are best presented in the sequence given, since each assumes a certain background covered by previous units. The units begin with a short introduction, followed by vocabulary list, background information for the teacher, pre-questions, pre-site activities, ideas for a field trip, post-questions, post-site activities, a section on National Parks and Monuments that illustrate concepts of the unit, and a reference list for teachers and students.

The text following the vocabulary list gives the teacher enough information to teach the units without having to do a lot of research. A list of references found at the end of each unit is for teachers and students who wish to expand on the information provided.

Activities
Activities are designed around a field trip but easily adaptable for groups unable to visit a site. The pre-site activities prepare the student for a field trip. This is accomplished through a variety of exercises including vocabulary lists, games, art projects, slide programs, and an interactive computer program on population dynamics. These materials also acquaint students with the philosophy behind the national park idea.

The post-site activities, a critical part of the overall curriculum, provide the connection that enables the learner to apply what they have experienced at the field trip site to their own lives. The exercises are designed to stimulate further interest, and a greater appreciation for fossils. (A very popular activity, "The Fossilization Game," from unit one, follows.)

Traveling Kit
Accompanying each curriculum guide is a traveling kit that includes: casts of real fossils from different geological times; plaster of Paris and modeling clay; 25 magnifying lenses; a "Geologic Time" poster; a map of National Parks and Monuments; park brochures from each of the fossil parks; an interactive computer program on population dynamics; a slide program introducing the basic principles of fossils and paleontology; and a slide program that introduces environments and adaptations.

The kit contents and curriculum guide are contained in a plastic box easily mailed to any school or group interested in using them for a two to three week period while teaching about fossils. Schools are only responsible for the return postage.

Field Testing
Field testing of each unit occurred in September and October of 1993 in Laramie, Kemmerer, and Evanston, Wyoming. The teachers involved were very excited about the curriculum and found it to be complementary to their required curriculum. Several good ideas have been incorporated into a Growing Section in the back of the curriculum guide.

Additional Funds
In 1994, a Parks As Classrooms grant of $12,000 was received through the Rocky Mountain Regional Office to duplicate 12 additional kits. Six will be used by Fossil Butte and the others will be loaned out to other fossil resource parks.

Beyond Science
Paleontology involves the integration of many different areas of expertise. We hope these exercises will help teachers to encourage the various talents their students have to offer. While only a minority of students may feel a calling to become scientists, with luck, those who do not will be stimulated by the cultural or artistic aspects of paleontology, and perhaps better identify with scientists in general. The primary message of these units should be that science is fun!

If you have any questions about the curriculum, please contact Marcia Fagnant at Fossil Butte National Monument, 307-877-4455.

The Fossilization Game

Message: It is not easy to become a fossil. Many plants and animals never have the chance to be preserved as fossils.

Materials: You may make copies of the fossilization cards or have the class design their own.

The fossilization game is a fantasy and role-playing exercise that helps children understand fossilization processes.

Procedure

- Choose an environment. The game begins with the class or smaller group choosing an environment in which there is a depositional setting such as a lake, pond, stream, river in a forest, sea floor. The students can use their imaginations to describe this setting in as much detail as they desire.

- Choose roles. Roles that the participants choose for themselves are possible animal or plant inhabitants of the chosen setting. For example, in the aquatic settings possible roles include not only snails, clams, fish, salamanders, turtles, alligators, and other aquatic animals, but also horses, deer, monkeys, rabbits, and birds that come there to drink.

- Begin play. When play begins, the children act out their roles, with each given a turn to make vocalizations or gestures. For example, a child playing a fish could wiggle his body with a fish-like motion and make gulping motions with his mouth. A child playing a prairie dog might pretend to dig a burrow and make high-pitched barks. They can also interact with each other as they would in their natural environment. For example, the carnivores could chase the herbivores.

- "Freeze" and decide the fate of the characters. At a time determined by the teacher, action "freezes" and the time for possible fossilization begins. The students draw cards that tell their fate:

a. You are eaten by scavengers.

b. You rot away before you can be preserved.

c. You are swallowed by an alligator.

d. You are swallowed by a big fish.

e. You are washed away by the current.

f. You are buried by a mudslide and preserved as a fossil.

You can make several copies of the page of cards in the curriculum. If you make your own, the proportion of "fossilization" cards to "destruction" cards should be small, mimicking the small chance of becoming fossilized in the real world.

- Discuss the meaning of this exercise. When the entire class has drawn cards, discussion can begin. Have each student discuss his or her role as an organism and what happened to this organism after it died. Make a list of these organisms on the blackboard. Which animals became fossils? Which were destroyed? Remember, the only animals and plants future paleontologists will know anything about are the ones that become fossils. You will become aware of the important question of bias in the fossil record when you compare the list of fossils with the complete list of living animals. Is the list of fossils a good representation of the living community? Why not?

If time allows, play the game again with the same animals and plants. How are the results similar or different?

Beneficial Impacts of Large Construction Projects on Paleontological Resources: Results from Construction of the PGT/PG&E Pipeline, Washington, Oregon, and California

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Fossils are valuable, nonrenewable natural resources which, when destroyed by ground-disturbing construction projects, are lost forever. Our only record of prehistoric life and much of our basis of interpreting paleoenvironments are lost with them. Paleontological resources, like archeological, cultural, and historical resources, deserve to be protected and preserved if we want the prehistoric record available in the future.

Federal and state laws protecting fossils on public lands (and adjacent private lands) require that ground-disturbing construction projects mitigate negative impacts on paleontological resources. These mitigation measures may include pre-excavation literature, museum, and field surveys to determine the likelihood of encountering significant fossils; monitoring by qualified paleontologists of all ground-disturbing excavation; and salvaging of all fossil remains discovered. Mitigation is not considered complete until all recovered specimens are identified, described, and curated into a public repository where they are available for study by the scientific community. With the increasing concern of government regulatory agencies for protection of **all** paleoresources (**not** just vertebrate fossils), coupled with the increasing sensitivity of engineering and construction companies to be in compliance with the laws protecting fossils, significant beneficial impacts can be realized from paleoresource mitigation programs. A clear example of these beneficial impacts was provided by construction of the PGT/PG&E natural gas pipeline through the states of Washington, Oregon, and California.

During trenching for the PGT/PG&E Pipeline Expansion Project, five entirely new fossil leaf floras were discovered: upper Miocene Alkali Canyon Formation and Pliocene Yonna Formation in Oregon; the Pliocene Tuscan Formation and upper Cretaceous Redding Formation in northern California; and the Paleocene Laguna Seca Formation in central California. In addition, over 250 specimens of petrified woods were collected from the Oligocene to lower Miocene John Day Formation and over 100 charcoalified logs were sampled from the 6,845-year-old ^{14}C-dated pre-Mazama Ash forest in Oregon. Besides fossil leaves and petrified wood, these floras also produced fossil pollen and spores which aided greatly in understanding the regional vegetation contributing plant parts to the depositional site.

Study of these seven floras will greatly enhance our understanding of Tertiary through Holocene vegetation change. The five new leaf floras would probably never have been discovered and, although the two wood floras were previously known, they probably would never have been as thoroughly collected and possibly never studied if it had not been for pipeline construction.

Fossil faunas discovered during the pipeline construction included: remains of fourteen Pleistocene mammoths in the Columbia Basin in eastern Washington and north-central Oregon; a beautifully preserved and nearly complete Pleistocene ground sloth in northern California; a very large assemblage of both large and small mammals, birds, and reptiles from the upper Miocene Alkali Canyon Formation in north-central Oregon; a large fossil fish fauna (including giant, "saber-toothed" salmon) from the Pliocene Yonna Formation in south-central Oregon; a large fauna of shark/ray teeth and invertebrate fossils from the upper Cretaceous Redding Formation in northern California; and several Pleistocene bison, horses, camels, and numerous small mammal faunas from various localities.

The most amazing thing about all of these significant fossil finds is that the PGT/PG&E Pipeline was constructed parallel to and only 30 feet away from a similar pipeline constructed in the mid 1960s. Although this earlier line probably unearthed similar rich fossil floras and faunas, because paleontological monitoring was not required at that time, **no** fossil remains were reported during the earlier construction! The lesson to be learned from this experience is that paleontological mitigation programs **do** protect fossils that might otherwise be destroyed. When public land management agencies require compliance with the laws protecting fossils, scientifically and educationally valuable specimens are salvaged and preserved for future generations to study and enjoy.

Pliocene Climate of the Colorado Plateau and Age of the Grand Canyon: Evidence from Anza-Borrego Desert State Park, California

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The Vallecito-Fish Creek Basin of Anza-Borrego Desert State Park (southern California) includes a continuous sequence of Pliocene rocks. Previous paleomagnetic and radiometric studies provide excellent age control for these rocks, which were deposited in deltaic marine environments by the ancestral Colorado River as it transported detritus from the Colorado Plateau. Assemblages of fossil pollen from part of the Pliocene section in the Vallecito-Fish Creek Basin contain reworked Cretaceous pollen, some of which have restricted biostratigraphic ranges and paleobiogeographic distributions elsewhere in North America. The stratigraphic distribution of reworked Cretaceous *Proteacidites* and *Aquilapollenites* in these Pliocene rocks reflects the paleobiogeographic distribution of these fossils in the Upper Cretaceous Mancos Shale of the Western Interior of North America.

Stratigraphic distribution of this reworked pollen indicates that, in the southern part of the Colorado Plateau, erosion of Cretaceous rocks that contain *Proteacidites*, but lack *Aquilapollenites*, began by the early Pliocene. Pollen of *Aquilapollenites* from the northern part of the Colorado Plateau first appears in the Vallecito-Fish Creek section at about 3.9 Ma. Thus, erosion of Cretaceous rocks from the northern part of the plateau did not begin until around the middle part of the Pliocene. This indicates that rapid and extensive erosion of the Colorado Plateau occurred during the Pliocene and supports the hypothesis that much of the Grand Canyon was cut during the Pliocene, rather than earlier in the Tertiary. Rapid erosion during the Pliocene would have required significantly increased precipitation in the area and suggests that the climate on the Colorado Plateau at that time was much wetter than today.

Pliocene delta-plain sediments in the Vallecito-Fish Creek Basin also contain silicified fossil wood of dicotyledons and monocotyledons that provide a glimpse of the vegetation growing in southeasternmost California (Salton Trough-Gulf of California) during the Pliocene. Families present in the paleoflora include the Lauraceae (represented by *Umbellularia*), the Salicaceae (represented by *Populus* and *Salix*), Oleaceae (represented by *Fraxinus*), Hippocastanaceae (represented by *Aesculus*), Arecaceae (represented by *Sabal*), and the Juglandaceae (represented by *Juglans*). Inferences based on this petrified wood assemblage and tree ring growth analyses suggest that the paleoclimate was temperate with winter rainfall dominance. Thus, the palynological and paleobotanical results are in accord and suggest that the Pliocene climate in southwestern part of the United States was wetter and cooler than today.

The Use of Geographic Information Systems (GIS) for Paleontological Data Capture, Analysis, and Presentation: Overlays of Badlands National Park

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Geographic Information Systems (GIS) are rapidly assuming a prominent role in paleontology. Traditional data collection techniques of field surveying, coupled with other precise methods of capturing spatial data such as Geographic Positioning Systems (GPS), are facilitating new levels of precision in both field and laboratory data collection.

Analysis of paleontological results may now be furthered by the direct incorporation of many peripheral databases, such as TIGER census data and USGS Digital Elevation Models (DEMs). The data may then be directly analyzed with statistical programs, spreadsheets, and peripheral databases.

The resulting mapping and charting capabilities allow for an almost infinite combination of data overlays and permit presentation to be accomplished with incredible precision. Furthermore, macro programs that present a user friendly environment may be constructed to allow users unfamiliar with GIS interface software to access information in the form of texts, charts, and maps. Research and data collection from the Chadron and Brule formations of Badlands National Park have been used as a case study.

Twenty-six USGS 7.5 minute Digital Elevation Models (DEMs) were loaded into a SUN/UNIX server running ARC/INFO geographic information system (GIS) software. We converted the DEMs into a rectangular set of evenly spaced positions referred to as lattices.

We then assembled the DEMs into grey-scale graphical representations to illustrate the topography of the region. The resulting overlays represented slope, aspect, and elevation. These may be viewed by differential shading, coloring, or by draping a patterned surface over the modeled topography giving a three-dimensional effect.

Contour overlays may be produced which resemble USGS topographical maps. Both the region and the contour interval may be selected by the user for modeling. Ten meters has proven to be a useful contour interval for our modeling purposes. A contour cover generated from a 7.5 minute USGS lattice is slightly less accurate than a photorevised USGS quadrangle as a result of the thirty meter sampling interval of the DEM.

Drape overlays model a three dimensional data source (x,y,z) by "draping" a patterned layer over the z-axis value and by selecting; 1. vantage point above the horizon; 2. azimuth bearing; 3. distance from the center of the map. Geometric points can be added by the use of coordinate geometry (COGO) to delineate additional geological strata and any other linear features that are important to appropriate resource management or educational applications.

Slope overlays have proven useful when various subtle slope changes are selected for coloration. A resulting map may display topography as it actually appears from above. For example, the Badlands of South Dakota are recognized by their lack of vegetation on the steeper slopes and immense prairie grass cover across the flat basins and on top of the flat buttes. Differential coloration models this simply and effectively.

Geographical data may be entered into GIS in many ways. Scanning and digitizing are useful ways to incorporate existing maps (assuming they are geographically referenced to an existing map projection). Useful data for paleontology also includes DEMs, digital line graphs (DLGs), TIGER census data (for political boundaries, roads, and infrastructure locations), soil types, geological maps, land use descriptions, and digital ortho-quadrangles (DOQs) when available.

One of the more important data sources is the information collected from global positioning systems (GPS). These may be used to correct or confirm the location of features entered from other data sources such as roads, USGS bench marks, and physical landmarks. GPS is especially critical for entering specific paleontological localities. Once entered into a GIS, paleontological localities can be viewed relative to geological contacts or other natural landmarks, and are available for archival or management purposes.

GIS would be limited if it didn't offer a direct means for certain types of data analysis. GIS allows constraints such as specific soil type, absolute elevation, aspect, slope, constant area, and proximity to (or away from) a feature to be selected to give a geographically referenced model of all areas that fit the given parameters. For example, all exposures of a certain rock formation that has yielded a certain fossil species may be selected and charted. This aids in both analysis of distribution and prospecting. Furthermore, a specific outcrop may be selected and all of the fossils collected from that location may be queried.

Nearly every newspaper or magazine published today uses GIS to create maps. The presentation uses of GIS are well established. However, user interface software now allows people unfamiliar with GIS commands or programming logic to access GIS maps by querying menu-driven programs. Once the program is constructed, a user may choose such parameters as the model type, the size and extent of a specific area, colors, shades, textures, contour intervals, angle of observation, and the direction of illumination. The user may superimpose many geographical overlays to create site specific maps and query specific features for information.

The applications of GIS are limitless for paleontological education, management, and research. As government facilities and universities invest in GIS technology, it is time to explore and utilize these paleontological applications.

Places of Discovery: Paleontological Research in the National Park System

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The fossil record is necessary to understanding the relationships and distributions of all organisms. Attention has recently been focused on the role of fossil assemblages in understanding extinction, biodiversity, and other phenomena in modern ecosystems (see, for example, Jablonski, 1991). Viewed by a paleobiologist, what appear to modern ecologists to be dramatic changes in populations may be nearly static episodes in the broader storyline. The blurred processes and events in the histories of ecosystems are resolved using the lenses of paleontology and evolutionary theory.

Formulating testable hypotheses about biotic change over time requires access to complex sequences of fossiliferous strata scattered in many localities. Importantly, retrieved samples must be accessible to investigators in reliable, systematic, public collections repositories. More prosaically, for fossils to be of the broadest value, the integrity of the sites must be safeguarded, significant specimens must be recovered and professionally curated, and accompanying data must be suitably maintained. The National Park Service (NPS) can be a leading participant in providing access to these data and techniques, for both the research community and the public.

NPS Paleontology

The NPS administers well over fifty areas that preserve significant fossil assemblages, a range nearly as vast as the North American fossil record itself (see Chure and Fremd, 1987). That many of these assemblages are within NPS boundaries is partly a result of farsighted planning that took place in the 1950's. Other localities were luckily included within borders drawn up with different nationally notable resources in mind. Paleontological peer review evaluation of any of these sites was rare. Conversely, some of the most outstanding paleontological localities in the country are **not** preserved in the system. Recognizing that strata do not stop at federal boundaries, the role of the NPS in the conservation of fossils through partnerships with other land management agencies has become increasingly important (Fremd, 1992a,b; Zancanella and Fremd, this volume).

For many years, servicewide fossils within the NPS were not treated as "natural resources" or given much attention, as evidenced by an absence of paleontological planning guidelines prior to the latest revision of NPS-77. Indeed, previous Service policies indirectly suggest that fossils should be allowed to weather away naturally. Non-disturbance of fossils has also been advocated as a valid approach on other federal lands, in circumstances where wilderness and/or spiritual values might have been compromised by excavation. To fulfill the mandate of preservation, however, **in no way should scientifically significant specimens be permitted to disintegrate or remain in jeopardy.**

Researchers should not be turned away simply because a project can be "done outside the park." The collection and curation of important, threatened materials by qualified investigators should be encouraged. However, "specimen" collecting without a supporting research design, or methods that are insensitive to the overall preservation mandate of the monument, are incompatible with appropriate Servicewide management policies and should not be permitted.

Research Benefits

Fortunately, the Service is upgrading from a passive caretaker to an active participant and facilitator of research (e.g., papers cited in Santucci, 1993).

The immediate benefits of paleontological research are to the needs of **people**: the visitor, scientist, interpreter, and manager. In order for a particular research project to be contracted by the National Park Service, or supported by Service funds, it should relate to all of these needs and benefit resource management. Nearly all forms of research meet this criteria by adding to the park's database, and should therefore be stimulated insofar as possible. Even projects that are deemed to be peripheral to the "core mission" of the monument should be encouraged, but investigators may be asked to seek funding from other sources.

Interpretation
Public appreciation is enhanced as a result of the **process** of research and its results. The pursuit of knowledge should **itself** be interpreted in the parks, and perhaps can be done better than anywhere, because the parks are the actual places of discovery; the laboratories of geologic inquiry. Accurate interpretation of the **science** of paleontology in the midst of active exploration and excavation (rather than merely expounding how this process is done "elsewhere") is important. This has also been shown to be effective at a variety of non-NPS sites (e.g., at the LaBrea Tar Pits, the Cleveland Lloyd Dinosaur quarry, Berlin-Ichthyosaur State Park, and The Mammoth Site of South Dakota). Additionally, it is crucial to the credibility of the NPS that the most accurate, up-to-date information possible is presented to the public (reference NPS-6 for a discussion) and erroneous or outdated theories are removed from programs.

Interpretation without access to an active research program is like a radio without an antenna. By maintaining dynamic research within a park, new information continually updates and increases the interpretive benefits of sites. Therefore, nearly all research is justifiable on interpretive grounds alone. Additionally, the Service plays a needed national role interpreting the educational importance of scientific concepts, such as evolution, to natural history studies.

Similarly, research and researchers may help promote the involvement of citizens in working with the resource. Public involvement with discovery leads to understanding. Examples include volunteers in parks who assist with fieldwork or in the laboratory, as well as organizations (such as "EarthWatch") that have aided investigators at the Mammoth Site of South Dakota, the Crazy Mountains of Montana, and Dinosaur National Monument in Utah.

Curation
Museological activities clearly benefit from scholarly study. Reluctance to support pure taxonomy is myopic. Beyond opening vistas of relationships, taxonomic studies not only identify material but are the basis for establishing the relative significance of specimens; information that otherwise could not be known. The competence of a curator to determine the "value" of specimens, both in the field and in the collections, is essential. This value can only be ascertained through a thorough familiarity with the literature, reference collections, and time/stratigraphic relationships made available through research.

Natural Resource Management
At the present time, modern ("neontological") resource management activities receive the sabertooth's share of attention at numerous NPS sites. This is especially puzzling in areas established primarily **for** their excellent fossil record. Perhaps this is because "rocks" supposedly do not appear to demand the relatively constant surveillance modern ecosystems require, or simply lack the zealous advocacy applied to cultural resources.

In fact, it is only within approximately the last 15 years that Servicewide paleontological localities have been viewed as manageable resources. Realistically, it is the case that in many strata, fossils are so abundant, durable, and/or widespread that they are not threatened and need little managerial oversight. In others, however, deterioration of the resource is very real and depressingly measurable.

Positive steps have been taken at several parks to quantify these threats and diminish and/or record the effects of extrinsic factors on rare fossils. Factors such as weathering and theft, for example, are well known, but the precise extent of the damage they cause is difficult to enumerate. There is a potential to overstate the negative effects of weathering in some strata, while ignoring losses of material elsewhere. Controlled studies of these threats provide valuable tools for the manager. Similarly, the process of planning and design of park facilities is enhanced by accurate information regarding effects on the resource, including prevention of unmitigated disruption during development of facilities.

Likewise, research also enhances the ability of the manager to control public use patterns; for example, determining the need for closing areas to the unescorted public depending on the significance and vulnerability of resources. Park localities warranting proportionately greater amounts of monitoring will be identified.

Research Planning
What may be required in many NPS units is a comprehensive **Paleontological Research Plan.**

A plan is necessary to:

- Ensure continuity in the research program.
- Knowledgeably evaluate both solicited and unsolicited research proposals.
- Notify the research community of opportunities for study.

A Paleontological Research Plan, prepared by the park paleontologist (e.g., Fremd, 1989) or qualified staff, with peer review, should provide managers with:

- A sense of the broad variety and diversity of investigative procedures, and the relative benefits of these methods in terms of their ability to contribute to public enjoyment, scientific investigation, and preservation of the resource.
- A basis for obtaining funding, and suitable methods for identifying institutional cooperation.
- An orderly means of acquiring, storing, and analyzing data that will enable management to forecast, rather than react to, research needs.
- A **coordinated program** with depth and continuity, funded and adhered to, maintaining a **long term commitment** to an increase of the monument's data base.

It is critical that the National Park Service be an active participant in such a program, and not merely a passive recipient of completed reports. The National Park Service **must** be knowledgeable concerning the resource to evaluate ongoing work and utilize its findings efficiently.

Inventory and monitoring, cyclic prospecting, and other methods become tools in a feedback loop with good research planning. A well-organized, systematic collection becomes the central component of a preservation system. Finally, probably the most important need is for paleontological expertise to be available at each area, in the form of a permanent staff member, answerable directly to the superintendent of the unit.

References
Chure, Daniel J., and Theodore Fremd, 1987, Protecting fossil resources in the National Park System. Natural Areas Journal., Vol. 7, No. 4.
Fremd, Ted, 1989, Paleontological research plan, John Day Fossil Beds National Monument. MS.
Fremd, Ted, 1992a, Paleontological resources management and its practical applications. Third Conference on Fossils in the NPS, Program with abstracts, 15.
Fremd, Ted, 1992b, Cooperative management of paleontological resources in the John Day Basin, central Oregon. Seventh Conference on Research and Resource Management, George Wright Society, 24.
Jablonski, D., 1991, Extinctions: a paleontological perspective. Science, 253: pp. 754-757
Santucci, Vincent L., Editor, 1993, National Park Service Paleontological Research Abstract Volume. Technical Report NPS/NRPEFO/NRTR-93/11.

Dinosaurs, Teachers, and Science: A Partnership for Research and Improvement of K-8 Teaching

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The discovery of Late Cretaceous (90-68 Ma) dinosaurs along the Colville River on Alaska's North Slope has added significantly to the current debate regarding dinosaur extinction, behavior, and physiology. Dinosaurs were first collected in 1961 by a Shell Oil Company geologist, but their true identity was not appreciated until 1983 when a US Geological Survey scientist reviewed and sent them to a specialist in Texas. Discoveries in 1978 and 1983 to the south and west on the Colville and Kokolik Rivers reinforced the importance of the North Slope as a dinosaur hunting ground. The first systematic collection and study of dinosaur remains from Alaska began in 1985. Research since 1985 has resulted in the identification of six families and seven species of dinosaurs. In addition, several fish and mammals have been documented. Most of the dinosaurs are concentrated in several "bone beds" along a two mile stretch of steep bluffs that are found along the lower portion of the Colville River near Ocean Point. The stage of research completed, the abundance of fossil materials available, and the proximity to good camping and landing sites makes the bone bed locality well suited for use as a teacher training site. The principal drawbacks to this area are the dangers presented by having to work at the base of high, steep bluffs, permafrost, and a short field season due to weather and the proximity of Peregrine falcon nesting sites.

The last decade has witnessed an extraordinary growth in research and interest in dinosaurs and their world. School age children have demonstrated an unabating fascination with dinosaurs that is unusual in its longevity. Teachers fortunate to have the proper backgrounds in biology and earth science have found that using dinosaurs as a focus in their science curricula can awaken an interest in science in general and lead to the integration of biology, math, physics, and geology. Few teachers in grades K-8 have had the opportunity to be exposed to field geology, let alone hands-on experience with vertebrate paleontology. With acceptance of the premise that turned on teachers will turn on their students, and the importance of nonscientists being given the chance to understand science as a human process, the following program was developed.

Structure and Composition of the Program

The program is comprised of two parts. The first involves teachers directly in field work and research on dinosaurs and associated vertebrates of Alaska's North Slope. The second develops Alaska specific lessons and classroom activities through a program of teachers networking with one another, as well as partnering with researchers at the University of Alaska, Arctic Sivunmun Ilisagvik College, Museum of the Rockies, and the Royal Tyrrell Museum of Paleontology. The University of Alaska Museum acts as a resource and coordination center where topical workshops, curation, and follow up research on field collections are held throughout the year.

The field program involving K-8 teachers and librarians has been carried on since 1991. Participants are required to take two Summer Session courses as prerequisites to the nine to ten day field experience. These prerequisite courses include introductions to dinosaurs and their world, and a week of camping and geologic instruction along the Haul Road that connects Fairbanks with Prudhoe Bay. Prudhoe Bay is the staging area for flights into the excavation base camp on the Colville River. Teachers are assigned to a series of 1m x 1m x 1m quarries in teams of two or three. Each team is responsible for mapping, at a precision of 1 mm, all vertebrate fossils encountered in their quarry. Most teams are able to map and record over a hundred skeletal elements during the course of their stay on the Colville. These elements range from tiny *Troodon* teeth to large limb and pelvic bones that require careful jacketing before removal. In addition to the demanding requirements of excavation and mapping, participants are also given experience in washing and screening microinvertebrate deposits.

The camaraderie, excitement, and newly acquired self esteem gained in the field are reinforced during the subsequent school year as the participants are offered the opportunity to become partners in the scientific enterprise by engaging in follow up curation and research. The vast majority of participants over the last three years have attended workshops on curation, molding and casting of specimens, the physics of dinosaurs, and other topics suggested by them. In addition, 30% of those who completed the field experience have opted to complete a related project for additional academic credit. Although each field season is limited to 10 to 12 teacher participants, the prerequisite courses, workshops, and related activities have engaged over three times that number each year. The teachers have been joined by librarians, undergraduate students, and parent volunteers in many of these post field activities.

Evaluation and Program Results

The Dinosaurs, Teachers, and Science program has directly engaged 137 teachers and librarians from 1991 to 1994. Over 1500 students have been directly involved in program activities, and an estimated 5000 students have indirectly benefited from the program through their classrooms. One librarian who completed the field program in the summer of 1993 has subsequently taken her dinosaur bone box "act" to several schools in Fairbanks as well as Huslia, the Aleutians, and even Texas where she contacted some 1600 students and teachers.

Several different evaluation instruments were used over the last three years. These included Student Opinions of Instruction as formulated, normalized, and compiled by the University of Washington, as well as independent assessments by four different evaluators. The last and most comprehensive survey was done by an independent evaluator who randomly queried 11% of the total population of 137, or 40% of the field participant's. This survey concentrated on the classroom impact of each participants experience with the program and asked each respondent to compare their attitudes, instructional content, and integration of disciplines before and after this experience. Although the amount of time spent on science instruction changed by only 9 percent points, significant attitudinal changes were perceived by the respondents. It should be pointed out that the individual teacher has to conform to district-wide time apportionment guidelines regarding subjects covered each day. Ninty one percent said that they thought that participation in the program had positively affected their teaching, had prompted them to acquire related educational materials, and develop partnerships with other teachers. Eighty two percent indicated that these partnerships continued beyond the program, and one hundred percent indicated they had shared their newly acquired knowledge with teachers not involved with the program. These results closely coincided with the original intent and stated goals of the program.

When two groups of respondents, distinguished by the number of direct experiences with the program, were asked to evaluate their classroom application of math and science procedures and concepts, the areas of science processes, relating other materials, a building on personal experience showed the greatest average increase. Both groups indicated that they spent more time each week demonstrating math and science processes, as well as engaging in hands-on activities in their classrooms than is the norm for their respective schools. The significance of these differences is hard to evaluate in the absence of district-wide statistics that are categorically comparable. A study of 7th grade science teaching practices was available and comparable in a few categories. When all of the results of all of the evaluation instruments are analyzed, several results stand out consistently. Participants in the field experience and hands-on workshops greatly enhanced their self-esteem, and this led to a new confidence in their ability to understand and teach science and math.

This new self image, especially for K-6 teachers, has definitely engendered a new attitude about science and mathematics. The following quotes from participants say it best: "We sometimes forget that math and science are used the real world and not just an activity in the classroom. We need to remember to relate these areas to everyday living.

This course has been a big help in this area." Another commented, "CONFIDENCE - I know about dinos and dinos in Alaska. I've seen the bones! I know about the rocks and geologic formation. I've seen them. Before this class I thought dinosaurs were only for kids. I had no idea how paleontology was so historical. The idea of mass extinctions as the norm was fascinating." Ninety percent of the respondents to the evaluations described the field experience as mentally and physically challenging, but the most beneficial part of the program. One participant put it this way; "This has added new depth to my program. By letting go, I can see where the students are getting so much more out of our topics. The students are now coming up with multiple predictions...their ability to observe has really developed."

Dinosaurs, Teachers, and Science has certainly matured over the last three years. Even though K-12 teachers were consulted and involved in planning prior to the first year of operation, both the program and its author took their lumps in the early going. The procurement of a Title II Eisenhower Mathematics and Science grant for two years greatly aided in rectifying initial shortcomings and unrealistic expectations concerning the level of discomfort that could be tolerated before it interfered with the academic and attitudinal goals of the program. A great deal of mutual respect and admiration finally developed out of self-doubt, test taking angst, environmental dislocation, and poor communication structures that marked the first and second years of operation. An expanded staff, relegation of most of the logistics, and institution of many of the constructive and insightful suggestions of the participants have been responsible for the fine program that it has turned into - a program that received an "exemplary" rating by the Alaska Department of Education's Office of Program Support in 1993.

As a result of the program and grant support, the instructional program at the museum now has two teaching slide sets with accompanying explanations, a 23 minute color training video, and an extensive updated curricular and reference library on dinosaurs and closely related fossils.

In addition to the pleasure derived from the association with such fine students and seeing many go through such an astounding personal metamorphosis, the Dinosaurs, Teachers, and Science program generated a number of important contributions to the research program of the Principal Investigator and the University of Alaska Museum. The following is an incomplete listing of these:

- Produced over 3000 skeletal elements for taphonomic, osteological, and paleoecologic research. Ninety five percent of these are mapped.
- Provided over 300 hours of volunteer work on the dinosaur collections including cleaning, conservation, and curation of bones and teeth. Led to a cadre of seven volunteers who continue to work on the collections.
- Provided funds and travel opportunities for the Principal Investigator that led to cooperative research programs at three major research museums.
- Helped support a special symposium on Late Cretaceous dinosaurs of the Arctic Margins in Anchorage in 1992, resulting in publication of a contribution to the symposium proceedings by the Principal Investigator.
- Supported the publication of a paper in the Journal of Vertebrate Paleontology on the first ankylosaur from Alaska.
- Provided training and materials for molding and casting of selected teeth and bones from the museum's dinosaur collections.

In Search of Behavior in Ancient Life: Animal and Plant Trace Fossils in National Parks and National Monuments in the Four Corners States

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Trace fossils, including tracks, trails, burrows, and nests, preserve the behavioral interaction between organisms and the substrate on/in which they live. The recognition and interpretation of trace fossils in ancient continental depositional environments significantly enhances our understanding of the interrelationships between organisms and their environment. Understanding organism-substrate relationships better defines the interactions between ancient plants and animals, their environment, and climatic setting, all of which constitute the paleoecosystem framework. Each type of trace fossil and its environment of occurrence records a specific organism-substrate relation important to paleohydrologic and paleoecologic reconstruction. Continental trace fossils preserve the physiological characteristics of organisms, as well as the biodiversity of invertebrates and vertebrates not commonly preserved in the fossil record.

National parks and monuments in the Four Corners area (Arizona, Colorado, New Mexico, and Arizona) comprise various ages of continental rocks known for their natural beauty and sculptured appearance. These same rocks, particularly those deposited during the Triassic Period (225 Ma to 208 Ma), contain abundant and diverse trace fossil assemblages that are scientifically important and potentially of public interest because they preserve unique evidence of ancient terrestrial and aquatic life. Many interesting organisms not represented in the Triassic fossil record were documented by their trace fossils discovered in Canyonlands and Petrified Forest National Parks, and Colorado National Monument. A few of these many unknown natural treasures are introduced and briefly described in the following sections, including their significance to ancient ecosystem studies.

Ancient Organisms and Their Trace Fossils

Trace fossils (ichnofossils) are the result of organism-substrate interactions that preserve the behavior of organisms with respect to the environment in which they live. These behavioral interactions are preserved in ancient rivers, lakes, floodplains, and deserts, many of which constitute the types of rocks in the national parks and monuments in the Four Corners area. Trace fossils from the Upper Triassic Chinle Formation in Canyonlands National Park, Petrified Forest National Park, and Colorado National Monument listed below represent different types of organisms with specific types of behavior. The trace fossils are described with an abbreviated diagnosis and short discussion about the trace-maker and significance of its behavior.

Scoyenia gracilis White 1929

Diagnosis: Slender burrows with rope-like surficial morphology. Burrow diameters range from 0.2 cm to 10 cm, and lengths from a few cm to 10 cm. Burrows are unbranched, quasi-horizontal to vertical in orientation, and sometimes exhibit peristaltic thickening. Burrow interior is meniscate, backfilled.

Discussion: The burrow surficial morphology suggests that the trace was produced by deposit feeding insect larvae probably of beetle origin. The burrow scratches reflect the limb morphology and the organism was adapted to burrowing in moist, compact substrates such as the silty clay in which *Scoyenia* is found. *S. gracilis* is common in the floodplain mudstones and paleosols of various immature stages of development, but also occurs in marginal-lacustrine and lacustrine deposits. It is absent from more mature paleosols and coarser grained deposits. The mode of occurrence would suggest that this ichnofossil is indicative of very high soil and sediment moisture approaching 100% saturation of freshwater. In general, *Scoyenia* occurs only in continental and marginal marine deposits with thin continental interbeds. *Sycoyenia gracilis* and *Scoyenia* sp. are indicators of moist to saturated substrates (100% of the pore space), which include immature paleosols and marginal fluvial and lacustrine strata.

Koupichnium Nopcsa 1923
Diagnosis: Heteropodous tracks of great variability. Two kinds of track imprints are common:
1. Two chevron-like series of tracks each of 4 oval to round holes or bifid V-shaped impressions or scratches;
2. one pair of digitate or flabellar, toe shaped imprints with or without a medial drag mark.
Discussion: Freshwater horseshoe crab (limulid) crawling and resting trace fossils occur in marginal fluvial (point-bar) and lacustrine deposits. Freshwater limulid ichnofossils in continentally deposited strata have been recorded in Paleozoic and Mesozoic rocks throughout the world and are not unique to continental depositional systems.

Continental freshwater limulids are indicative of environments that contained ample amounts of water in continental depositional systems. Their traces are often found in strata that represent shorelines of lentic and lotic paleoenvironments, and are best preserved when the sediments were moist but not submerged. Experiments with tracks of other arthropods have shown that they are best preserved in moist and saturated conditions. The limulid ichnofossils represent foraging out of the water onto the shoreline.

Camborygma Hasiotis and Mitchell 1993
Diagnosis: Architectural morphology varies from complex structures with multiple openings, shafts, corridors, and chambers, to simple, quasi-vertical shafts with simple chambers. Burrows sometimes preserve chimney structures at their tops. Burrow diameters in centimeters and lengths from 30 cm to 200+ cm. Surficial burrow morphology includes scrape marks, scratch marks, mud- and lag-liners, knobby and hummocky surfaces, pleopod striae, and body impressions.
Discussion: These traces represent crayfish burrows and associated with these burrows are fossils of the earliest known freshwater crayfish. Comparison of Triassic burrows to modern crayfish burrows concluded that the Triassic burrows were produced by crayfish using identical burrowing methods and exhibiting similar behavior patterns despite 220 million years difference in time.

Like modern crayfish, the burrow architecture of Triassic crayfish reflects the depth and fluctuations of the water table, thus preserving the hydrology of the Colorado Plateau during the Late Triassic Pangaea. Burrow length and complexity of the architecture reflects the depth and stability of the water table in that area. In general, crayfish biological characteristics and ethology are expressed through their burrows and body fossils. They are useful for paleohydrologic, paleoclimate, and paleoenvironment reconstructions of the strata in which they occur. Crayfish burrows and their stratigraphic succession reflect the depths and fluctuations of the water table, as well as the amount of water in a system (overall precipitation), seasonality and climate.

Plant Roots: Rhizoliths
Diagnosis: Rhizoliths, or root trace fossils, taper downward and exhibit diameters that range from 1 to 4 cm. They range in length from 0.5 to 1 m. They typically bifurcate downward and laterally, commonly terminating to a taper or as diffuse filamentous traces. Rhizoliths display lavender or white interiors with lavender highlights and are surrounded by reddish-purple and yellow reduction alteration haloes. The well-preserved portions of the roots display fine, hair-like structures that penetrate the haloes and continue for a few cm into the surrounding matrix.
Discussion: These biogenic structures are interpreted as primary and secondary branches of root trace fossils, most likely of woody plants on the basis of their morphology. The filamentous structures represent root hairs that grew from the main roots to increase water and nutrient absorption from the paleosols. The root alteration haloes were probably the result of plant-substrate interactions and water table fluctuations. The length of the roots, presence of root hairs, and local alteration haloes suggest the roots grew in moist, well-drained portions of the paleosols that experienced seasonal fluctuations in the water table.

Adhesive Meniscate Burrows: Bown and Kraus, 1983
Diagnosis: These burrows are back-filled, 0.3 to 2 cm in diameter, and range from 1 to 8 cm in length. They are

found in great abundance and occur in discrete groupings between 1 and 1.75 m below the uppermost surface stacked paleosols. The burrows contain meniscate that are thin, ungraded, and composed of fine grained materials stained with alternating zones of oxidized and unoxidized iron compounds. The burrow walls exposed in the matrix are commonly smooth; their terminations are rounded or enlarged.

Discussion: These burrows are termed "adhesive" because they cannot be easily removed from and do not differentially weather from the matrix. Comparisons of the burrow morphologies to other modern infaunal soil organisms suggest they are most likely the result of the activity of invertebrates from the insect order Hemiptera, commonly termed "soil bugs". These modern organisms burrow in moist sediment (between 10% and 40% moisture) that contains detrital organic material and roots. Triassic organisms similar to modern soil bugs probably fed on both live and dead roots, detrital organic material, as well as other soil organisms.

J-Shaped, Inclined Burrows

Diagnosis: These burrows are commonly 0.3 to 1 cm in diameter and range in length from 5 to 10 cm, though many are incomplete because of their oblique orientation to the outcrop surface. The burrows are vertically oriented, have a J-shaped architecture and locally continue laterally into the substrate. They also occur as horizontal burrows that do not show a vertical component. The burrow-fillings are variable in texture, lithology, and grain size, indicating both passive and active filling.

Discussion: The J-shaped burrows commonly occur in the upper portions of the paleosols in areas of the substrate with little to no apparent mottling. When mottling is present, it is brownish-red to red in color. The inclined, J-shaped burrow morphologies are similar to modern burrows constructed by insects of either orthopterid (cricket) and scarabaeid (beetle) affinities. The modern burrowing insects construct burrows with similar J-shaped morphology for brood nests, storage vaults, and feeding mines in well drained and well aerated upper portions of soils. By analogy, the Triassic burrows represent upper zones of the paleosols that had more variable moisture levels, with better drained and aerated substrate conditions. These conditions are also evidenced by fewer mottles in the uppermost horizons of the paleosols where these burrows occur. In other, more complete paleosols with wetter characteristics, these burrows may reflect well drained settings with infrequent periods of extreme wetness.

Significance

Trace fossils represent the behavior of organisms preserved in ancient substrates that include sand, mud, soils and wood. These and other trace fossils of terrestrial and freshwater aquatic organisms, through comparisons to modern burrowing analogs, allow for accurate reconstruction of ancient organism behavior, the physiochemical mechanisms that regulated organism distribution, and the internal and external environmental components that shaped ancient ecosystems.

Continued research on the occurrence and distribution of ancient organisms in Triassic and other geologic age rocks on public lands will document the importance of continental trace fossils as environmental indicators. Ancient behavioral and environmental information gained from ongoing studies in national parks and monuments can greatly enhance our understanding of paleoecosystems and their changes as a result of ancient climate change and geologic processes.

Summary

Trace fossil resources are poorly understood and overlooked by park paleontologists, rangers, and scientists alike because this type of research is typically not a media "head-line grabber" like dinosaur hunting and archeology. One of the objectives of this paper is to illuminate and educate others about a part of our fossil heritage that requires recognition and study in our federal and state lands and parks. The general public needs to be educated concerning the valuable information contained in trace fossils because they represent organisms in the geologic record that are rarely preserved as body fossils. Educating others about trace fossils and the organisms which created them will increase the demand for more research in parks and other public lands in the future, creating a greater awareness by both professionals and the public, of a valuable resource that awaits discovery.

Fossil Collections and Paleontologic Databases in the Branch of Paleontology and Stratigraphy of the U.S.G.S.

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Paleontologists have performed an essential role in the geologic activities of the U.S. Geological Survey (USGS) since its founding in 1879. USGS fossil collections span the full spectrum of broad taxonomic groups, including microfossils (pollen and spores, calcareous nannofossils, foraminifers, diatoms, ostracodes, radiolarians, chrysophytes and conodonts), invertebrate macrofossils (mollusks, brachiopods, coelenterates and cnidarids, pelmatozoans and other echinoderms, bryozoans, etc.), vertebrate macrofossils (mainly mammals), plant megafossils (compression and impression floras, petrifactions, etc.), and trace fossils (ichnofossils), in descending order of number of collections and individual specimens. The collections of microfossils and invertebrate macrofossils are quite large in contrast to the other broad groups cited. These USGS collections are predominantly from throughout the United States, although significant collections exist for several marine (oceanic) and international areas where the USGS has been involved programatically.

Fossils are used by the USGS paleontologists to document: interpretations of geologic ages; stratigraphic correlations: geologic and structural relationships; paleoclimate; paleogeography and paleobiogeography, depositional environments; source of detrital sediments (geologic provenance); and basin evolution. Fossils also are primary data used for energy and mineral resource evaluations (including analyses of thermal and burial histories) and geologic hazard analyses. As a matter of policy, paleontologic data are included in publications by USGS personnel and collaborating geoscientists, where they are part of the primary data used in geologic interpretations. These reference collections are generally the only documentation for the informal Examination and Reports (E&R's) made by the Branch of Paleontology and Stratigraphy (P&S) and provide control on their quality because they can be re-examined and checked by subsequent workers. Time and personnel permitting, collections are made available to USGS geoscientists and qualified members of the scientific community for use in evaluating published reports and for use in research.

The USGS fossil collections are unquestionably the largest in the world. A conservative estimate is that 250,000 discrete collections of fossils are currently under the control of the P&S Branch, where, historically, most of the paleontologic expertise in the USGS has been concentrated. (Other fossil collections exist in several other Branches within the USGS, but these are much smaller and are not considered in this paper.) The number of individual fossils in the P&S sets is estimated to be in the tens of millions of specimens, particularly considering that the individual collections of microfossils are the largest single "group" of collections. The largest block of collections resides at the USGS National Center in Reston, VA, followed closely by the collections housed at the Denver Federal Center, and at the Smithsonian's National Museum of Natural History (USNM) in Washington, DC. Smaller but significant collections also reside at Menlo Park, CA, and Woods Hole, MA, where the P&S Branch also has active research paleontologists.

Following the requirements of the Organic Act (Organic Act of 1879, 43 USC 31) by which the USGS was founded, the policy of the P&S Branch has been to accession to the National Museum of Natural History (USNM) of the Smithsonian the following fossil material: all primary type specimens; figured, measured, and referenced specimens from published monographs and geologic papers; certain exceptional specimens and collections; and blocks of collections no longer considered essential to the ongoing programmatic activities of the USGS. The remaining collections, by far the bulk of the material, have been retained as stratigraphic reference sets to support continuing mission-oriented research.

USGS fossil collections initially were located at the duty stations of the specialists. Because most of the early paleontologists were stationed in Washington, D.C., it is not surprising that the largest block of collections still resides in the Eastern Region (Reston, Va., Washington, D.C., and Woods Hole). Through the 115 year history of the USGS, staffing has changed drastically. As many personnel moved from one duty station to another, the residence of the fossil collections themselves in large part also has not remained static. It is important to note that, generally speaking, **poor correspondence exists between the region from where the collections were obtained and their current residence**.

Paleontologic "databases" in varying formats are associated with, and appropriately reference the collections themselves. These likewise reside in the P&S centers and contain a more or less standardized set of geographic, stratigraphic, and paleontologic data ranging from very generalized to highly detailed and specialized. These databases, both historical (or "inactive") and active sets to which information is being developed and added, are in a wide array of formats, ranging from card catalogues, ledgers, bound and loose leaf notebooks, field notebooks, and electronic data processing (EDP) systems (exclusively on personal computer databases). The databases are arranged by general geologic age, general broad taxonomic group, or program group, and may be categorized in three general units. These are referred to as the **General Paleontologic Databases** (**GPD**'s), the **E&R Files**, and the USGS **Global Change-Climate History Databases** (**GCCHD**'s). With the notable exceptions of the GCCHD and E&R Files, relatively few of the total number of records, however, are on EDP formats, impeding ready access to the wealth of information potentially available. The USGS is mandated by the National Geologic Mapping Act of 1992 (PL 102-285) to develop the **National Paleontological Database** (**NPDB**), a National-scope **metadatabase** that would include not only the USGS fossil databases but those from other sources as well. The first phase of the creation of the NPDB will be to get the USGS records in EDP systems. Tables 1, 2, and 3 document the residence, by region, of the major USGS paleontologic databases.

Policy for broader access to these databases is under review and will be modified with input from the Federal land management agencies, as well as State and local agencies. The development of fundamental policy such as this must balance two issues that may conflict to some degree: 1. The scientific community's fundamental interest and need for reasonably unfettered distribution of, and access to primary scientific information; 2. The requirements of the land managment community to "protect and conserve" what progressively is becoming viewed as impacted paleontologic resources. These USGS data are available to Federal and State land management agencies, within limits of available personnel and funds to compile these data and provide them to requestors. The USGS and several of the Federal land management agencies have devised several **Memorandums of Understanding** (**MOU**'s) and **Interagency Agreements** (**IA**'s) involving collaborative paleontologic and geologic investigations and sharing of expertise and information, of which these databases are a part. One of the deficits in the geographic (locality) fields of the USGS paleontologic databases is reference to "ownership" or domain of the land on which the collections were obtained. Although most of the USGS collections were made on public lands in the western United States and Alaska, many of the USGS collections precede the formation of the Federal land-managing agencies and most of the National Parks. Only within the last several years has this issue assumed primary importance to Federal agencies other than the National Park Service. This "omission" has developed historically and has not resulted from policy decisions. In requesting and accessing these databases, however, be aware that this deficit exists.

NOTE
For an update on the disposition of these USGS functions and collections, see Addendum on page 2.

Table 1-Inventory of principal paleontologic databases residing in Eastern Region developed and controlled by P&S Branch. Approximate number of records or reports in square brackets.

PALEONTOLOGIC DATABASES, EASTERN REGION

(Reston, Va., Washington, D.C., and Woods Hole, Mass.)

Examination and Report (E&R) National Register-Mainly microfossils and invertebrate macrofossils; Palezoic through Cenozoic; mainly United States and Alaska, also international and oceanic regions; uses other database numbers for material reported in the E&R's. [22,000 reports (mostly EDP)].

USGS Global-Change-Climate History Database (GCCHD)- Data from palynology, foraminifers, ostracodes,and other microfossils, some macrofossils. EDP based, includes detailed taxonomic identifications. [11,000 records].

Cambrian-Ordovician (CO) National Register -Invertebrate macrofossils and conodonts; Cambrian through Ordovician; from surface outcrops and core; North America including Alaska, some international. [11,000 records].

Silurian-Devonian (SD) National Register -Invertebrate macrofossils and conodonts; North America including Alaska, some international. [15,000 records].

Mesozoic National Register -Invertebrate fossils; North America including Alaska but mainly Atlantic and Gulf Coast Areas. [33,000 records].

Cenozoic National Register - Invertebrate fossils originated by USGS personnel but currently maintained by USNM (Smithsonian); still used by USGS personnel in Reston. [25,00 records].

Woods Hole Foraminifer Register - Planktic and benthic foraminifers; Mesozoic through Cenozoic; from core and surface outcrops of Atlantic and Gulf Coast area and cores and dredging on continental shelves. [7,500 records].

Reston Palynologic Register -Palynomorphs; Mesozoic and Cenozoic; mainly Eastern Region and Gulf Coast. [4,500 records].

Reston Nanofossil Register - Nanofossils; Mesozoic and Cenozoic; mainly Eastern Region and Gulf Coast. [8,000 records].

Reston Diatom Register - Diatoms; Mesozoic and Cenozoic; mainly marine from eastern U.S.7,500 records].

Conodont Registers - Several registers: Conodonts (microfossils), Paleozoic and lower Mesozoic; mainly United States including Alaska, some international. Collections entered into appropriate National Registers when cited in publication; separate register kept for Conodont Alteration Index (CAI), locality, age, and other information in computerized database. Recently obtained conodont collections from Shell Western being put into separate database (approximately 9,000 collections). [Approx. 20,000 records, mostly EDP].

Table 2-Inventory of principal paleontologic databases residing in Central Region (Denver, Colo.), developed and controlled by P&S Branch. Approximate number of records in square brackets

PALEONTOLOGIC DATABASES, CENTRAL REGION

(Denver, Colo.)

Upper Paleozoic National Register (PC-Files) - Two subregisters. Invertebrate macrofossils and conodonts, some other microfossils; Mississippian through Permian ("Permo-Carboniferous, PC); conterminous United States plus Alaska, some foreign. [45,000 records].

Denver Radiolarian Register (DENRAD) - Radiolarians; Mesozoic and Cenozoic, some upper Paleozoic; mainly western United States and Alaska; some deep-sea material. [5,000 records.]

Denver Diatom Register - Nonmarine diatoms, mostly Quaternary; mainly western and central United States. [3,500 records].

Vertebrate Registers - Three separate registers maintained in Denver. **(1) Menlo Park Vertebrate Register** - Cenozoic, mainly western U.S. 1,500 records. **(2) "Old" Denver Vertebrate Register** - Central and western United States; historical register. [1,000 records]. **(3) New" Denver Vertebrate Register** - Microvertebrates; mainly Eocene, Wyoming, Utah, Kansas. [900 records].

Denver Mesozoic Invertebrate Register - Macroinvertebrates; mainly Cretaceous, Western Interior; minor west Coast and Alaska. [13,000 records].

"Denver" Lower Mesozoic Macroinvertebrate Registers - Five separate "registers", mainly early and middle Triassic ammonites and other marine macroinvertebrates; Western United States and Alaska. [22,500 records].

Denver Lower Paleozoic Macroinvertebrate Registers - Two registers; invertebrate macrofossils; Cambrian and Ordovician, mainly western United States, especially Great Basin. [12,700 records].

Denver Silurian-Devonian Invertebrate Register - Invertebrate macrofossils; mainly western United States. [400 records].

Denver Fossil Plant Registers - Two registers (collections to be turned over to USNM). **(1) Compression-Impression Plant Register**; Mesozoic and Cenozoic. [1,000 records]. **(2) Cleared-Leaf Register**; Holocene, world-wide [20,000 records].

Denver Ostracode Registers - Two registers; mainly Mesozoic, Cenozoic, and Holocene; mainly United States, some foreign. [10,000 records].

Denver Palynomorph Registers - Two Palynomorph registers. **(1) Non-Climate Program**; upper Paleozoic, Mesozoic and Cenozoic. [7,000 records]. **(2) Climate Program (subset of Global Change- Climate History Database)**; Cenozoic, mainly western and central United States and Alaska; some Canadian and Artic. [7,000 records].

Shell Paleozoic Foraminifer/Fusulinid Register - Mainly upper Paleozoic, primarily Central and Western United States, some Alaska and international. [Collection of approx. 250,000 prepared thin-sections from about 50,000 collections, mostly boreholes; figures not included in summary numbers in text].

Table 3-Inventory of principal paleontologic databases, residing in Western Region, developed and controlled by P&S Branch. Approximate number of records in square brackets

PALEONTOLOGIC DATABASES, WESTERN REGION
(Menlo Park, Calif.)

Menlo Chrysophyte and Pollen Register - Neogene and Quaternary; Western North America. [7,500 records].

Menlo Diatom Registers - Three registers, marine diatoms. (1) Mesozoic and Cenozic, Western North America, Pacific Ocean, Antarctica. (2) Subset of Menlo Microfossil Register; Mesozoic-Cenozoic; California borderland. (3) Climate Program samples, Pliocene. [10,000 records].

Menlo Nanofossil Register - Nanofossils; Deep-Sea Drilling Program/Offshore Drilling Program [DSDP/ODP); world-wide oceans. [7,000 records].

Menlo Mesozoic Macrofossil Register - Macroinvertebrates; Mesozoic, some Paleoecene; Western United States and Alaska, some Midcontinent. [8,700 records].

Menlo Cenozoic Macrofossil Register - Macroinvertebrates; Cenozoic; Alaska, western United States, Japan, former Soviet Union. [9,500 records].

Menlo Foraminifer Registers - Two registers. (1) Cenozoic benthic and planktic foraminifers; western US, Alaska, oceanic. [2,500 records]. 2) Mesozoic; western United States, global. [7,500 records].

Menlo Radiolarian Registers - Primarily Paleozoic and Mesozoic, some Cenozoic; mainly western United States, Alaska, and global. [8,000 records].

Upper Paleozoic Fossil Collections and Databases of the U.S. Geological Survey

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Upper Paleozoic Fossil Collections and Registers

The first collections made from upper Paleozoic (Mississippian, Pennsylvanian, and Permian) rocks by U.S. Geological Survey (USGS) personnel date from the early 1880's. Subsequently, over 45,000 discrete fossil collections of invertebrate fossils (mostly megafossils, but including conodonts, foraminifers and fusulinids, and other microfossils), approximately 8,000 collections of compression and impression plants, and roughly 5,000 palynomorph (pollen and spores) collections were made by USGS geologists from upper Paleozoic sections (Mississippian through Permian). The invertebrate fossils and conodonts were kept in two subregisters, known collectively as the **Upper Paleozoic Fossil Locality Register** or the **Permo-Carboniferous (PC) Fossil Locality Register**. Locality data for the plant megafossils were kept in another separate register, the **Paleozoic Fossil Plant Register**, into which also was entered a small amount of data from the Devonian collections. Upper Paleozoic collections of fusulinids and smaller calcareous foraminifers used **Upper Paleozoic Fossil Locality Register** numbers and a separate numbering system. Small collections (< 200) of upper Paleozoic radiolarians exist in both Denver, Colo., in a register called **Denver Radiolarian Register (DENRAD)**, and in Menlo Park, Calif., in a separate radiolarian register. The large collections of upper Paleozoic palynomorphs reside in Denver and are entered in the **Denver Fossil Plant Register**. The overwhelming majority of upper Paleozoic fossil collections are from the conterminous United States and Alaska. Most of the invertebrate, foraminifer (including fusulinid), and conodont collections are from public lands of the West, including Alaska. Most of the plant collections (megafossils and palynomorphs) come from the coal fields of the Midcontinent region and eastern US, especially the Illinois and Appalachian basins.

From about 1950 until the early 1980's, most of these upper Paleozoic collections included in the **Upper Paleozoic Fossil Locality Register** and the **Paleozoic Fossil Plant Register** were housed at the National Museum of Natural History (USNM) of the Smithsonian Institution in Washington, D.C., under the control of the USGS. The upper Paleozoic fossil plant collections, the corresponding register, and the smaller calcareous foraminifers and fusulinids were accessioned to the USNM in 1985. Conodont collections from the upper Paleozoic were moved to the USGS National Center in Reston, Va., in the 1980's. In 1987, about 30 percent of the upper Paleozoic invertebrate macrofossil collections were moved to the Federal Center at Denver, Colorado, where large collections were located already (Dutro and Henry, 1991). The remainder of the upper Paleozoic macroinvertebrate collections remain at the USNM under USGS control. Personnel responsible for the maintenance of the **Upper Paleozoic Fossil Locality Register** are stationed in Denver. For further information on these collections and registers, refer to Henry (1995, this volume).

Value of Computerized Databases

For the research paleontologist, land manager, or museum curator, electronic databases provide significant and obvious advantages over card based and other types of registers. The user has direct access to periodically updated sets of files that can be used for specific applications. The structure of a given data file can be customized to eliminate some data fields or to include other kinds of information not originally built into the main file structure itself. Such databases for paleontologic material collected on public lands are a valuable resource for land management agencies that require information to effectively manage paleontologic resources, including regulating specific types of fossil collecting activities by scientists, t[he] general public, or other parties on public lands. Computer technology permits easy access to, and transfer of, geographic, stratigraphic, and taxonomic information among federal and state geological surveys, museums, and federal and state land management agencies.

Computerized databases also provide the potential for merging several paleontologic databases in order to produce regional inventories and for "reassembling" single collections now housed as separate collections in different museums, institutions, or repositories. The need for such merged databases of paleontologic material collected on public lands has become progressively more apparent in recent years. For additional information, refer to Glenister and others (1977). Paleontologic data files can be used concurrently with other files constructed to handle different kinds of geologic or paleontologic information (e.g., photographic records or publication databases) or converted for use in other database and spreadsheet software. Indeed, transfer of data between different types of software and across different platforms has become the rule rather than the exception.

Upper Paleozoic Fossil Locality Register
The Upper Paleozoic or Permo-Carboniferous (PC) Fossil Locality Register is one of several files developed and maintained by the P&S Branch (see Dutro and Henry, 1991; Henry, this publication). The upper Paleozoic files were more or less standardized in the late 1940's and early 1950's to incorporate a minimum set of geographic and stratigraphic data about fossil invertebrate collections. In spite of the standards, the quality of the data within the information fields varies from collection to collection, although they are generally accurate and of high quality. Data from this register are being entered into a computerized register known as **PC-FILES**, under the auspices of the National Geologic Mapping Act of 1992 (PL 102-285), which charges the USGS with the development of the **National Paleontological Database**. **PC-FILES** refers to the complete, computerized USGS **Upper Paleozoic Fossil Locality Register**. We estimate that the entire computerized database for the complete **PC-FILES** will exceed 40 megabytes, a size too large for easy manipulation on the current generation of personal computers. Therefore, the databases for each of the 36 states for which upper Paleozoic collections exist will be presented as individual files representing subsets of **PC-FILES** using the US Postal Service abbreviation for the state as the first two characters in the file name. For example, the database for Nevada is **NVPCFILE.dbf**; that for Kansas is **KSPCFILE.dbf**, etc.

Borland's dBASE IV™ Version 1.1 is the software used to manage **PC-FILES**. The structure for records in **PC-FILES** is shown in Table 1. The groups and field names are discussed briefly here. The reader is referred to Henry, Williams, and Holroyd (1993) for an in-depth discussion of **PC-FILES**, protocols used in entering data, the sets of standardized abbreviations, a discussion of the limitations of the computerized database developed from the **Upper Paleozoic Fossil Locality Register**, and examples of the types of searches that can be conducted with **PC-FILES** using dBASE IV™. Most field names are self-explanatory. A command line for a search in dBASE IV is based on a set of conditions involving one or more fields and is limited to 254 characters. Furthermore, as many fields as possible in **PC-FILES** have names in common with the other computerized dBASE databases in use within the USGS (for example, **DENRAD**) so that similar searches can be easily made in both registers.

The database structure for **PC-FILES** was designed to include information normally entered in the **Upper Paleozoic Fossil Locality Register**. Field size and type was determined by experience and by the need to include as much pertinent information as possible. Each record in the **PC-FILES** consists of 25 fields and 735 characters or spaces (see Table 1). The fields fall into one of six groupings: Catalogue Number Fields; Geographic Fields; Stratigraphic and Age Fields; Collector and Related Information Fields; Fossil Type Field; and Miscellaneous Fields. These groupings are not reflected in the database file itself, except by the order in which the fields appear.

Geographic information is entered into a group of fields, most of which are self-explanatory. The quadrangle, quadrangle series, and original map fields are especially important because a location correctly and accurately located on older versions of maps or smaller scale maps may not be transferred easily to a modern or larger scale map. Thus, the limits on accuracy of a geographic location are partly a function of the map used when the collections originally were made. Furthermore, most collectors have used the public land survey grids (township, range, etc.), where available, rather than latitude and longitude or other geographic locators. However, land surveys have improved and are normally different from version to version of the same scale map, again placing constraints on the accuracy of geographic location of a given fossil collection. Anecdotal geographic information (e.g., highway logs, landowners, quarry names, etc.) are entered in the Miscellaneous Fields.

Stratigraphic nomenclature is changing constantly, and names for the same rock-stratigraphic unit may vary within a single sedimentary basin and at political boundaries. We have attempted to use nomenclature approved by the Geologic Names Unit (GNU) of the USGS (see MacLaughlin and others, 1994) for consistency. However, use of a given stratigraphic name within the stratigraphic and age fields is not intended to imply endorsement of that name by the USGS. Many older collections were collected from stratigraphic units whose nomenclature is now significantly revised. Also, non-USGS collectors may have employed other stratigraphic nomenclature schemes.

Information regarding the type of fossils included in a PC-collection is entered in the Fossil Type field. Potentially, this is a highly valuable but "sensitive" data field (particularly for the land-managing agencies). The majority of **Upper Paleozoic Fossil Locality Register** records lack detailed information on what types of fossils are included in the individual collections. As research is conducted on the older collections, and when new collections are added, data progressively are entered into this field. Detailed taxonomic information (e.g., to the level of genus or species), where available, will not be entered in the **PC-FILES** databases but are instead placed in relational databases for specific studies and activities.

Two Comments fields comprise the Miscellaneous Fields. Any additional information that was present in the card files of the **Upper Paleozoic Fossil Locality Register** is given there. These fields are used to provide detailed information for finding localities (commonly in the form of a road log), more detailed stratigraphic information (commonly identifying specific beds or lithologies), and references to any previous publications based on these collections.

NOTE

For an update on the disposition of these USGS functions and collections, see Addendum on page 2.

References

Dutro, J.T., Jr., and T.W. Henry, 1991, Paleontologic note: Fossil invertebrate collections moved from National Museum: Journal of Paleontology, v. 65, no. 1, p. 171.

Glenister, B.F., and others, 1977, Fossil invertebrates - Collections in North American repositories, 1976: Published by The Paleontological Society [A Report of The Paleontological Society ad hoc Committee on North American Resources in Invertebrate Paleontology (COLNARIP)], 67 pp., 1 fig., 11 tbls., 8 appendices.

Henry, T.W., 1995, Fossil collections and paleontologic databases in the U.S. Geological Survey: National Park Service Natural Resource Report [this volume], 2 pp., 3 tbls.

Henry, T.W., O.B. Williams, and P.A. Holroyd, 1993, USGS Permo-Carboniferous fossil locality register - Part 1: Introduction to **PC-FILES**: U.S. Geological Survey Open-File Report 93-513, 59 pp., 2 figs., 2 tbls., 2 appendices.

MacLaughlin, M.E., W.A. Bryant, T.W. Judkins, O.B. Williams, E.D. Koosmin, R.C. Orndorff, M.L. Hubert, C.R. Murdock, S.W. Starratt, and J.R. Le Compte, (compilers), 1994, Stratigraphic nomenclature databases for the United States, its possessions and territories: U.S. Geological Survey Digital Data Series DDS-6, Release 2; consisting of Geologic Names Unit Lexicon (GNULEX) and Geologic Names of the United States (GEONAMES).

Disclaimers

Table 1 - dBase IV Structure of fields for computerized USGS Upper Paleozoic Fossil Locality Register (PC-Files). From Henry, Williams, and Holroyd (1993).

Field Contents	Field Name	Type	Width	Dec.
		PC Catalogue Number		
Prefix	PX	Character	2	
Number	NUMBER	Numeric	7	0
Suffix	SX	Character	5	
		Geographic Fields		
State	ST	Character	2	
County	COUNTY	Character	15	
Quadrangle	QUADRANGLE	Character	20	
Quad. Series	QDSER	Character	6	
Original Map	ORIGMAP	Character	20	
Latitude	LATITUDE	Numeric	7	4
Longitude	LONGITUDE	Numeric	8	4
Quarter	QUARTER	Character	20	
Section	SEC	Numeric	2	0
Township	TNSP	Character	4	
Range	RNGE	Character	4	
		Stratigraphic and Age Fields		
System	SYS	Character	5	
Series	SERIES	Character	10	
Group	GROUP	Character	20	
Formation	FORMATION	Character	20	
Member	MEMBER	Character	20	
		Collector and Related Information Fields		
Project Chief	PROJCHIEF	Character	12	
Collector	COLL	Character	18	
Date Collected	DATECOLL	Character	10	
		Fossils Field		
Fossil Type	FOSSIL	Character	50	
		Miscellaneous Fields		
Comments	COMMENTS	Character	254	
Addnl. Comments	COMMENTS2	Character	254	

The Nature of the Plant and Invertebrate Fossil Record: Implications for Paleontological Resource Management

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While the fossil record is composed of plants, invertebrates, and vertebrates, the majority of regulatory efforts have been devoted to fossil vertebrates. In order to demonstrate how management of invertebrate and plant paleontological resources must necessarily differ from that of vertebrate fossils, this paper will:

- Discuss nature and occurrence of plant and invertebrate fossils.
- Give a brief overview of the types of research being done on these fossils.
- Address the value of invertebrate and plant fossils to the amateur, commercial, scientific and educational communities.
- Provide guidelines for evaluating the significance of specific plant and invertebrate fossils and fossil localities.
- Discuss aspects of the management of plant and invertebrate fossil resources.

Nature and Occurrence of Plant and Invertebrate Fossils

Nonvertebrate fossils are common constituents in many sedimentary rocks such as coal, limestone, dolomite and mudstone. Some of these rocks are comprised entirely of fossil matter. Plant fossils generally occur as compression-impression fossils in sandstone or mudstone, or as petrifactions. Plants also form the bulk of coal seams. Petrifactions, such as fossil tree trunks, have traditionally posed the most difficult problem from a management point of view because, being resistant to weathering, they are therefore visible at the surface, and are sought by rockhounds. Several petrifaction sites have already been protected within national or state parks. These include Petrified Forest National Park in Arizona, Ginkgo State Park in Washington, Specimen Ridge in Yellowstone National Park, and Florissant Fossil Beds National Monument. Present regulations allow for the private collection of "reasonable" amounts of petrified wood and other plant and invertebrate fossils on Bureau of Land Management (BLM) land.

Compression-impression fossil plant sites are extremely abundant in terrestrial sedimentary rocks but are typically only noticed if the sedimentary rock is hard enough to preserve bedding planes. In most cases compression fossils are only found by active digging. As a result, they are commonly uncovered by road crews and building excavations. The term "surface prospecting" does not apply to most of these localities since some digging is required to determine if fossils are present. Since more complete specimens are more valuable scientifically than partial ones, typical fossil leaf excavations usually exceed one cubic meter. Some classic compression leaf sites such as those in the Green River Formation near Bonanza, Utah, are preserved in hard white shale and are durable and attractive enough to have warranted commercial value. In general, compression plant fossils do not yet have much of a commercial value. Certain compression sites have a relatively higher scientific value because they preserve rare organisms or preserve fossils extremely well. The Miocene Clarkia lakebed in Idaho is such a site. Fossil leaves from Clarkia are so well preserved that some contain original DNA. In general, although fossil leaf sites are very common, very few have received comprehensive scientific study.

Coal deposits are composed almost entirely of fossil plants. The coal itself is vegetable matter and the surrounding sedimentary rocks often contain abundant compression leaf, trunk, and root fossils. The extensive coal fields of the American West generally contain coal of Cretaceous and early Tertiary age. Coal mines provide opportunities to study fossils that would otherwise not be exposed. On the other hand, mines and quarries destroy the fossils that they uncover.

Management of fossil plant resources must recognize that research opportunities are both created and destroyed by mining activity. Interaction of scientists, mine operators and appropriate land managers provide a method by which all sides achieve their goals. Mining practices and reclamation laws are such that mines must be viewed as temporary opportunities to acquire scientific information.

Invertebrate fossils generally occur as body fossils or as trace fossils. They can also form the body of rock as in limestones. The most common invertebrate fossils vary with the age of the deposit and the original depositional environment. In the American West, invertebrate fossils are found in rocks that range in age from the Cambrian to the present. Some of these rocks such as the ammonite producing Cretaceous marine shales of South Dakota and the trilobite producing Cambrian marine shales of Utah have received fairly intense amateur and commercial exploitation. Others such as the oyster-bearing freshwater and nearshore rocks of Cretaceous and Tertiary age preserve abundant fossils of little commercial value. West of Henrieville Utah, Cretaceous oyster fossils are so common that they are used as road metal. The most attractive fossils in Cretaceous marine shales are preserved in concretions, hard rock masses that formed around an organic nucleus. These concretions are often eroded from the shales and redeposited in younger deposits, thus losing much of their scientific context. Pleistocene gravel pits in central South Dakota that contain fossiliferous Cretaceous concretions are a good example of such deposits. Limestone quarries in the midcontinent such as the extensive Silurian deposits near Chicago are analogous to coal mines; the bulk of the quarried material is of fossil origin. The presence of the quarry provides the opportunity to study and collect fossils but the quarry by its very nature also destroys these fossils.

Occasionally, fossil sites will contain an abundance of soft-bodied or rare fossils not preserved elsewhere. These sites, sometimes known as lagerstatten, are of extremely high scientific value and include sites such as the Cambrian Burgess Shale of British Columbia. Other sites will occasionally produce fossils of extreme rarity. Examples of this include the Green River Formation in western Colorado. Specific horizons contain huge numbers of fossil insects and leaves and have been collected for many years. During this time, a single fossil scorpion and a few fossil butterflies have been recovered.

Some types of plant and invertebrate fossils are extremely common in certain geologic formations. While these fossils are not "renewable", they are certainly re-occurring, and the supply far outweighs the demand. Access to these common fossils is limited only by the amount of available outcrop, whether natural exposure or exposure created by mining, quarrying, construction, or road building. Extensive collecting at these sites is the type of activity that eventually yields the rare fossils. In situations of limited outcrop exposure, the fossiliferous exposure itself may be considered the resource rather than the fossils it contains.

Research on Fossil Plants and Invertebrates

Scientific research on nonvertebrate fossils takes many forms. The most basic form of research is the alpha taxonomy of a formation or simply determining the types of fossil organisms that occur in each rock unit. In the American West, this work began in the mid 19th century and continues today. From this point of view, the more fossils of a species from a specific formation there are, the less valuable each fossil becomes because it adds little new information. These excess fossils are appropriate for collection by amateurs. The problem is that it is impossible to know when the inventory of a formation has been completed. The nature of the fossil record is such that extremely rare finds (new species) will continue to show up for as long as the site is collected.

The study of taphonomy (how a fossil was formed and deposited) is important in establishing context for fossils. Taphonomic data is usually very contextural and fossils removed from the outcrop without thorough documentation lose their context. These studies are closely related to studies of paleoecology. Paleoecological studies make use of fossils and their sedimentological context to reconstruct ancient ecosystems and biotic interactions.

Evolution of life through time can be studied by comparing fossils from different ages. Many researchers pursue individual fossil lineages through time to establish evolutionary trends. These trends are useful for establishing biostratigraphies which in turn are used to date rocks by the process of correlation. In addition to dating, biostratigraphy provides the basis for understanding the nature and magnitude of extinction events. In both types of studies it is important to acquire large numbers of specimens from many stratigraphic levels and geographically distant sites in order to quantify population variation and geologic and geographic range of ancient species.

Fossil plants are also useful for interpreting paleoclimate and perhaps even paleoelevation. Comparison of fossil floras with modern ones of known climate provides an accurate method of assessing ancient climates.

Values of Fossil Plants and Invertebrates to Different User Communities

The scientific community uses fossil plants and invertebrates in the manner listed above. Fossils studied by scientists are usually stored in museums and universities and are available for study and display. They are preserved in perpetuity for the public good. Amateur collectors achieve the joy of discovery and relish in the collecting and owning of the fossils. Amateurs appreciate the aesthetics and in some cases, the scientific and/or commercial value of fossils. Some amateurs develop a very sophisticated understanding of ancient life and become contributing members of the scientific community by collecting and donating specimens and, in some cases, by undertaking research. Fossils are also an educational resource for school children, college geology students, and educators. Many fossils, not just dinosaurs, are useful to attract students to the study of science. Fossil plants and invertebrates are important to industry because they are the components of coal, oil, building stone, concrete, and other industrial materials. Commercial paleontologists make a living by selling attractive fossils to collectors, museums, and schools. All of these user groups should have the right to utilize the resource as long as its scientific value is not compromised.

How to Determine Significance of Plant and Invertebrate Fossils

While some fossil plants and invertebrates are extremely common, others are extremely rare. The common fossils of most geologic formations are generally known and can be researched in the geologic literature. Most formations also contain rare fossils that are currently unknown or are poorly known to science. Paleontologists at museums, universities, and the USGS are the best resource for evaluating the significance of a fossil, but it is important to realize that fossils are very diverse and most paleontologists are specialized. It is therefore important to locate a scientist who specializes in the appropriate subfield. In general, a fossil is scientifically significant and worthy of protection if:

- It is a new or rare species.
- It is a known or common species, but is found in a new location or formation.
- It is extremely well preserved, or preserves specific anatomical detail in an unusually fine manner, or if it preserves an interesting behavior, pathology, or interaction with another species (an insect gall on a fossil leaf, for example).
- It is part of an ongoing research project (taphonomic studies are often based on all of the fossils at a given site, even the poorly preserved or common ones).

It is often the very act of scientific research that attaches scientific significance to fossil sites or specimens. As a general rule, removal of a specimen from its context without collection of precise locality and stratigraphic data dramatically decreases the scientific value of the specimen.

Implications for Management of Nonvertebrate Fossil Resources

Plant and invertebrate fossils are different from vertebrate fossils in many of their modes of occurrence, and are generally more common. The scientific information contained by plant and invertebrate fossils is as important as that obtained from vertebrates but the nature of the plant and invertebrate fossil record demands a different management strategy.

All uncollected fossils face the same ultimate fate of destruction by erosion. In some cases, such as poorly lithified badlands, riverbanks, or beach cliffs, this erosion happens at a fast and measurable rate, mandating a collections based management strategy. In other cases where the rocks are well lithified, erosion poses a threat only on geologic time scales.

Human based threats to fossil resources include industry, construction, and road building, all of which expose fossils and make them available to be collected, but eventually destroy them. Scientists, amateurs, commercial collectors, students, and random citizens are responsible for discovering and collecting a great number of fossils each year for a variety of uses. Depending on how these fossils and their data are collected, threats include over-collecting, uneducated collecting, and improper collecting techniques.

Geologic maps are good indicators to the nature of the fossil resources that are present in specific areas. Resource management should begin with an inexpensive, map-based inventory of potential resources. Knowledge of local geologic formations, their characteristics, and common fossils provides a good basis to begin determination of what is rare, significant, and worthy of specific attention. Partnerships between land mangers and professional paleontologists provide an additional pathway for ascertaining the significance of specimens and sites. In certain cases, protection of specific sites may be warranted. Good examples of site protection in Colorado include the Kremmling Resource area administered by the BLM and the Florissant Fossil Beds National Monument administered by the National Park Service. Site protection of fossil localities characterized by rapid erosion should include a component of collection based management so that the very act of "protecting" a site does not contribute to a situation where fossils from the site go uncollected and are destroyed by the elements.

Regulations that are overly restrictive to general paleontological collecting can be a threat to fossil resources and scientific knowledge. A fossil left in the ground to weather away is no good to anyone. The metaphor of the land manager as the librarian in the library of earth history is a good one. Little public good is achieved if no one is allowed to check out books. Some books are old or rare enough to be restricted to rare book rooms where they can only be handled by experts. Others are common enough that they can be borrowed and used by schoolchildren. Many fossil plants and invertebrates are common enough that their use by any interested party should be encouraged. Education of all parties about the importance of precise locality data and the uses of fossil data should be the first step towards wise management of plant and invertebrate fossil resources. A sound plan of management of plant and invertebrate fossils is one which allows widespread use of the resource by many user groups and, at the same time, seeks to preserve specific significant sites and specimens for scientific research and education.

Salvage Paleontology: Recent Examples from Colorado

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Fossil plants and invertebrates are common in certain sedimentary rock formations. Construction and road building activities often expose fresh outcrops of these rocks and allow paleontologists access to new sites. Construction often uncovers sites that would not otherwise be discovered or exposed. While construction often buries and/or destroys fossil sites, timely mitigation in cooperation with property owners and construction crews can allow for the retrieval of valuable paleontological data. Most paleontologic mitigation work can be carried on without disrupting construction schedules. The Denver Museum of Natural History (DMNH) has had success in mitigation by working closely with construction supervisors to schedule paleontological mitigation work in such a way that it does not interfere with construction activities or schedules. This cooperation is mutually beneficial and has generated a number of scientific and educational by-products. This paper will illustrate recent examples of mitigation work at the Denver International Airport, Coors Baseball Stadium, Colorado Department of Transport road building sites, and Denver area housing developments.

Earth moving at the site of Denver International Airport (DIA) began in 1989. Workers on site noticed the distinctive fossils of palm leaves and the state archaeologist was contacted. DMNH was informed of the site and made approximately 20 visits to the airport construction site between June, 1990 and June, 1993. The visits were coordinated with airport security and the foremen of the various earth moving projects. DIA staff were, in all cases, supportive, and paleontological fieldwork was scheduled so as to not affect any construction activities. The excavations, which resulted in large exposures of the early Paleocene Volcanic ash beds in the base of concourse B, provided the opportunity for US Geological Survey scientists working cooperatively with DMNH to palynologically and radiometrically date the site. With funds from private donors, DMNH was able to mount a permanent exhibit that will be installed in the main terminal at DIA. This exhibit discusses the nature of the paleontological work undertaken and presents a reconstruction of the site as it looked 65 million years ago.

Ground breaking for the new Coors Baseball Stadium in Lower Downtown Denver began in early 1993. Excavators soon encountered exposures of the Late Cretaceous Laramie Formation. A construction foreman discovered what turned out to be a portion of a dinosaur rib near the future site of home plate. Coors Field construction contacted DMNH. Inspection by DMNH indicated that the dinosaur material was probably isolated. Nonetheless, DMNH staffed the construction site with two volunteer amateur paleontologists who were graduates of the Museum's Certification Program in Paleontology. These volunteers worked closely with the site foremen to monitor the site as excavation continued. In addition to the dinosaur bone, fossil palm leaves were also recovered. The high profile press coverage of these activities resulted in the Colorado Rockies choosing a Triceratops dinosaur as their mascot and increased public awareness of the proximity of paleontological resources to downtown Denver.

Housing development in the greater Denver area is exceedingly active. Many of these housing sites are located in the Denver Basin. For this reason, excavations have the potential to encounter rocks of Late Cretaceous, Paleocene, Eocene, and Pleistocene age. Cretaceous rocks are both marine and terrestrial origin while the Tertiary rocks are wholly terrestrial. Since a great number of different contractors and subcontractors are involved with these projects and since the land is most often privately owned, there is no formal process for notification of paleontological remains. Typically, interested parties, whether they are construction workers, neighbors, or others, will call DMNH when they notice something of interest. In these cases, DMNH will evaluate the calls and send out museum staff or volunteers to make a preliminary inspection of the site. A recent example of this type of mitigation occurred in 1992 when a man walking his dog noticed a large bone protruding from a house site in Littleton. The museum inspected the site and eventually excavated the femur, partial tibia, scapula-coracoid, several teeth and a caudal vertebra of a Tyrannosaurus rex dinosaur. In this case, construction schedules resulted in a less complete excavation than would have normally been undertaken, but this was partially mitigated by having a large crew on site. Sites such as these are complicated because the land is privately owned and the landowner has title to the paleontological resources on his/her property. In this case, the landowner donated the specimen to the museum.

The Colorado Department of Transport (CDOT) has in place a series of mitigation procedures for paleontological and archaeological discoveries on state highway projects. These projects operate under permit from the State Archaeologist's office, and the resulting paleontological specimens are curated either at the University of Colorado Museum in Boulder or the Denver Museum of Natural History. CDOT has a staff paleontologist who evaluates road projects and attempts to identify sensitive sites. During certain road projects, this staff member has the ability to hire paleontological assistants to help retrieve the specimens as the roadwork proceeds. As a recent example, on highway 286 north of Broomfield CDOT hired a recent graduate of the DMNH Certification Program in Paleontology to collect fossils as the road was being widened. This resulted in a superb collection of Late Cretaceous fossil leaves that would never have been acquired if the road were not widened.

Salvage paleontology is a tricky business because of the random nature of the occurrences and the short time frames under which the discoveries often occur. It is made more difficult by the fact that the number of professional paleontologists is limited, as is their time. In addition, the distinction between archaeology and paleontology is not well understood by the general public, and construction foremen are generally reluctant to report discoveries that may slow or halt their construction activities. These problems can be addressed by developing teams of trained volunteers who are able to make initial assessments of sites and by informing the construction industry about the nature of the paleontological record and the fact that paleontological mitigation can often occur with no disruption of construction activities.

Compelling Fossils: Developing A Story At Florissant Fossil Beds National Monument

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The concept of a Compelling Story is promoted as the driving force for an "Interpretive (R)Evolution" in the National Park Service. During the agency's 75th anniversary in 1991, a clear objective for Interpretation emerged, "It should be the responsibility of the National Park Service to interpret and convey each park unit's and the park system's contributions to the nation's values, character and experience." Each park has been encouraged to identify a Compelling Story, and develop ways to tell the story in a compelling manner.

During the process of developing a Compelling Story for Florissant Fossil Beds, I realized that it was already written. The story line was set about 35 Ma. It was our job as interpreters, educators, and scientists to discover, research, interpret, and communicate this story (in a compelling way) to a highly interested public.

This session will outline the process used at Florissant to identify a Compelling Story. At Florissant, we found that the process was as valuable as the product. Through a series of individual and group exercises, the park interpreters were asked to focus on the significant message of their program. The concept of Compelling Stories challenges the interpreter, as well as the public, to focus on the relevant and significant. The challenge to express the story in a compelling manner has the potential to motivate the interpreter and visitor to a course of action.

Two suggested measures of the success of a park's Compelling Story are:

1. The visitor's reexamination of their "values" relative to the park's significant resources.
2. The emergence of "universal truths" from the telling of the tale.

There are controversial aspects, especially if park areas try to develop scientific themes into "universal truths." We need to focus the message in a way that will challenge visitors, lead to re-examination of their values, and perhaps even move them to action from our honest interpretation, without exaggeration or misrepresentation, of the scientific significance and relevance of the story.

References

Compelling Stories Think Book, 1995, National Park Service.

Rudd, Connie, 1994, Compelling Stories...Compellingly Told: Ranger: Journal of the Association of National Park Rangers, v. X, no. 3, pp. 8-11.

The ZiNj Education Project: Enlisting Kids and Families in Preservation and Education

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The ZiNj education program is a heritage education initiative sponsored by the Utah Division of State History (UDSH), the US Forest Service (USFS), the National Park Service (NPS), and the Bureau of Land Management (BLM). Its goal is to share the delights of history and prehistory with kids, helping them to understand and appreciate heritage resources, which, in the long run, will enhance the efforts of the sponsoring agencies and others in preserving, protecting, and interpreting these fragile resources.

ZiNj magazine brings three fundamental elements to informal science/heritage education: a strong commitment to solid, cutting edge science; the integration of preservation and protection messages; and the involvement of kids in all aspects of the program. This means that scientists, heritage specialists and kids are active participants in all aspects of producing the magazine. This approach has proven to be an effective means to reach kids with good educational material, and when combined with striking graphics, design, and a sense of humor, is readable and entertaining.

Background

The ZiNj Education Project was established by the Utah Interagency Task Force on Cultural Resources as a tool for combatting the loss of rare heritage resources through neglect and vandalism. Our nation's archaeological, paleontological, and historic resources are under siege in many parts of the country. In the Four Corners over 75% of the Anasazi sites have been vandalized. While most of the damage is done by adults, adult education is costly and often ineffective.

The Task Force concluded that its efforts should focus on increased law enforcement and positive peer pressure to combat current vandalism, and that special emphasis should be given to educating kids so that the next generations could be a part of a long term solution to the problem. Kids, after all, are fascinated by dinosaurs, ancient cultures, and other "old stuff." We had an interested audience, interesting subjects, a national network of interpreters and cultural resource specialists, access to the greatest natural and cultural resources in the country, and an important mission - the preservation and protection of the past.

ZiNj was established in 1992 by the Interagency Task Force on Cultural Resources. Partners in the project are the UDSH, the NPS, the USFS, and the BLM. These partners provide funding, technical assistance, and access to the greatest scientific, scenic, cultural and natural treasures of the United States. Stories and ideas provided by these agencies ensure that ZiNj reflects the preservation objectives of the agencies and supplements their heritage education programs. Articles that focus on National Parks, Forests, and BLM lands promote interest in, and sensitivity to, agency-managed resources.

ZiNj was designed to share the wonders and delights of archaeology, paleontology, and history with kids and their families so that they would develop a personal preservation ethic.

ZiNj is dedicated to presenting only top quality science, primarily from original sources - the top scientists themselves -and involving ZiNj KiDs at every stage of production

Specific Objectives of the ZiNj Project

ZiNj targets kids as part of an effort to preserve our culture and natural heritage in the long term. We know that many kids love dinosaurs and exotic ancient cultures. They are receptive to learning **if** the subject matter is interesting and well presented. ZiNj is designed to engage kids on a number of levels and in a number of ways. We involve kids in all aspects of the production of the magazine, from brainstorming about topics, to writing, critiquing, and input on design. We attract their attention with lively design, striking graphics, a smart attitude, and lots of wit and double entendre.

Articles are written by scientists and other authorities, not rewritten and diluted. This approach lends authority and authenticity and introduces kids to the world of science by exposing them to real scientists. We also want each article to tell a story, not just be a reporting of facts. We don't want to just tell about a discovery, we want to tell how it was made, how the research was conducted, what were the personal observations and feelings of those involved. We also want to emphasize what scientists would like to know, but presently don't. This approach supports open ended inquiry into a subject and demonstrates the scientific method by encouraging kids to think about how we might go about investigating something as yet unknown.

Too often kids get the impression that science already knows all the answers and that they should just memorize these answers. **We want to let kids in on the fact that science doesn't know everything, that there are endless opportunities to learn something new, and that scientists don't always agree - that science often progresses because researchers don't agree.**

Most importantly, ZiNj was created to be read and used. If it has the right message, but isn't being read by kids, we have failed. If it has the right message and is read and discussed by kids in the classroom and at home, we have succeeded.

A similar approach should guide our taking ZiNj from print to video. **We want kids to be engaged in the material, to think the show is cool, and to to be challenged to think, not just fed facts.** To do this we need to involve kids as completely as we do in the production of the magazine; as contributors and writers, "experts," so that their involvement extends beyond being included as talent. We want each piece to be a complete story, not just presentation of facts.

Communication Strategy for ZiNj Magazine Content

ZiNj content is guided by two foremost criteria: good science, featuring top scientists whenever possible; and fun, including contributions by kids, kid style humor, lots of energy, and an "attitude." The subject areas include all aspects of prehistory and history, leaning toward archaeological and paleontological approaches. Science is presented as a way of learning through critical thinking, not lists of facts or a string of science "experiments" that are actually only "gee whiz" demonstrations. If we present demonstrations, we want them to be hands-on activities that the kids can safely replicate themselves with readily available materials. The content is selected to be compatible with, and contribute to, learning related to elementary and junior high core curricula in the social, physical, and earth sciences, math, and reading.

Style of the Message

- Interactive, encouraging reader and viewer contributions, comments, questions, and criticisms. Encourage a hands-on approach to use of the magazine by providing cut-outs, collector cards, stickers and other interactive materials. The magazine and television show will also present stories about outdoor activities, encourage visitation of museums, parks, forests, and other public lands, provide information about opportunities for research and hands-on participation in scientific projects to expand the classroom and encourage kids to experience historic and prehistoric resources first hand.

- Colorful, full of good art and images, striking graphics, unusual fonts, eye-catching design, and powerful images.

- Authentic, unpredictable, and based on real experience.

- Original, bold, innovative, and to avoid the trite or hackneyed; to zig where other education programs and magazines zag.

Creating a ZiNj based Television Program

A similar approach to television would represent a significant departure from entertainment and educational programming, and would also, like the magazine, have the potential to be very popular with kids, parents, interpreters, educators. It would support the work of natural and cultural heritage resource professionals.

In scanning kids programming there seems to be a lot of the "gee whiz" approach to science - presenting facts and demonstrations designed to amaze and astonish viewers. Although this may be entertaining, in the long run it is not effective in teaching real scientific principles. **The ZiNj television program will demonstrate that it is cool to know things and that learning is a fun way to spend time**. We want to avoid the "nerds do science" image and focus on real kids interacting with real scientists, doing real science, asking real science questions, and having fun.

To accomplish these goals, some elements of the ZiNj approach will include:
Involvement of kids as integral parts of each segment - kids as experts - participating in a dig, demonstrating how a packrat midden is sampled, how a dinosaur bone is jacketed, how a ceramic vessel is reconstructed - and kids as kids - making mistakes, being goofy, getting excited. An audience of kids will be interested in watching young experts and learning from ZiNj KiDs as they vicariously experience the process of learning about a subject, interviewing scientists, and actually doing science.

Focus on how science is conducted, not facts that are known. This means on-site visits, discussions with scientists, examining current studies which have not yet yielded answers, focusing on controversy, disagreement, things the scientist would love to learn, and methods of investigation, such as how questions are asked, how data are collected, and how ideas are tested.

A style that favors the unexpected, keeping the viewer watching because they want to see what will happen next. A technique that might work well is to allow kids to make mistakes - such as when asking a question during an interview, showing a poorly-framed question, and then cutting in a "time out" showing the same kid in another setting saying "Whoops, what I meant to ask was, ..." then cutting straight back to the interview. This might work well also for times when a new word is introduced. Quickly cut, as in a kind of a footnote, to a kid who gives a concise definition, then cut immediately back to the original piece. Leaving in some of the "bloopers" could serve two purposes: 1. showing that the kids and others on the program are "real"; 2. adding some humor.

Content that is varied in complexity. Some aspects of the program might be understood by a six-year-old, and some might be beyond her. Some gags might be a bit obtuse for even the older kids, but things like that will keep interest, and keep them paying attention. They don't need to be talked down to, they like to be challenged. We have the opportunity to challenge them in each program with information, humor, and oblique references.

A commitment to authenticity. We do not want to show how an archaeologist works by using graphics or showing a sandbox dig, we want to go to the field with real archaeologists, involve kids, let them learn by doing and share that experience with the viewer. The ZiNj partnership with the USFS, the NPS, and the BLM provides access to innumerable opportunities for authentic learning experiences on some of our country's most beautiful cultural and natural sites. Filming a group of kids participating in the National Park Service's "Parks as Classrooms" program, learning through field experiences and reenactment will fit the ZiNj approach perfectly. Kids involved in a USFS "Passport in Time" project, showing them getting dirty, discovering things, having a great time, will be a very positive way to share enthusiasm and values with viewers. There are many such programs and opportunities, from the BLM's "Young Steward's Club" and "Intrigue of the Past" programs to projects in individual parks and forests, where kids are participating in fun projects while at the same time learning to respect cultural and natural resources. Careful work with our partners will enable us to bring the wonderful experiences kids are having in these programs to a much greater number of people through television.

Calls to action. Prompt kids to experiment, explore, learn through doing things in their own homes, in their yard or a field, going to a museum, zoo, library, National Park, Forest, or Public Land, to read a book, to write a story, to send in a question, idea, suggestion, or criticism. We want to invite action, not just provide a program to be viewed by couch potatos.

Networking to Solve Resource Management Problems

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Public sector managers are often faced with resolving complex natural resource problems that exceed our jurisdictional boundaries. We frequently find that the greatest threats to the resources we are mandated to protect and conserve come from external sources beyond our legal borders. We further discover that we are lacking statutory authority to implement or mitigate a solution.

What do we do? This presentation will examine one model, currently in process at Hagerman Fossil Beds National Monument (HAFO). The effort involves diverse levels of problem/conflict resolution and deals with a variety of subjects, ranging from technical scientific evaluation processes to artful social and political gymnastics, all in a struggle to save some fossils.

Issue
Irretrievable loss of significant paleontological fossil resources and related scientific information is continuing at a consistent and alarming rate as a result of mass wasting. Five major landslide events have occurred within the monument's boundaries in the last ten years, involving over 100 million cubic feet of fossil-bearing sediments. The landslides are the result of pond and irrigation canal seepage from the Bell Rapids farming project. As water leaks from the irrigation system, the subsurface topography channels the water toward the slopes. The silt and clay sediments saturate and liquefy, resulting in mass failure of the slope.

Status
NPS and a multidisciplinary task force, including participants from the private sector, have been working to identify the best solutions to mitigate the cause of the land slides. Consensus has been reached to pursue a pilot project to dewater one slope face and line one mile of canal in order to demonstrate the feasibility of canal and pond lining as a permanent solution. HAFO received National Resource Protection Program (NRPP) funding in FY94 for a total of $870K over a three year period.

Background
Specialists have concluded that additional mass failures are imminent. If corrective action is not taken, the area most likely to experience the next landslide event is located in the immediate vicinity of the scientifically significant and internationally renowned Smithsonian Institution Horse Quarry, the premier fossil site at HAFO.

Resolution
Since groundwater recharge is occurring outside HAFO, and, as it is the result of actions undertaken by private individuals beyond the direct control of the NPS, several actions have been pursued.

Developing Consensus: Considerable time and energy has gone into collection of data in order to understand cause and effect relationships related to the problem. Consensus opinion was then developed in order to define mitigatio[n] or corrective actions.

Scientific Fact Finding: A Task Force was formed for the purpose of characterizing existing data, defining needed research, evaluating techniques and methods for proposed projects, and assessing results of completed projects.

Politics - External and Internal: As complex as the physical sciences may become in order to comprehend the problem, understanding the social and political realities may be far much more complicated. Further, it may be equally critical in successful problem resolution.

Developing a Strategy: Once the problem has been defined and the existing knowledge applied, developing a strategic plan for accomplishing the desired result is essential.

NRPP Funding: Competing for project funding can be intricate and elaborate.

Legal Complications: Money and knowledg[e] does not ensure success. You must be able to legally apply the proposed actions against considerable barriers.

The Colorado Geological Advisory Group (GAG): A Case Study

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The Geological Advisory Group (GAG) was a committee of geologists and paleontologists convened in 1984 by the Colorado Department of Natural Resources and the Bureau of Management (BLM). The purpose of the GAG was to identify localities of geologic and paleontologic significance on BLM administered lands, and to recommend appropriate management options to BLM. The committee was voluntary and included scientists from academic institutions and museums, the Colorado State Geological Survey, the US Geological Survey, private industry, and staff from the Colorado Department of Natural Resources and the BLM. The purpose of the committee was not only to identify significant localities, but to delineate their boundaries, rank their significance, and make recommendations for their protection. The GAG became an excellent opportunity for scientists and land managers to work together.

The public lands of Colorado contain some of the most striking geologic features in North America. The GAG was created to acquire information about the geologic importance of known paleontologic localities and geologic features on BLM lands in Colorado. Questions about the known sites included:

- What was the research and educational significance of these sites?
- Was any significant fossil material remaining at the paleontologic sites?
- What other sites were on the lands that were important for research or education?

Advisory group members were assembled from institutions throughout the state based on recommendations of the committee members. Interested land managers and scientists from Colorado and outside of the state, assisted the advisory group on a case-by-case basis. Timing of the creation of the GAG was critical. BLM was in the midst of preparing resource management plans for every BLM Resource Area in Colorado. The GAG provided geologic information that was integrated into the resource plans and management alternatives.

Program costs included meetings, field excursions, some funding for site evaluation expenses, and publication costs of the final report. These costs were minimal; much of the work was done by a core of volunteers who were concerned with the state's geologic resources. Funding for the GAG was cooperative, with the majority of funding provided by BLM and secondarily by the Colorado Department of Natural Resources. This arrangement generated information at a minimal cost to the taxpayer.

Early meetings of the GAG focused on defining goals and criteria for site evaluation and recommendations. The goals were:

- Evaluate the scientific and educational value of rare or exemplary geologic features on public lands in Colorado.
- Provide scientific information to public land managers in a cost effective manner.
- Provide an open forum for public land management.
- Recommend management alternatives for research and educational use of geologic features.

The criteria used for choosing a site for evaluation included:

- Sites that had statewide, national, or international significance determined by published data or ongoing studies.
- Sites with rare or unusually well preserved fossils.
- Sites that provide important research or educational opportunities.

The evaluation criteria for the significance of a site included:

- The quality of the site for research, teaching, or interpretive use.
- The condition that the site is relatively free of disturbance, can withstand some multiple land uses, or can be adequately protected from disturbance.
- The site can be maintained with appropriate management and is not likely to be lost through natural processes or pre-existing human activities.
- The site has topographic or political buffers that geographically remove it from areas of development, has a small likelihood of being developed, or has such significance that natural values outweigh development values.

By working with land managers within the GAG process and during the locality evaluations, management recommendations and later designations minimized potential conflicts with existing land use.

The procedure developed by the GAG included identifying sites of geologic importance, evaluating the sites from published literature and data from field studies, and recommending management actions for the sites. Geologic site reviews resulted in the GAG meeting at least twice a year. In May or June, prior to the summer field season, the GAG met at a BLM area office to hold one or two days of field evaluations of the various sites recommended in the area. These field tours allowed for the group to visit and discuss the proposed sites and to determine if further on-site evaluations were necessary. Land managers from the BLM area and district offices accompanied the committee members during these field visits, allowing for informal discussions about the importance of sites and land management concerns. The excursions were followed by a half to full day meeting in the local area or district office to formally discuss the sites with BLM land managers. Many sites were determined to be important enough to warrant further evaluation by individual committee members during the following field season. These evaluations ranged from defining boundaries for the sites to the mapping of geologic and paleontologic features in an area. The second meeting each year was held in late fall to review results of the previous summer's field evaluations, develop criteria for evaluating and ranking the sites, and making final recommendations on the protection of the site. Suggestions for the upcoming spring meeting occurred during the late fall meeting. Special meetings, typically in the summer, were organized to discuss important issues concerning individual sites.

Ranking of sites by the GAG using criteria for evaluating geologic values ranged from most to least significant by the following site management recommendations: Research Natural Area (RNA), an Outstanding Natural Area (ONA), Area of Critical Environmental Concern (ACEC), and no special management (NON). These formal designations are contained in federal law or BLM regulations. Several "hybrid" management recommendations were also used by the GAG to provide additional management recommendations. These included:

- Special Management Area (SMA), usually for large areas that would be little affected by specific surface uses.
- Off-Road Vehicle (ORV) restrictions to limit damage to geologic and paleontologic features.
- Recreation Use (REC) for areas with scenic viewpoints or where recreational use will not affect geologic features.
- No Surface Occupancy Stipulation (NSO) which restricts surface disturbances that will affect geologic features.

The GAG evaluated 39 geologic and paleontologic sites in Colorado (Kuntz, Armstrong, and Athearn, 1989). Fourteen of these were recommended as RNAs, 10 were recommended as ONAs, 2 were recommended as ACECs, and the rest were recommended for no special management (NON). Four areas were recommended to be SMAs and 1 was recommended for a recreational use area (REC). Examples of the evaluation, ranking, and land management recommendations for 8 of these sites are given in Evanoff and Kuntz (1987).

Benefits from the GAG extended well beyond site identification. Land managers were provided with a source of scientific expertise to assist in land management decisions. Productive working relationships were forged between Colorado's research community and public land managers. Members of the GAG frequently discussed the geologic significance of sites in Colorado with state agencies and governor-appointed boards. Scientific contributions resulted from GAG. For example, two of the areas (Garden Park and the Dolores Triassic Fish Locality) had detailed mapping of the geology and paleontologic resources, resulting in scientific publications. The GAG helped design and streamline the paleontologic permitting process for the state and the Colorado BLM. Finally, public education in the form of nature trails, active quarrying of dinosaur sites involving volunteer workers, and the development of public visitor centers resulted from the initial work undertaken by GAG members. The GAG helped to emphasize the importance of research and education on public lands.

The GAG was an excellent example of a successful cooperative program between several state and federal agencies, land managers, and scientists. Managers benefited from receiving information directly from the scientific community, and the scientists benefited by having direct access to land managers. The GAG provided a direct link between public land users and public land managers. A group like GAG can be successful in other states, if the state's public land managers and scientific community are committed to working with each other to accomplish mutually beneficial goals. A similar Geological Advisory Group would also be successful with other land management agencies, such as the US Forest Service or the National Park Service.

References

Evanoff, Emmett, and D.W. Kuntz, 1987, The Geological Advisory Group - a partnership for managing geologic features on public lands: Natural Areas Journal, v. 7, pp. 179-193.

Kuntz, D.W., H.J. Armstrong, and F.J. Athearn, 1989, Faults, fossils and canyons: significant geologic features on public lands in Colorado: Bureau of Land Management, Colorado State Office, Cultural Resource Series 25.

Paleontological Resource Inventories of the Oglala National Grassland: A Model for Generating Paleontological and Geological Research on Public Lands

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In 1991 the Nebraska National Forest (NNF) contracted with the University of Nebraska State Museum (UNSM) to inventory paleontological resources within the Oglala National Grassland (ONG) near Toadstool Park in Sioux County, Nebraska (see LaGarry-Guyon 1992a, 1992b, 1992c, 1994). Inventorying has continued through 1994 (see LaGarry-Guyon et al. 1993, LaGarry et al. 1994). The objectives of the inventories were to:

- Map the geology of the ONG in order to educate the NNF about ONG vertebrate fossil resources.
- Define the nature, abundance, and sensitivity of ONG fossil vertebrate resources.
- Quantify the nature and frequency of illegal removal of ONG fossil vertebrates.
- Provide the NNF with detailed documentation of inventory results.
- Offer recommendations based upon the geology, sensitivity of resources, and evidence of illegal collecting.

These inventories were the first systematic assessment of vertebrate fossil resource on Forest Service lands, and the first description of fossil resources in the USA at this level of detail (see also Evanoff and Kuntz 1987). The purpose of this report is to describe the results and recommendations of the 1991-1993 inventories, and to illustrate how paleontological resource inventories can initiate research on public lands. Details of procedures used during the inventories and the status of the fossil material collected can be found in unpublished reports submitted to the NNF (LaGarry-Guyon and Hunt 1992, 1993a, 1993b; LaGarry and Hunt 1994a, 1994b, 1994c; LaGarry and Stepleton 1993).

Summary of 1991-1993 Inventories of the Oglala National Grassland

After fifteen weeks (1991-1993) of pedestrian surveys we have inventoried 51,420 acres of the ONG (LaGarry and Hunt 1994b). The 1991 inventory focused on the Toadstool Park region (Roundtop 7.5' USGS Quadrangle) because:

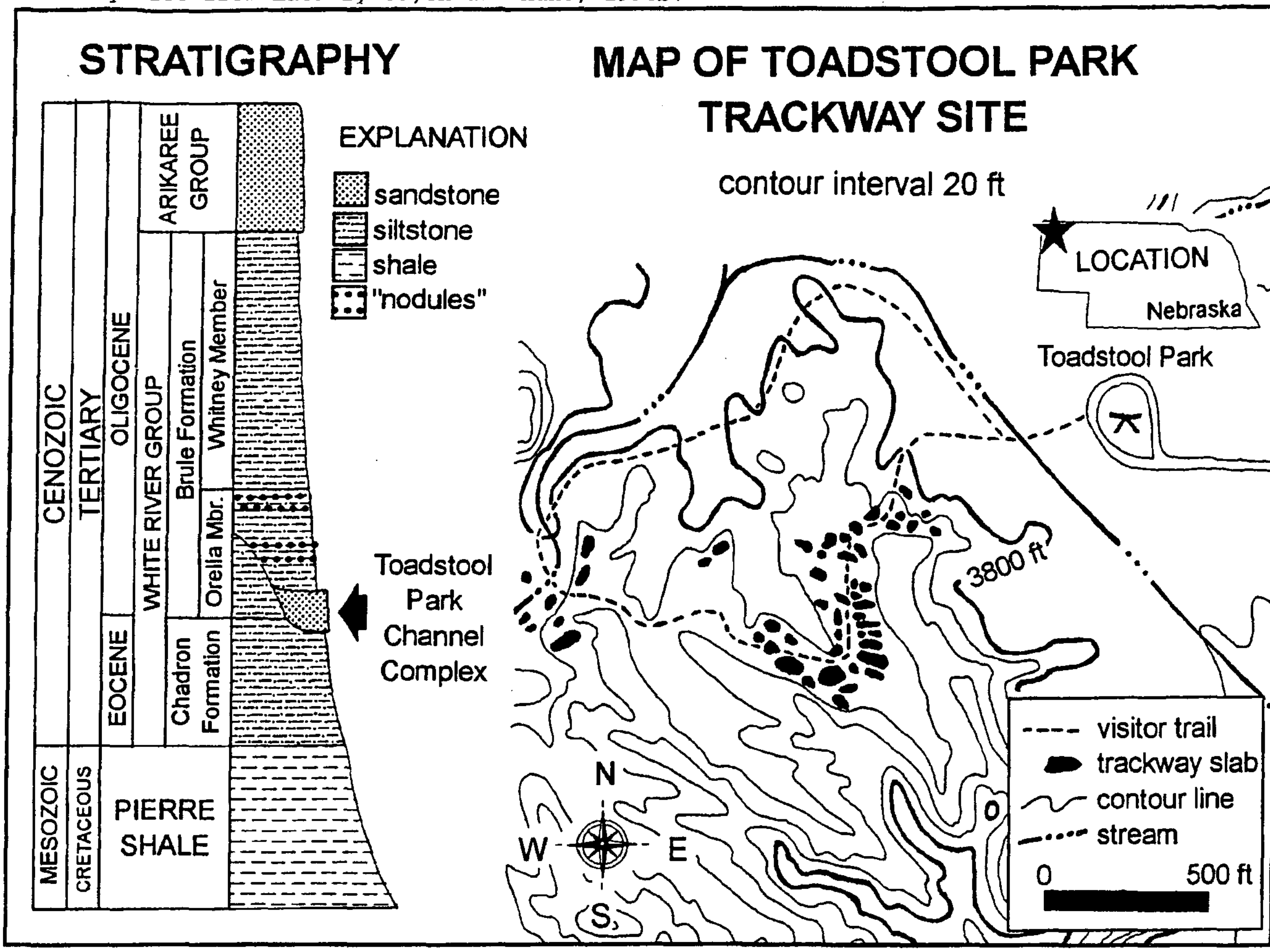
- The NNF originally requested an inventory of the fossiliferous rocks there.
- Defining exposures of several geologic units (Schultz and Stout 1955) and fossil faunas (Wood 1949) are located there.
- Important collections of vertebrate fossils in North American museums and universities were collected there.
- The UNSM has had a long history of research and collecting there.
- NNF wanted an assessment of the impact of tourism on the fossil resources there (LaGarry-Guyon and Hunt 1992).

In 1992-1993 we expanded the inventory coverage to include badlands in the adjacent Orella, Horn, Montrose, Wolf Butte, and Five Points 7.5' USGS Quadrangles (LaGarry and Hunt 1994b, 1994c).

Geologic Investigations

The fossiliferous bedrock in the ONG (Figs. 1, 2a) is primarily the Eocene/Oligocene White River Group (see Clark et al. 1967, Harksen and MacDonald 1969 for review). These rocks are claystones and siltstones rich in volcanic ash and locally derived sandstones deposited during an interval from about 29-38 million years ago. Fossil occurrences, primarily mammals and tortoises (Savage and Russell 1983), were a result of the geologic history and depositional circumstances of the bedrock. Bones occurred scattered throughout some rock units, and were concentrated at particular horizons

Figure 1. Generalized stratigraphy of the White River Group, ONG, and generalized map of the Toadstool Park Trackway Site. Stratigrapgy does not reflect proposed changes by Terry and LaGarry (1994). Map of trackway site from LaGarry-Guyon and Hunt, 1994b.



within others. Fossil vertebrates occurred as skeletons weathering out of the Chadron Fm. horizontal and completely exposed, or as bone protruding from the vertical cliffs of the Brule Fm. Quaternary surface deposits (Fig. 2a) contained widely scattered, yet highly significant fossils and archaeological resources (Schultz et al. 1965, LaGarry and Hunt 1994b, 1994c). The only way of determining this information was by detailed geologic mapping.

Assessment of Resource Sensitivity
We recorded the frequency (sparse, frequent, abundant); mode of occurrence (scattered, concentrated); sensitivity of fossil resources encountered; and salvaged exposed specimens (LaGarry-Guyon and Hunt 1993a). By 1993 we had designated 138 Sensitive Sites consisting of concentrations of skulls and skeletons (Fig. 2b). In 1992 we documented an extensive fossil vertebrate trackway site (Fig. 1) within sandstones at Toadstool Park. By 1993, our inventories had identified 57 extensive trackways of invertebrates and 11 contemporary vertebrate species (including shorebirds, ducks, oreodonts, entelodonts, camels, rhinoceroses, and carnivores) along more than 1 km of paleostreambed (Nixon and LaGarry-Guyon 1993a, 1993b). We also documented erosion by unrestricted foot traffic and bicycles, vandalism, and theft of fossils endangered the site. We obtained paleobiological collections that form the basis of paleoecological reconstructions of the area, and salvaged small trackway-bearing slabs. In 1993 we experimented with replicating trackway-bearing sandstone slabs with latex peels (LaGarry and Hunt 1994b).

Assessment of Illegal Collecting
In 1993 we concluded that normally

highly-fossiliferous White River Group rocks yielded infrequent fossils during our inventories because illegal collecting prior to 1991 had reduced the amount of fossil material available (LaGarry and Hunt 1994b). Twenty-five percent of 138 Sensitive Sites, most of those located within the Chadron Fm. (Fig. 2b), showed theft of vertebrate fossils. Based upon the size of illegal excavations, we concluded that oreodonts, turtles, and titanotheres were most frequently stolen (Fig. 2c). Forty-two percent of the 31,360 acres inventoried in 1991-1992 showed evidence of illegal fossil collecting (Fig. 2d). Most violations occurred in the Chadron Fm., which has low topography and is accessible to vehicles. Fewer violations were observed in the Brule Formation, probably because it weather into steep, relatively inaccessible cliffs. We made numerous observations of unauthorized removal of fossils from Toadstool Park and elsewhere on the ONG (Fig. 2d). Our 1993 monitoring of Sensitive Sites showed that theft continued despite low level efforts at patrolling and interdiction. Thirteen previously undisturbed Sensitive Sites had material removed since being designated in 1991-1992 (Fig. 2e).

Permits and Report Requirements
Our inventories were conducted as

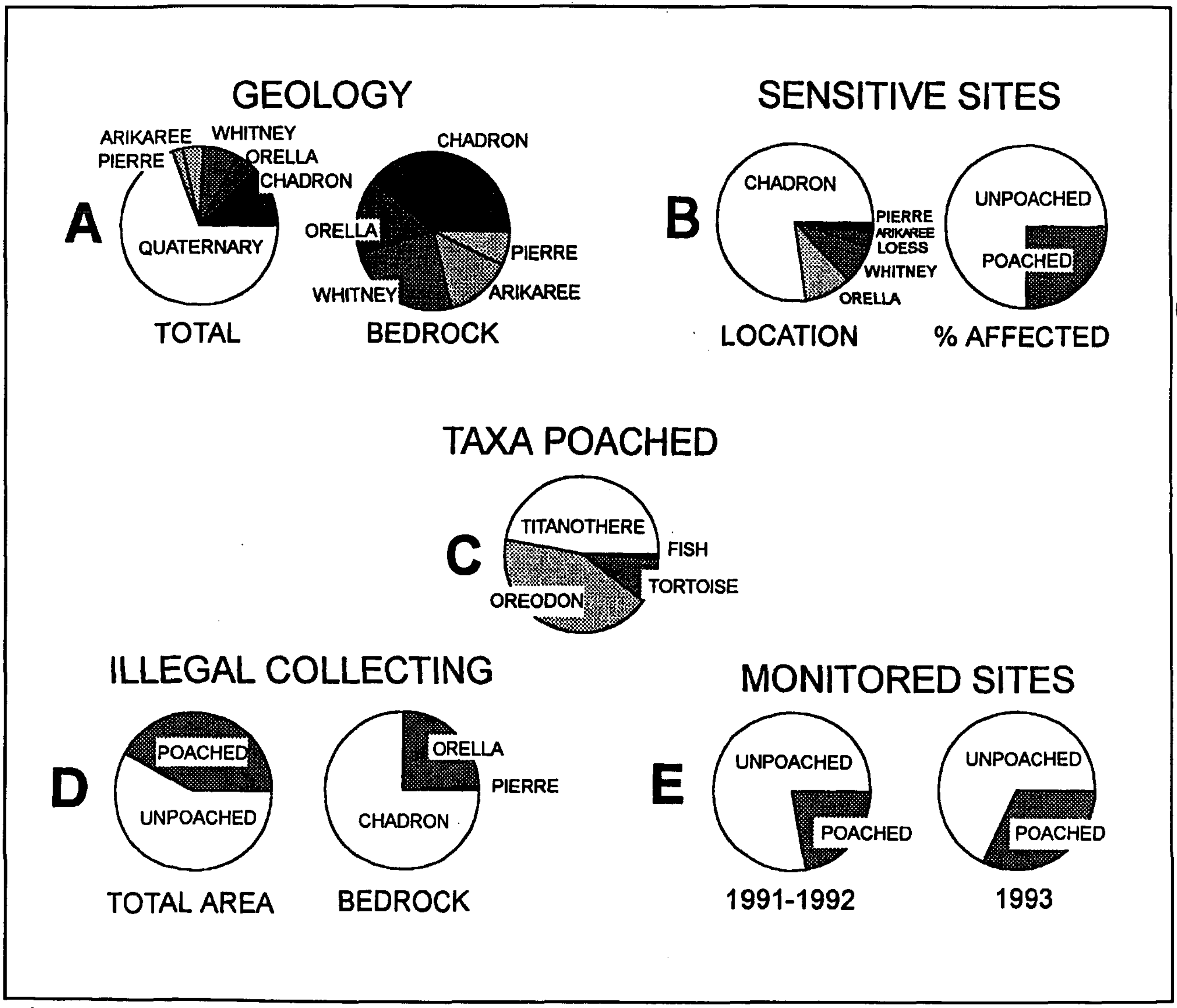


Figure 2. A) Surficial and bedrock geology of ONG; B) Geologic unit of occurrence and amount of sensitive sites recognized through 1993; C) Fossil vertebrates stolen from ONG; D Area of ONG affected by illegal collecting of fossil vertebrates; E) Increase in poaching of 80 sensitive sites monitored in 1993.

partnerships between the NNF and the UNSM in the form of Challenge Cost-Share Agreements. These agreements required us to provide annual reports detailing areas inventoried, methods, expenses, locations and conditions of resources, evidence of poaching, and the disposition of salvaged fossils. These requirements were not overly difficult or burdensome. Fossils salvaged during the course of our inventories are housed in perpetuity by the UNSM based upon an associated Curatorial Agreement.

We conducted the 1991-1992 inventories under a US Department of Agriculture Forest Service Special Use Permit. Because we had the only permit allowing excavation of vertebrate fossils, we recognized all other excavations as having been done illegally. USDA Forest Service Special Use Permits reduce or eliminate incidental damage to fragile ecosystems on public lands because negligent or destructive behavior can result in their revocation. Unrestricted access to public lands would lack the accountability associated with permits, and would result in damage to, and loss of, limited or unique resources. Since 1992, we have continued the inventories under a Memorandum of Understanding from the NNF, and the ONG has been closed to permit-regulated fossil collecting.

1992-1993 Recommendations
The UNSM is a nonprofit, publicly funded educational institution and repository of vertebrate fossils from Nebraska and elsewhere. We abide by a professional code of ethics governing our collections and are opposed to the commercial sale of vertebrate fossils and the unregulated exploitation of public lands for the commercial use of natural history objects. These codes are set forth in various federal and state museum accrediting agency requirements, and resolutions of the Society of Vertebrate Paleontology, the principal professional organization of vertebrate paleontologists worldwide.

Recommendations made to the NNF as a result of our 1991 inventory (#s 1-9) can be found in LaGarry-Guyon (1994). Based upon the results of our 1992-1993 inventory (LaGarry and Hunt 1994b, 1994c), we recommended that:

- Interdiction of illegal fossil collecting be focused on the greatest concentrations of Sensitive Sites.

- Fences delimiting Federal lands be clearly and accurately marked and maps of the ONG be updated following land exchanges.

- NNF personnel be trained in surveillance and interdiction of illegal collecting, putting the available personnel to the most efficient use in these efforts.

- The NNF assess the current market value of vertebrate fossils from White River Group rocks to determine the level of criminal prosecution sought against illegal collectors.

- The Toadstool Park trail be moved to divert foot traffic away from trackway-bearing slabs and Sensitive Sites.

- NNF personnel be maintained on site or conduct frequent patrols of the vicinity to maintain trail markers, bury exposed fossils until properly and legally collected, and deter vandalism.

- Law enforcement agencies increase their presence and visibility in the area as a deterrent to large-scale illegal vertebrate fossil collecting.

- Inform tourists of the sensitivity of the fossil resources on the ONG and the laws and regulations (and associated penalties) prohibiting vertebrate fossil collecting via interpretive displays at visitor centers having paleontological themes.

- Sensitive Sites be revisited annually to monitor the condition of the site, record evidence of theft and/or vandalism, and salvage fossils for placement into an appropriate repository.

- The NNF actively promote the research, casting, and documentation of the Toadstool Park Trackway Site in the event of unavoidable loss of the resource to natural weathering processes.

- Access to paleontological resource inventory reports and supplements be monitored to prevent the locations of Sensitive Sites from becoming public knowledge and, therefore, compromising the scientific value of known paleontological resources.

Research on the Oglala National Grassland

Fossil resource inventories of the ONG initiated research efforts of two types:

1. Research necessary to accomplish inventory goals.

2. Research stimulated by inventory results and incidental discoveries made during the inventories.

Type 1 research included:

- The first investigation of fossil resources on Forest Service lands.

- The first detailed geologic maps of northern Sioux and Dawes Counties, NE.

- The first detailed assessment, desciption, and maps of vertebrate fossil resources.

- The first detailed assessment, description, and maps of illegal vertebrate fossil collecting.

- Recognition of a unique and important trackway locality.

NNF has addressed all of the offered recommendations, and is transforming Toadstool Park into a resource protective, multiple use demonstration area. Type 2 research includes:

- An expanded program of geologic mapping by the University of Nebraska Institute of Agriculture and Natural Resources (Conservation and Survey Division) and the US Geological Survey (LaGarry and Armantrout, unpub. data).

- Revision, redefinition, and redescription of the stratigraphy of the White River Group in Nebraska and South Dakota (Terry and LaGarry 1994).

- Detailed investigation of the depositional environments and paleoecology of the Toadstool Park Channel riparian ecosystem (Nixon and LaGarry-Guyon 1993a, 1993b; Wells 1994; Wells et al. 1994).

Inventories of the ONG will serve as a model for future work investigating geologically and paleontologically different areas of the NNF, and will initiate new research efforts in as yet unforeseen directions.

Acknowledgements

I thank the many people who participate in conducting the four years of inventories, and those individuals within the NNF who recognized the value of this work and kept it going. The inventories were funded by USDA Forest Service Challenge Cost-Share Agreements 02-07-91-013 (1991), 02-07- 92-025 (1992), and 02-07-93-011 (1993) between the University of Nebraska/Lincoln and the Nebraska National Forest. All fossils collected during these surveys are housed in the research collections of the University of Nebraska State Museum, Lincoln, NE, and were collected under a USDA Forest Service Special Use Permit (User No. 2033) from the Nebraska National Forest, Chadron, NE, issued to Hannan E. LaGarry and Robert M. Hunt, Jr.

References

Evanoff, E. and D. W. Kuntz, 1987, The Geological Advisory Group - a partnership for managing geological features on public lands, Natural Areas Journal, 7(4):179-193.

Clark, J., J. R. Beerbower, and K. K. Kietzke, 1967, Oligocene sedimentation, stratigraphy, paleoecology, and paleoclimatology in the Big Badlands of South Dakota, Fieldiana Geology Memoir 5.

Harksen, J.C. and J. R. Macdonald, 1969, Type sections for the Chadron and Brule Formations of the White River Oligocene in the Big Badlands of South Dakota, South Dakota Geological Survey Report of Investigations 99.

LaGarry-Guyon, H. E., 1992a, 1991, Paleontological resource survey of the Oglala National Grassland (Roundtop 7.5' Quadrangle), Sioux County, Nebraska [abstract], Kansas Academy of Science Abstracts, 11:22.

LaGarry-Guyon, H. E., 1992c, The impact of unauthorized collecting of vertebrate fossils on the Oglala National Grassland (Roundtop 7.5' Quadrangle), Sioux County, Nebraska [abstract], Proceedings of the 102nd Annual Meeting of the Nebraska Academy of Science, p. 69.

LaGarry-Guyon, H. E., 1992d, Unauthorized collecting of fossil vertebrates on federal lands in northwest Nebraska: a case study. [abstract], Seventh Annual Meeting of the Society for the Preservation of Natural History Collections Program and Abstracts, p. 17.

LaGarry-Guyon, H. E., 1993, Survey of paleontological resources on US Forest Service lands (Oglala National Grassland) in NW Nebraska [abstract], Journal of Vertebrate Paleontology-Abstracts, 13(3):45A.

LaGarry-Guyon, H. E., 1994, Results and recommendations of the 1991 paleontological resource survey of the Oglala National

Grassland, pp. 69-72 in R. Benton and A. Elder, eds., Proceedings of the Third Conference on Fossil Resources in the National Park Service (Natural Resources Report NPS/NRFOBU/NRR-94/14).

LaGarry-Guyon, H. E. and R. M. Hunt, Jr., 1992, 1991 paleontological resource survey of the Oglala National Grassland (Roundtop 7.5' Quadrangle), Sioux County, Nebraska, USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-91-013).

LaGarry-Guyon, H. E. and R. M. Hunt, Jr., 1993, 1991 paleontological resource survey of the Oglala National Grassland (Roundtop 7.5' Quadrangle), Sioux County, Nebraska; Supplement #1: Results of paleontological investigations, USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-91-013).

LaGarry-Guyon, H. E. and R. M. Hunt, Jr., 1993b, 1992 paleontological resource survey of the Oglala National Grassland (Roundtop, Horn, and Orella 7.5' Quadrangles), Sioux and Dawes Counties, Nebraska. USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-92-025).

LaGarry, H. E., and R. M. Hunt, Jr., 1994a, 1992 paleontological resource survey of the Oglala National Grassland (Roundtop, Horn, and Orella 7.5' Quadrangles), Sioux and Dawes Counties Nebraska - supplement #1: results of paleontological investigations. USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-92-025).

LaGarry, H. E. and R. M. Hunt, Jr., 1994b, 1993 paleontological resource survey of the Oglala National Grassland (Montrose, Orella, Wolf Butte, Five Points, Roundtop, and Horn 7.5' Quadrangles), Sioux and Dawes Counties, Nebraska - Part 1: Inventory. USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-93-011).

LaGarry, H. E. and R. M. Hunt, Jr., 1994c, 1993 paleontological resource survey of the Oglala National Grassland (Montrose, Orella, Wolf Butte, Five Points, Roundtop, and Horn 7.5' Quadrangles), Sioux and Dawes Counties, Nebraska - Part 2: Recommendations, USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-93-011).

LaGarry-Guyon, H. E. and E. Stepleton, 1993, 1992 paleontological resource survey of the Oglala National Grassland (Roundtop, Horn, and Orella 7.5' Quadrangles), Sioux and Dawes Counties, Nebraska - Supplement #3: 1991 & 1992 Field Notes, USDA Forest Service-University of Nebraska/Lincoln (Challenge Cost-Share Agreement No. 02-07-92-025).

LaGarry-Guyon, H. E., D. A. Nixon, and W. B. Wells, 1993, 1992 USDA Forest Service survey and assessment of Toadstool Park as a sensitive site [abstract], Proceedings of the 103rd Annual Meeting of the Nebraska Academy of Science, pp. 61-62.

LaGarry, H. E., D. A. Nixon, W. B. Wells, and B. A. Beasly, 1994, 1993 paleontological resource survey of the Oglala National Grassland, Nebraska [abstract], Kansas Academy of Science Abstracts, 13:24.

Nixon, D. A. and H. E. LaGarry-Guyon, 1993a, Oligocene trackways in the White River Group type section at Toadstool Park, Sioux County, Nebraska [abstract], Proceedings of the 103rd Annual Meeting of the Nebraska Academy of Science, pp. 64-65.

Nixon, D. A. and H. E. LaGarry-Guyon, 1993b, New trackway site in the White River Group type section at Toadstool Park, Nebraska: paleoecology of an Oligocene braided stream, riparian woodland, and adjacent grassland [abstract], Journal of Vertebrate Paleontology-Abstracts, 13(3):51A.

Savage, D. E. and D. E. Russell, 1983, Mammalian Paleofaunas of the World. Reading, Massachusetts, Addison-Wesley Publishing Company.

Schultz, C. B. and T. M. Stout, 1955, Classification of Oligocene sediments in Nebraska: a guide for the stratigraphic collection of fossil mammals, Bulletin of the University of Nebraska State Museum, 4(2):17-52.

Stout, T. M., V. H. Dreeszen, and W. W. Caldwell, 1965, Central Great Plains: Guidebook for field conference D, International Association for Quaternary Research (VIIth Congress) 124 pp.

Terry, D. O. and H. E. LaGarry, 1994, Lithostratigraphic correlation and provisional redefinition of the Eocene-Oligocene White River Group, Nebraska and South Dakota [abstract], Geological Society of America Abstracts with Programs, 26(7):249.

Wells, W. B., 1994, Paleoenvironmental and paleoclimatic implications of multiple cut and fill paleovalley sequences within Oligocene sediments of northwest Nebraska [abstract], Proceedings of the 104th Annual Meeting of the Nebraska Academy of Science, pp. 54-55.

Wells, W. B., D. O. Terry, and D. A. Nixon, 1994, Multiple cut and fill paleovalley sequences within Oligocene sediments (White River Group) of northwestern Nebraska [abstract], Geological Society of America Abstracts with Programs, 26(7):492.

Wood, H. E. II, 1949, Oligocene faunas, facies, and formations, Geological Society of America Memoir 39, pp. 83-90.

Characterization of the Glenns Ferry Formation, Hagerman Fossil Beds National Monument, Idaho

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Purpose

Hagerman Fossil Beds National Monument (HAFO) was established in 1988 to preserve the Hagerman local fauna, a world famous locality of Pliocene vertebrate mammalian remains. Presently, piezometric landslides resulting from irrigation practices nearby are destroying the valuable fossil resources. This study, which is facilitating a masters' thesis, was funded through a cooperative operating agreement between Idaho State University and the National Park Service (NPS). The study is characterizing the Pliocene Glenns Ferry Formation in a portion of the monument endangered by future mass movements. A stratigraphic framework is being developed to:

- Determine the three dimensional geometry of sedimentary units contributing to landslide occurrence.
- Infer the depositional environment of the site during the Pliocene.

The information obtained will be used by the NPS in its management plan for mitigating further landslides and for creating interpretive exhibits of geologic processes working at the monument in the past and present.

Results

The rocks existing in the monument originated from canyon cutting and filling at the location since the Pliocene. The Pliocene Glenns Ferry Formation (Tg) is the major unit exposed and it entombs the famous Hagerman local fauna.

70-80% of the Glenns Ferry Formation is composed of layers of silt overlain by clay. Silt layers (Lithofacies Fs) may reach 2m in thickness, are tan to brown in color, and may contain carbonate nodules, root casts, and mollusc fossils. Olive to dark brown clay layers (Lithofacies Fc) overlie silts by sharp or gradational contacts, and are up to 1 m thick. Successions of silt and clay layers may reach 30 m in thickness and are continuous laterally for thousands of meters. Successions terminate at sand bodies. Lithologies interbedded with silts and clays include carbonaceous shales or lignites, and diatomites.

20-30% of Tg is composed of sheet-shaped sand bodies thousands of meters wide and up to 10 m thick. Sand bodies contain vertical successions of sand lithofacies (Sg, St, Sr, and Ss) that decrease in grain size and scale of sedimentary structures upward within bodies. Massive, trough crossbedded, pebbly sands (Lithofacies Sg) overlay erosive contacts with silts, clays or sands. Trough crossbedded sand (St) continues upward, being overlain by ripple crosslaminated sand (Sr). Scour fills of sand or silt, occur within St and Sr. The tops of sand bodies become more silty until silt-clay successions continue.

Also included in the formation are two basalt flows, three silicic ashes, and numerous basaltic ashes.

A fence diagram composed of data obtained from this study and from previous studies was created to determine the three dimensional geometry of Glenns Ferry Formation sedimentary units. Three sand bodies exist in the upper 65 m of the unit. These bodies have up to 20 m of relief and are continuous laterally for up to 2000 m before pinching out in less than 200 m. The sand bodies are vertically distinct, and are separated by silts and clays. The Tuana Gravel, which erosionally overlies the Glenns Ferry Formation, truncates silts and clays, and may also truncate sands somewhere in the subsurface.

Conclusions

High permeability lithologies (composed of sand or gravel) within the Glenns Ferry Formation and Tuana Gravel act as aquifers. The general arrangement of lithofacies, and the lateral geometry and extent of Glenns Ferry Formation sand bodies indicate they were formed by laterally migrating meandering stream channels. Low permeability silt and clay lithofacies act as aquitards which cause downward moving groundwater in an aquifer to move laterally upon reaching the contact. Groundwater discharging onto slopes from these contacts forms areas of dense vegetative cover. Seepage sites are prone to failure due to the increased weight and lack of strength caused by the addition of water. Silt and clay layers are interpreted to have formed on floodplains as vertically accreting overbank deposits during flooding of the meandering streams. Diatomites and carbonaceous shales accumulated in shallow ponds on the floodplain. Volcanic activity occurred during the time of sedimentation from basaltic volcanoes nearby and silicic volcanoes far away.

Protecting Vertebrate Fossils on Public Lands: Saving the Earth's Library

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A 20 year dispute over the right to collect fossil vertebrates on public lands led to the introduction in July 1992 of a new bill in the US Senate by Senator Max Baucus (D-Montana). The Vertebrate Paleontological Resources Protection Act (VPRPA) has created a nationwide debate among scientists, amateurs, and entrepreneurs in the paleontological community.

The introduction of the VPRPA was intended to stimulate dialogue in order to bring consensus on how to protect vertebrate fossil remains on federal land. Unfortunately, instead of encouraging constructive and intellectual dialogue, commercial fossil dealers launched an effective assault against the proposed legislation, using misinformation aimed at the general public and amateur fossil hunters. Ironically, if the commercial industry is ultimately successful in convincing Congress that such a law is not needed, serious ramifications for amateurs, educators, scientists, and the general public will result.

Federal and state land managers have the difficult task of trying to protect and preserve our natural resources on public lands so that they can be retained for future scientific, educational, and recreational uses by the American people. In spite of extant laws to protect such fossil resources, these resources are disappearing at an ever accelerating rate.

Stronger emphasis on educating the public about proper fossil collecting, and stiffer penalties and fines for those who knowingly break the law are needed to deter irresponsible fossil collecting. Most importantly, the public must be made aware of the commercial aspects of fossil collection. The commercial industry has created an international fossil market where millions of dollars are exchanged every year. Fossils are part of our natural heritage, and collecting them illegally from public lands and selling them violates an American trust.

To better understand issues surrounding this debate, consider these questions and answers.

Is legislation needed to protect vertebrate fossil resources?
Vertebrate fossils are rare, nonrenewable resources that require proper care and conservation. Significant fossil discoveries should be held in museum repositories in perpetuity to guarantee their availability for scientists and educators, and appreciation by the general public. Only on public lands can fossil resources be protected. This legislation will benefit museums, schools, science, and the general publ[ic] by permitting collection of vertebrate fossils on public lands without commercial intervention.

For many years and especially in recent years, significant fossil discoveries have shed new light on the behavioral and paleoenvironmental aspects of past life on Earth. Most prevalent of these discoveries are the dinosaurs. The popularity of dinosaurs has piqued the interest and curiosity of everyone from layman to scientist. Unfortunately, it has also bred greed. If the American public is ever forced to pay commercial fossil dealers for fossils collected from public lands, this will violate a resource held in common trust for learning and will provoke the collapse of the development of paleontological science.

How will the Vertebrate Paleontological Resources Protection Act benefit the public?
VPRPA will provide management of, and funding for the protection of paleontological resources on public lands. The public will have more access to fossil areas than ever before on land administered by the Department of Interior and the US Forest Service.

Cooperation and coordination of uniform rules and regulations among agencies will ultimately increase the responsible collection and research of vertebrate fossils to everyone's benefit.

By directing and channeling information through a federal land manager with a background in paleontology, schools, amateur fossil clubs, and community sponsored groups, such as the Boy Scouts and Girl Scouts of America, will have access to information regarding fossil finds and facts, which will lead to increased volunteer support. VPRPA will ensure that every child, teacher, amateur, and scientist will have the freedom to collect fossils for research, learning, and recreation.

If I collect a fossil on federal lands, who owns it?
The American people own these resources in common - not individually; when a fossil is collected from federal lands, it is publicly owned under the jurisdiction of the US government. This has always been the case and will not change under VPRPA. When you receive a permit to collect fossils on federal land, it is your responsibility to take care of them for everyone's benefit. You become part of the stewardship process that will help to protect our natural heritage.

Does the Vertebrate Paleontological Resources Protection Act prohibit fossil collecting on private land?
Absolutely not. VPRPA only protects vertebrate fossil resources on federal lands. Public lands are the only lands that the US government can protect through legislation for the benefit of the American people.

What will the Vertebrate Paleontological Resources Protection Act cost taxpayers?
In 1979 the Archaeological Resources Protection Act (ARPA) became law. It not only protects cultural resources, but also includes a mechanism within the federal system to properly manage and care for those resources on public lands through federal land management agencies. Because there is no similar act for paleontological resources, archaeologists have also had to manage paleontological resources. VPRPA is designed after ARPA, but differs in allowing amateurs and hobbyists to obtain permission to collect fossils on federal lands. The implementation of management strategies for vertebrate paleontological resources will require hiring some paleontologists and law enforcement officials. The cost to taxpayers will be minimal, especially considering the vast resource protection coverage this legislation will provide. Thanks to concerned archaeologists, much of the administrative and planning work has already been done.

Will taxpayers have to pay to prosecute violators?
Taxpayers are already paying a price when illegal fossil collectors are arrested. Prosecution of these offenders is difficult under the present law, and many times criminal cases require an immense outlay on labor and time. VPRPA will make the law clear to those who are considering collecting fossil vertebrates for commercial purposes on federal lands, and make prosecution more effective and less costly.

Even through vertebrate fossils may be rare nonrenewable resources, why can commercial collectors not sell fossil vertebrates where they are found in abundance?
The quantity of certain vertebrate fossil species is not the issue. Commercial exploitation of any fossil vertebrates found on public lands endangers the future of our natural heritage.

Will this law destroy the commercial fossil industry?
Not only does VPRPA pose no threat to the commercial fossil industry, it provides the industry with more opportunities. Reputable commercial fossil dealers only sell fossils found on private land through arrangements with private landowners. VPRPA supports federal agencies and other institutions that would like to hire commercial firms to conduct paleontological surveys and excavations. All vertebrate fossils will be reposited in a museum or academic facility for scientific and educational purposes when contracted projects are completed.

Why are amateurs siding with the commercial industry?
Because of the misinformation campaign directed at amateurs by the commercial fossil industry. Amateurs should read the bill and decide for themselves whether this will dramatically affect their hobby.

For the most part, amateurs have not been allowed to hunt fossils on public lands, but for centuries researchers and educators in every field of science have depended heavily on information from amateurs. Understanding the significance of their contributions to paleontological science, VPRPA allows for amateur collecting on federal lands as one of its prime objectives.

True amateur fossil hunters have no reason to side with the commercial fossil industry. Although everyone will be required to obtain permission to collect fossil vertebrates on public lands, the only people who will be denied access to collect fossils are those who wish to collect them for commercial purposes. Commercial fossil dealers pretending to be amateurs are deliberately confusing the issue.

Conclusion
In the months to come, the Vertebrate Paleontological Resources Protection Act will be reintroduced in Congress, with modifications. This time, let us hope that reintroduction can spark honest open public debate. Our Earth bears a wealth of information from which we can all learn, and, by supporting the Vertebrate Paleontological Resources Protection Act, we can all preserve that information.

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IMPACT: A Seldom Used Tool for Paleontological Resource Management

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Utah was the first state to define and pass laws for protecting and collecting fossils, and, wisely, at the same time to provide for a State Paleontologist. In 1977, the office of the State Paleontologist fell heir to answering the many questions that focus on fossils and paleontological resource management. The State Paleontologist was expected to manage the permitting program for the collection of fossil resources, coordinate paleontological activities concerning the various land managing agencies (state and federal), and attempt to address the needs of the many professional paleontologists studying and working in Utah.

Professional paleontologists in Utah included various combinations of educators, scientific researchers, and consultants. Over the years, educators routinely took advantage of the state's paleontological wealth and diversity in an ideal setting, where vegetation rarely masks the fossil localities. Researchers were interested in a plethora of fossils, ranging from Cambrian trilobites and phyllocarids to the mammalian giants of the Late Pleistocene, such as mammoths and mastodons. The paleontological consultants did their best to see that our fossil resources have been given an even-handed consideration in the numerous environmental impact studies precipitated by explosive development of Utah's natural resources. Unfortunately, many land managers remained unconcerned or chose to be uninvolved.

Common problems for paleontologists working in Utah or any other state are that of land ownership; to whom one must ultimately turn for permission to trespass and/or collect. Early on, it was also difficult to find an agency representative knowledgeable and/or responsible for the management of fossil resources; someone who could answer the obvious questions. Improvement has been very slow through the years. In some agencies, given the turnover in jobs and the limited emphasis on paleontological resource management, it is still very difficult to locate the individual responsible for permit applications to collect, survey, or even prospect for fossils.

Commonly, to use the Bureau of Land Management (BLM) as an example, one had to gain permission for fossil collecting (vertebrates at least) on public lands through a permitting process inefficiently administered through the mid-seventies by the "Departmental Archaeologist" seated in the Smithsonian Institution under the direction of the U.S. Department of the Interior.

Some years ago, vertebrate fossils were judged by a slow witted jurist not to be included under the Antiquities Act of 1906, and only Cultural Resources were thereby protected. The disgrace was further magnified by the blundering of archaeologists, who often still stand as impediments to the reasonable management of paleontological resources. As this paper is being read, most paleontological resources in the United States are managed by archaeologists who are typically appointed by the bureaucracy with little concern for paleontological professionalism.

The solution to these permitting woes was to organize a network of knowledgeable professionals in Utah who were involved with the use or management of fossil resources at any level and for any reason. As an afterthought, the surrounding states were included as a buffer, because geology and, therefore, fossils do not follow political boundaries.

In a single year what was dubbed IMPACT, the **I**nter**m**ountain **P**aleontological **A**dvisory **C**ouncil and **T**elecommunication had been expanded to include most states west of the Mississippi having any fossil resources of consequence on the lands managed by any state or federal agency.

Assuming that vertebrate paleontologists had the most to lose by the bureaucratic mismanagement of fossil resources and the fact that some of my paleontologist friends and colleagues agreed to act as state coordinators, a contact list for IMPACT was generated with their help.

The contact list for each state was designed to include:

- A cross-section, not necessarily all inclusive, of professional paleontologists in each state with emphasis on representation from each institution of higher learning.

- The State Archaeologist.

- The State Geologist.

- The State Paleontologist (usually, acting only, except for Utah).

- Representatives of the US Forest Service (USFS), BLM, Corps of Engineers, US Fish & Wildlife Service, Soil Conservation Service, and Bureau of Reclamation.

In its simplest form IMPACT was intended as a user/manager directory with the following goals:

- To allow any professional paleontologist easy access to an individual in the appropriate agency with authority for granting permission to work on any public lands of state or federal ownership.

- To identify a coordinator, preferably a professional paleontologist, who is knowledgeable of their states paleontological resources and related studies or research.

- To name individuals in different agencies who can identify and confer with counterparts in other states.

- To provide agencies without access to paleontological expertise a contact with technical resources within their state or region.

Utah exemplifies the problems in BLM paleontological resource management. With the exception of a brief period of instability following the removal of the Smithsonian Departmental Archeologist as the permitting agent some 20 years ago, Utah BLM had a workable paleontological permitting program. But the program gradually deteriorated until several years ago, when the first BLM State Paleontologist was hired. Hired, incidentally, over the protests of a number of reputable vertebrate paleontologists. The individual was protested, not the position. The program was fumbled and bungled, its death punctuated by the resignation of the ineffective "professional." No replacement was named, and it was rumored that the slack would be taken up by the Colorado BLM State Paleontologist, who was assigned, coincidentally, to supervise programs for Arizona, Nevada, California, Washington, Oregon, and Alaska.

At this time the only solid BLM program in the United States is in Wyoming, with New Mexico running a close second in a field of three. This is not a slam at the paleontologists heading those programs, but it does point out the unrealistic approach to paleontological resource management by many state and federal agencies.

There appears to be no feedback, or record of help solicited from IMPACT members between agencies or individuals, in spite of the fact that the paleontologists listed had agreed to a[ct] as unpaid resources to the agencies making such requests for help.

Why does Paleontology continue as an orphan science in the eyes of many land managers, while the Nation's fossil resources continue to deteriorate beyond measure by the depredations of commercial collectors and their allies, the rockhounds? Why is there such disparity from one agency to another, and among the different subdivisions of a single agency?

The standard reply or excuse for indifference is either:

- We have no state or federal law to cover this situation.

- There is no money budgeted for the program this year.

- We don't have a paleontologist, and our archaeologists are all busy.

If interest is sparked at a lower echelon, it is usually quashed at the state, regional, or, ultimately, at th[e] national level.

Who are the champions of paleontology? They range from public employees to educators, but include relatively few researchers. Why not researchers? It may be called selfishness and/or self preservation. If one complains about the action or sloth of an agency in granting a permit, what do you think will be the call next time at bat? Researchers are often too busy to get involved for lack of interest, or the possible consequences resulting from academic administrators who fear political repercussions from one of their staff who has dared to question a US government land manager. Furthermore, if tens of thousands of grant dollars are at risk, one is not likely to rock the boat when a permit application is being held overhead.

Permits, curation agreements, and other bureaucratic demands must be handled well in advance of a grant proposal. More than one land manager has taken months in excess of a reasonable time for a permitting review, which could comfortably and effectively be accomplished in less than 72 hours.

It is a fact that many researchers, by their own admission, have elected to operate without a permit. Their explanation: "We are not about to suffer the denigration and childish, fraternity initiation-like treatment suffered at the hands of some land managers, too few of whom know enough about paleontology to even read a proposal, let alone evaluate it."

It sounds like there is a lot wrong. Is there anything right? Yes. The program assembled and operated by the National Park Service (NPS) has looked good for a long time and the USFS has started some real action in Nebraska. The BLM shows some progress, but shows a remarkable lack of communication from one state to another, and a greater communication problem from the state to the district and then the area offices.

The Plan

Employ the Paleontological Users of IMPACT in concert with the paleontological managers. Combined, these two groups can address all questions. Trust me! These are the sum total of individuals who should be dealing with the problems of Paleontological Resource Management. They represent the users and they represent the managers.

- Start communicating and identify representatives from each land managing agency with significant paleontological resources (see IMPACT).
- Together with Paleontologists from each state the agency representatives will approve a four page permit application similar to the current Wyoming document.
- The annual permit will serve several obvious purposes: allows the permittee to operate under the stated conditions; has a reciprocal agreement to allow work on more than one public land designation, i.e., BLM, NPS, USFS, etc.; easy annual renewal feature, providing every condition of the previous Permit has been satisfactorily met; constructs and maintains an accreditation list of permittees having fulfilled obligations under the uniform reciprocal permitting system.

Under this plan, states with State Paleontologists, BLM State Paleontologists, or equivalents in other agencies will have an immediate part to play. States without such positions can still utilize professionals from IMPACT.

Creative Partnerships Stretch Your Limits

Virginia Mast, Curator, Colorado School of Mines Geology Museum, Golden, CO 80401-1887

The Colorado School of Mines Geology Museum is long on collections and short on cash, personnel and space. To help achieve our goal of providing quality learning experiences in the Earth Sciences, we've developed partnerships with a variety of educational and other programs.

John Hanley Memorial Fossil Teaching Sets

Originally conceived by Bob O'Donnell, these kits were put together with US Geological Survey (USGS) labor, fossils, and materials, a huge volunteer effort by Jesse Bowles, money and labor from the Rocky Mountain Association of Geologists, money from Amoco and fossils, labor and money from the Geology Museum. First there were 10 kits. They were so popular that we made 10 more. Two are at each USGS facility; one is at Amoco; one is, alas, forever gone; the rest are at the Geology Museum. They go out for two weeks at a time for free, with the reservations handled through our Museum Tour desk. Teachers, students, scouts, and museums are respectful, careful, and delighted to have the opportunity to use the kits.

Red Rocks Elementary Earth Science Outreach: Where in the World Are We?

This is a pilot for a program that will eventually encompass the whole state. The main partners here are the Geology Museum, the Morrison Natural History Museum and Red Rocks Elementary School. Each class is involved in informal earth science exploration activities, with the activities building from one grade to the next. Of course, paleontology is a big part of what we do, especially with the first, second, and fourth graders, who study dinosaurs and geology anyway. The ultimate goal of the program is to foster an awareness of the world around the school; to get the students and teachers alike to develop a sense of the uniqueness of their little corner of the universe. On a state wide scale, the partnerships will be defined regionally, with a core facility (museum, college, library) and a number of school districts in each partnership.

Children's Museum Fossil Dig

Underwritten by Amoco, presented by the Denver Children's Museum, with fossils supplied by the Geology Museum, this was a fabulously successful program enjoyed by many school groups from all over the metro area. There is a small, permanent version of the Fossil Dig at the Morrison Natural History Museum. Again, the fossils are from the Geology Museum.

Return of the Native

Morrison was the site of the original dinosaur finds by Arthur Lakes of the Colorado School of Mines in 1877. The material ended up with O.C. Marsh at the Peabody Museum of Natural History at Yale. Some of it was never prepared, for shortly after the Morrison finds, the quarries at Como were opened, and the material there was more complete and less broken up. John Ostrom has loaned the genotype specimen of Stegosaurus, YPM 1850, to the Geology Museum and the Morrison Natural History Museum for preparation. One block (perhaps 75 lbs out of a total of 2 tons) has been moved out here and prepared. In this instance, Yale University provided the material, Morrison the expertise, and the Geology Museum funding and equipment. The Friends of Dinosaur Ridge have also been a supporting partner.

Long term Exhibit and Teaching Loans and Gifts

This is a changing partnership between the "have nots" and the "haves," with the Geology Museum taking the role of the "haves." We try to fill all teacher requests for earth science materials, both for classroom use and for exhibit. The classroom material is often given to the teacher. The exhibit material is loaned. The Geology Museum also has a policy of long term loans to other museums who can better use collections than we can. The museum has limited exhibit space, and, as with many small museums, new exhibits are slow to appear. It makes sense to have our collections available to as large an audience as possible. Specimens languishing in storage do little good, and often there are sites that can make better use of them. I am always willing better use of them. I am always willing to entertain requests for long term exhibit loans. There are currently such loans at Fossil Butte National Monument, the National Mining Hall of Fame, the Morrison Natural History Museum, Colorado Historical Society, and the Ouray County Historical Museum. In addition, we have the ability to deaccession collections and transfer them permanently to more appropriate institutions. While we have not yet started this process, storage space constraints are going to force us to do so soon.

Colorado Fossil Collection
The collection is a collaborative effort of the Western Interior Paleontological Society (WIPS), the Denver Museum of Natural History, the Geology Museum and others. WIPS will gather a type collection of Colorado's invertebrate fossils. The Denver Museum will house the collection, and the Geology Museum will receive a large amount of gratis curation for its collections. There are no longer teaching staff at Mines who are paleontologists.

Friends of Dinosaur Ridge Consortium
The Consortium was created as part of the Intergovernmental Agreement that allowed the Friends to acquire a visitor center. Its makeup was determined by Jefferson County Open Space, and includes Lakewood's Historic Belmar Village, the Morrison Natural History Museum, the Friends of Dinosaur Ridge, the Lookout Mountain Nature Center, and the Geology Museum. The Consortium's function is to oversee all plans involving the visitor center facilities and programs. The Consortium is also gaining the opportunity to closely coordinate the members' activities in such a way that we all benefit from each other's programs.

Colorado Earth and Space Science Education Network
This group is, no doubt, familiar to a number of you. Originally conceived of by Ed Geary at the Geological Society of America in Boulder, the group started out with a number of teachers, administrators, and resource representatives in the Denver metro area meeting to try to identify the status of earth science education in the area public schools. That was approximately three years ago. Now the group meets regularly to bring ourselves up to date on the activities we have been involved in: a news letter; an information network; a public radio program; booths at teacher conventions; and new information, products, projects, and initiatives. At first, individuals at the meetings bemoaned the lack of support, resources, contacts, and money for teaching earth sciences. Now, the value of the network is apparent. People come to share information. We are all aware of the each other, and there is a much greater feeling of a shared purpose. This is a partnership where everyone gives and receives equally.

Vail/Beaver Creek Interpretive Exhibits
This one is really fun! Eventually, the partnership will be the Geology Museum, the US Forest Service, and Vail Associates. Working with the Beaver Creek Children's Ski School Director, we will create outdoor interpretive signs and exhibits that will help kids and their parents learn about the local environment (rocks and fossils, as well as bugs and trees.) This will be a bit like the Red Rocks Elementary School project on skis. The exhibits and activities will be utilized by the ski school in the winter and by various other groups in the summer. They will also be available to the casual visitor.

Trends and Opportunities in National Park Service Paleontological Resource Management

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Significant fossil resources are found at more than 100 National Park Service (NPS) sites. Increasing recognition of their importance is illustrated by recent NPS funding for major paleontological projects, new servicewide opportunities for paleontological training, a strong commitment to investigating and prosecuting fossil theft cases, support for stronger legislative protection for fossil resources, and the impressive growth in the size and scope of this conference in comparison to its predecessors.

Budget and personnel constraints are likely to prevent significant additions to the small number of NPS paleontologists, so creative approaches will be necessary if the NPS is to effectively manage its fossil resources. Ideas include establishment of regional paleontological centers at a few key parks, expanded paleontological training and educational opportunities for NPS staff, sharing of scarce fossil management capabilities with other Federal and state agencies, increased use of cooperative agreements with universities and the US Geological Survey (USGS), and building stronger relationships with amateur paleontologists.

Current Paleontology Programs

With the recent addition of paleontologists at Badlands National Park and Florissant Fossil Beds and Fossil Butte National Monuments, paleontologists are now on staff at 6 national parks and monuments. Park paleontologists have repeatedly demonstrated the importance not only of their own work, but also their value as catalysts who attract numerous research projects that help us to better understand, manage, and interpret our fossil resources. A few of the many achievements of NPS paleontology programs are summarized in this volume. Some recent highlights include:

- Cooperation between John Day Fossil Beds National Monument and the BLM on cyclical prospecting and specimen preparation and curation.
- The excavation of a new carnosaur at Dinosaur National Monument.
- Work with the USGS and a number of other agencies to determine the causes for landslides that threaten the primary fossil resources at Hagerman Fossil Beds National Monument.
- Studies of the spectacularly preserved fossil flora and fauna at Florissant Fossil Beds National Monument.
- Interdisciplinary efforts by geologists and paleontologists from universities, the USGS, the NPS, and other agencies to characterize the Jurassic age Morrison Formation paleoecosystem over a number of parks in the intermountain west.
- Continued work by paleontologists from Northern Arizona University and elsewhere to assess the Pleistocene and Recent ecosystems of the Colorado Plateau, using skeletal material, packrat middens, and dung preserved in caves of the region.
- The discovery and excavation of an unusually complete skeleton of a pygmy mammoth in Channel Islands National Park in summer 1994.

Effects of the NPS Reorganization on Paleontology Programs

The proposed NPS reorganization aims to better allocate flat or declining funding and a shrinking employee base in a time of increasing park visitation and growing pressure on park natural resources. Under the plan, paleontological support could be provided to parks from 3 levels.

1. Technical support has traditionally been provided to parks from central office organizations covering Air Resources, Water Resources, Wildli[fe] and Vegetation, and Mining and Minerals. The reorganization proposes to group these into a Natural

Resources Center. Paleontology will be one of the responsibilities of the new Geological Resources Management Division, which will be built from the current Mining and Minerals group.

2. It is proposed to divide parks into 16 clusters, based primarily on ecosystem boundaries. Each of these clusters will have a System Support Office (SSO) from which technical support is to be provided to parks, as it has been through the current ten regional offices. Preliminary recommendations for minimum effective SSO staffs suggest including at least one geologist at each. To maximize sharing between parks and regions, and to build geological expertise throughout the National Park system, geologists with a variety of different specialties should be chosen, with selections based on the dominant geological resource management needs of each park cluster. Given the urgency of paleontological issues in a number of parks, some should be paleontologists. Staffing constraints may initially limit the size of SSO technical support organizations intended by the reorganization. It will nevertheless be important to develop clear justifications for specific resource management needs, so that SSOs can be gradually brought up to strength as money and FTEs become available.

3. Within each park cluster, the reorganization plan challenges superintendents to develop procedures for sharing scarce park staff resources. If the reorganization functions as planners envision, park based paleontologists might see increased requests for technical support from nearby parks, and spend significant amounts of time working on problems in those parks. However, discussions at this conference demonstrated support for more park based paleontologists when funding and FTEs are available, but not for substantial additional sharing of already overworked paleontologists currently on park staffs. Some interest was expressed in new positions designed for sharing among several fossil parks, but imposing significant multipark responsibilities on existing paleontologists was not felt to be desirable. Participants also noted a serious shortage of support staff to help park paleontologists with tasks such as fossil excavation, specimen preparation, and curation.

Paleontologists are one of the few categories of park scientists not transferred as a group to the National Biological Survey. With increasing appreciation of the value of fossil resources and the need for their effective management, the responsibilities of NPS paleontologists are inevitably growing. The resulting professionalization of these critical positions needs recognition by management, which should take steps to ensure that position classifications and grades are made comparable to those for analogous positions at other Federal agencies such as the USGS and the Smithsonian Institution.

Protecting Fossil Resources

Resource protection is a major concern for paleontology, driven by a vigorous collectibles market with prices that are very high and apparently continuing to rise. Given the money that can be made, Federal land managers face an increasingly determined cadre of collectors eager to remove commercially valuable specimens. Although most collecting on public lands is done by surreptitious removal from the field, thefts from museums are also increasing, and collection managers should make careful provision for the security of their commercially valuable specimens. Thanks particularly to the work of a few dedicated individuals, the NPS is moving to enforce existing laws against the unauthorized removal of fossils from NPS lands and is cooperating with other agencies to support prosecution of fossil thieves. Exemplifying this dedication was Badlands National Park district ranger Stan Robins, who, while fighting a tenacious illness, worked tirelessly to protect the park's superb fossil resources from looters.

The supposed ambiguity of current laws and regulations is being used by some illegal collectors to justify their activities, to provide a legal defense in resource violation cases, and to rally public sympathy for the lucrative trade in illegally collected fossils. Federal agencies involved in managing, studying, and curating fossils need to work together to draft legislation that will protect scientifically valuable resources while establishing reasonable rules of access for amateurs, school groups, and other educational users to fossil resources that are not scientifically significant. Although scientists and commercial collectors vehemently disagree about access to fossils on public lands, both sides will eventually benefit from laws that clearly delineate what is legal and what is not.

Working with the Public

Public support is crucial to protecting fossil resources, yet the public seems poorly informed about the meaning and importance of fossils. The paleontological community needs to proselytize the general public about the value of fossils, just as archeologists have been doing for many years with human artifacts. Inspiring the public about paleontology should be feasible, even as the excitement of Jurassic Park recedes. After all, what paleontologists study is nothing less than the history of life on our planet by adding the dimension of time to biology. The paleontologist sees the results of climate change, the dynamics of extinction, competition, and evolution, and thus endeavors to understand changes in ecosystems through time. As scientists, educators, and interpreters work to convey the value of paleontological knowledge to the public, more people will understand why fossils are more than art objects or collectibles and, therefore, why they are worth protecting.

The nation's many amateur paleontologists, whose love of fossils echoes the Latin root of the word amateur, are a major potential source of help for park programs, particularly in cyclical prospecting, excavation, specimen preparation, and curation. Extra eyes in the field can help discourage looters and find specimens before they are lost to erosion, and can multiply the capacity of an understaffed paleontology program. Training programs such as the impressive and rigorous one year program operated by the Denver Museum of Natural History can provide amateurs with the background and experience necessary to participate effectively in research and resource management projects. The NPS and other land management agencies should explore opportunities for cooperating with amateur paleontological organizations, and for developing and/or participating in effective training programs for amateur volunteers.

Partnerships

The conference theme, Partners in Paleontology, and its successful growth into multi-agency sponsorship emphasize the benefits of cooperation in managing fossil resources. The NPS has recently signed Memoranda of Understanding with the USGS and the Association of American State Geologists that will foster the development of a number of cooperative projects in geology. Initial work with both groups will focus on careful searches for existing map data at the state and Federal levels, and then will probably involve a substantial geologic mapping component. The states have roughly $17 million dollars authorized for use on a 50-50 matching basis with Federal funds for geologic mapping, a situation made to order for Challenge-Cost Share type of funding. The joint work by USGS geologists, university researchers, and NPS staff on projects as diverse as the Morrison Formation paleoecosystem project and the efforts to deal with serious slope stability problems at Hagerman Fossil Beds shows the value of joint agreements that can bring in a range of interdisciplinary help. The USGS agreement is expected to function through joint planning teams at the regional or park cluster levels that will assess geologic resource management needs, match the most critical needs with the talents of USGS scientists, and help design cooperative projects. NPS staff should work through regional offices to provide input to planning teams.

Training

A key to nurturing and expanding support for paleontology throughout the NPS is training. A recently completed 3 day paleontological resources management training course drew more than 20 students. Ideas for improvements included adding a day or two to the training so that more topics could be covered in more depth, and addition of a basic paleontology session at the beginning of the course.

Considerable interest has also been expressed in paleontological law enforcement training. Joint natural resources/law enforcement ARPA training has apparently worked well, and efforts are underway to include paleontology in that curriculum.

Many university geology departments offer introductory and advanced paleontology courses that may provide an ideal background for paleontological resource managers, and can go into much greater subject matter depth than a one week training course. Paleontological field methods must be learned through substantial field experience. NPS paleontologists may be willing to provide one-on-one field methods instruction in return for much needed help on excavation or cyclical prospecting projects.

Conclusion

Although budgets and staff are under pressure from large scale political and economic forces, the dedication and creativity of paleontologists are helping to build successful programs through partnerships and multidisciplinary projects. By better understanding our fossil resources, and communicating our knowledge to the public, we can develop increased support for their protection and management.

Interpreting Dry Mesa

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The US Forest Service has recognized the public's love affair with dinosaurs and acknowledges a need to provide interpretive opportunities highlighting the scientific uniqueness of the Dry Mesa Quarry site and its management by the Uncompahgre National Forest (UNF).

Management objectives for the quarry favors scientific use of the area over public recreation use until the excavation phase of research is completed. Management recognizes however that some people will intuitively visit the site. Encouraging visitation through guided tours will protect its integrity. This management strategy is preferred to closing the area completely to the public.

Additionally, management strives to maintain the primitive qualities of the site. Any on-site interpretation has been blended with the semiprimitive development of the recreation opportunity spectrum (ROS). It is equally important to develop interpretive programs off-site in order to further maintain the semi-primitive atmosphere of the area.

Background and Setting

The resting place of many of the world's largest sauropods is a high mesa overlooking the steep valleys of Escalante Canyon. For over 20 years, scientists from Brigham Young University (BYU) have extracted thousands of fossils from this obscure and scenic mesa. The isolated location and rugged terrain accentuates the harshness and tedium of removing fossils from their 140 million year old grave site.

With the advent of "Jurassic Park," both UNF and BYU, recognizing a need to become proactive in managing the quarry, teamed together to offer interpretive opportunities to the public. With the additional aid of paleontologists from the local area, UNF completed an Interpretive Master Plan for the quarry in May, 1993. Playing on the rugged setting and accentuating its remoteness, UNF implemented the following programs consistent with the master plan.

Interpretive Programs

On-site interpretation

As the quarry gains public notoriety, visitor demands for access to the quarry increase. UNF has responded in two ways; developing a guided interpretive tour on-site and installing improvements at the site.

On-site Tours

UNF accommodates visitors to the quarry by hosting an annual guided tour of the site. After two hours of rugged travel, the adventure begins at the Dry Mesa Trailhead. While hiking a 1/4 mile trail, Forest Service interpreters explain the quarry's history, clarify why the site is so highly regarded by scientists, define why it is critical to protect all paleo sites, and demonstrate how the UNF manages this one. Visitors begin to anticipate 140 million year old treasures being found in the earth. Crews from BYU are on-site, playing hos to the inquisitive. Technicians are uncovering and displaying specimens while paleontologists answer a variety of questions. The visitors are truly awed, and, if it weren't for the intensity of the sun along the exposed hillside, they might never move on.

In addition to this one event, other groups, scheduled and unscheduled, visit the site, often distracting paleontologists during excavation. UNF appreciates the time and effort that these crews take to entertain visitors and partially reimburses BYU for these impediments through a Challenge-Cost Share Agreement.

On-site Improvements

As a result of increased public use, UNF has installed a variety of improvements ranging from sanitary facilities to interpretive signs. All the improvements have been designed to blend with the primitive atmosphere of the quarry. Native materials have been used for sign posts, gates, and trail construction. Rock tables, affording managers low maintenance and site atmosphere, were installed at the trailhead. The public observed and approved of these efforts.

Off-site Interpretation
Because Dry Mesa Quarry is unique in both its scientific discoveries and its primitive location, UNF's management strategy of maintaining its primitive values through off-site interpretative displays becomes an essential piece of the total interpretive master plan.

Exhibits
UNF has recently entered into a Challenge-Cost Share Agreement with Dinamation International Society, Inc., managers of the largest and most diverse dinosaur museum in Western Colorado, the Devils Canyon Science and Learning Center. An exhibit is currently being developed that will highlight the quarry's significant scientific finds using interactive learning methods. The display will be featured as part of the Learning Center and will be displayed and maintained by Devils Canyon over the next five years.

Displays, Videos, and Brochures
In addition to a static display, UNF is developing mobile exhibits that can be used in response to repeated requests for information presentations on the Dry Mesa Quarry. Requests range from school groups to scientific conferences, necessitating a portable exhibit. The inclusion of "props" for display, and as teaching tools have been incorporated. Replicas of species represented at the site include casts of bone samples, a claw, a tooth, and a nine foot scapula!

To further accommodate the public's request for information, UNF has created a two minute video that briefly depicts the rugged and harsh location of the quarry, encouraging the public to visit the area during a guided tour. The video briefly describes where additional information can be obtained on Dry Mesa and dinosaurs, including museums, books, and additional documentary videos. UNF also plans to develop a brochure and an educational slide show.

Bone Preparation
Each year of ground excavation produces two years of laboratory work. While there is usually grant money available to the University for discovering dinosaur bones, there is little funding available for the tedious lab work that follows. UNF assists this process through a Challenge-Cost Share Agreement. This five year program will aid technicians in preparing the backlog of quarry specimens, making them available to scientists for study and research.

Summary
For twenty years the Dry Mesa Dinosaur Quarry existed virtually unknown outside of scientific circles. The long journey and the bad roads kept many away who might otherwise have ventured there. Yet today, the public's thirst for first hand exposure to dinosaurs propels many to attempt the trip.

Managing this unique and special resource holds many challenges:

- Protecting the site yet allowing public access.
- Developing interpretive programs, both on-site and off-site, to protect the science and informs the public.
- Presenting guided tours, where interpreters can reiterate the need to protect such sites.
- Developing off-site exhibits, which allow UNF to maintain the primitive setting of the site.
- Creating literature and educational programs, which deliver UNF's message of protection and management.

Dinosaurs are the hook thats gets people thinking. The hook allows managers the opportunity to slip in their message. Use the hook, interpret the site, and present your message.

Precision Location of Fossil Sites Utilizing a Laser Transit

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The expanding use of Geographic Information Systems (GIS) to record data for the management of natural resources requires increasing precision and accuracy in locating those resources in three dimensional space. **Precision** refers to the degree of refinement with which a measurement is taken, or the degree of resolution possible in documenting the position of a resource within a set of reference points. **Accuracy** refers to how close the measurement placed in the GIS is to the true position of the resource. The quality of both of these attributes is important if the data in GIS are to be manipulated and utilized as the basis for resource management decisions. The data should be consistent and easily replicated.

A technological innovation that complements GIS has been the increasing utilization of Global Positioning Systems (GPS) in nonmilitary situations, especially resource management. Utilization of GPS satellites to locate resources requires specialized equipment and, depending on the degree of precision and accuracy needed, this equipment cost can be high. Low cost equipment is available, but at the expense of decreased accuracy and precision. At a time of reduced budgets and tight money, it may be difficult to obtain the funding to purchase GPS equipment that will provide the needed level of resolution.

The degree of resolution needed is often determined by the areal extent and amount of topographic relief of the region in which the resources are found. In areas with millions of acres and thousands of feet of topographic relief, the precision needed in surveying the resources may only need to be within tens of feet either horizontally or vertically. In smaller areas or areas with limited relief, differences of just a few feet may be critical. The challenge is to maximize the precision and accuracy of the mapping of a resource and, at the same time, minimize the cost at which that information is obtained.

Hagerman Fossil Beds National Monument is a relatively small area consisting of 4,400 acres with a maximum relief of 600 feet. Many of the fossil sites containing bones and teeth of small animals (microvertebrates) such as fish, frogs, and mice, as well as snails and clams, are as small as anthills, so a system that would permit the location of a site with limited areal extent was needed. In order to generate the needed coordinates of these small sites, we purchased a laser transit. With proper use, a site which fits within an area of one cubic foot can be located. Although these sites could be located relative to standard survey monuments, such as section corners or benchmarks, we augmented these reference points with an additional set of 60 reference markers that were situated throughout the monument, but with no specific relationship to any fossil sites. For each of these additional markers we have coordinates (longitude, latitude, and state plane coordinates) and elevation.

The laser transit utilizes a laser beam that is bounced off a prism on the end of an adjustable length survey pole. The computer in the transit averages the amount of time it takes the light beam to travel between the transit and the prism and then calculates horizontal distance, slope distance, inclination and azimuth. The survey of each fossil site consists of determining its location relative to two reference markers to provide a double check of its location. The transit can be connected to a data logger (CMT MC-V) in which a unique site identifier is entered and the data can be later directly downloaded into a spreadsheet program. The program we use for collecting and downloading survey data is Traverse PC. This information can also be transferred directly into GIS.

Another advantage of the laser transit is that it has a built-in navigation device. This avoids the necessity of permanently marking and, thus, drawing attention to a site. The search for a site can start at any one of the reference markers, preferably one relatively close to the fossil site. The coordinates of the stating point are entered into the transit utilizing the transit's keyboard, followed by the coordinates of the fossil locality to be located. The hand held transit is then moved until an audio tone is produced, which is then used to direct the investigator to the site.

One of the disadvantages of the laser transit is the number of individuals required for the survey. Where a single individual can utilize a GPS unit, at least two individuals are required for the transit; one at the transit and one holding the prism at the site. If a third individual with a prism is available, the length of time needed is decreased. It is also useful for each person to carry a walkie-talkie to maintain communication, which adds to the initial costs. Despite these limitations, use of the laser transit can provide cost effective resource data collection for GIS with high levels of precision and accuracy.

Paleoelevation of the Florissant Flora, Florissant Fossil Beds National Monument, Colorado

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The Florissant flora of central Colorado is known from impression fossils and pollen that were deposited in lacustrine tuffaceous sediments within a drainage impounded paleovalley. Associated underlying mudflows contain large in situ stumps of *Sequoia*. These deposits formed on the late Eocene erosion surface of the southern Rocky Mountains (Epis and Chapin, 1975). The Florissant Formation is radiometrically dated as 34 to 35 Ma, indicating a latest Eocene age (Berggren et al., 1992). In a comprehensive monograph on the megaflora, MacGinitie (1953) recognized over 140 species.

MacGinitie (1953) concluded that the flora was deposited at a moderate elevation of 305 to 915 meters. His estimate was based upon qualitative floristic comparisons with the ecological distribution of living relatives of the fossil plant association. This estimate has since been widely used as a benchmark for the late Eocene erosion surface, providing evidence for significant uplift of the region during the late Tertiary. However, the application of a more recently developed methodology (Meyer, 1986, 1992) provides evidence that the Florissant flora was probably deposited at an elevation much higher than that suggested by MacGinitie.

Methodology

Determining paleoelevation from fossil floras uses estimates of mean annual temperature (MAT) from isochronous sea level and upland paleofloras in conjunction with lapse rates (Axelrod, 1965; Axelrod and Bailey, 1976). Most simplistically, paleoelevation is estimated using an equation $(MAT^{sl} - MAT^{u})(1000/5.5)$, where MAT^{sl} = mean annual temperature of a sea level flora, MAT^{u} = mean annual temperature of the upland flora, and 1000/5.5 derives the reciprocal (182 m/1°C) of the putative "normal" terrestrial lapse rate (usually taken as 5.5°C/km).

Revision of this methodology (Meyer, 1986, 1992) recognizes other variables that need to be considered in its application, including the effects of continental climates, elevated base levels (i.e., the lowest land surfaces within a region are at moderate to high elevation), areally extensive mountain massifs, geographical and seasonal variability in lapse rates, climatic changes, sea level fluctuations, and paleogeography. This revised methodology is based upon analyses of modern local terrestrial lapse rates calculated by linear regression. These data demonstrate that modern variability exists both in lapse rates and in projected sea level MAT. The method proposes corrective factors that can be used to compensate for this variability when Pacific Coast (sea level) and interior (e.g., Florissant) paleofloras are used to estimate paleoelevation (figure 1).

Application to Florissant

Only megafloral remains are considered here because they represent the vegetation proximal to the depositional basin, whereas pollen is more widely dispersed and may include taxa from different elevations.

Physiognomically, the Florissant megafloral assemblage consists of many broadleaved deciduous and broadleaved evergreen taxa as well as several conifers, suggesting a setting transitional between Broadleaved Evergreen forest and Mixed Coniferous forest (sensu Wolfe, 1979). MAT was about 13°C (fig. 1). Floristically, the diversity of oaks and the presence of members of Lauraceae support this interpretation. *Picea* is presently restricted to areas where mean warm month temperature is less than 20-21°C, although the scarce seeds of spruce may have reached the depositional basin from somewhat higher elevations. The large in situ *Sequoia* trunks at Florissant indicate that these trees grew on sites around the depositional basin; the thermal distribution of the modern Coast Redwood forest (Wolfe, 1979, pl.3) is coincident with the MAT of 13°C inferred here.

Because Tertiary terrestrial climates have involved significant temperature fluctuations over short intervals of time (Wolfe, 1978, 1994), it is important that an upland flora such as Florissant be compared with a sea level flora of the same age when estimating elevation. Florissant's radiometric age of 34-35 Ma corresponds with Kummerian megafloral assemblages (defined by Wolfe, 1968, 1981) including the Puget Group in Washington and the Comstock flora in Oregon. Both floras are associated with intertonguing marine formations, demonstrating their presence at sea level. The Goshen flora of Oregon is assigned by Wolfe (1981) to the informal Goshen stage. It also represents sea level conditions and, while undated, is correlated by Wolfe with the LaPorte flora of California, dated about 33.2 Ma. The LaPorte flora is not associated with marine deposits and may have grown somewhat above sea level. Multivariate physiognomic analyses (CLAMP) provide MAT estimates of 19-20°C for both Comstock and Goshen (Wolfe, 1992b, 1994). For purposes of estimating Florissant's elevation, it will be assumed that this CLAMP estimate validly represents sea level MAT.

In order for the sea level temperature estimate of 19-20°C to be applied in estimating paleoelevation for Florissant, it is first necessary to make adjustments for differential paleolatitudes. During the late Eocene, the Florissant flora was about 2° north of its present 38-39° latitude while the Comstock and Goshen floras were about 5° north of their present 44° latitude (Smith et al., 1981); hence, they were separated by about 9° paleolatitude. Using a paleolatitudinal temperature gradient of 0.35°C/1° (Meyer, 1992), it is necessary to add at least 3.0°C to the MAT for the Comstock and Goshen floras (fig. 1, between points 1 and 2), producing an estimated sea level MAT of 23°C at paleolatitude 40° (Florissant).

Following the method developed by Meyer (1992), a further adjustment is needed to compensate for the probable effects of continentality and elevated base level, assuming that the late Eocene erosion surface did, in fact, occur at moderate to high elevation. An analysis of modern temperatures (Meyer, 1992, fig. 8) indicates that projected sea level MAT increases at least 2° to as much as 10°C from coastal to interior areas, with about 8°C at latitude 40°. Mean annual range of temperature increases about 20°C. This pattern was probably less pronounced during the late Eocene due to the reduced effect of marine upwelling on lowering terrestrial temperatures near the coast and to the development of mountain barriers (e.g., the Sierra and Cascade Ranges). The hypothetical progression of projected sea level temperatures illustrated between points 2 and 3 in figure 1 represents about half of the present day magnitude of such change at this latitude. This suggests a value of 27°C projected sea level MAT during the late Eocene in the Florissant vicinity. A local lapse rate of 6.7°C/km (150m/-1°C) is applied to the equation based upon modern local lapse rates within the continental interior (Meyer, 1992).

In order that paleoelevation can be calibrated to modern sea level, 200 meters must be added to the estimate for Florissant because latest Eocene sea level was higher (Haq et al., 1987).

Results
The application of the methodology to Florissant is illustrated in figure 1. The difference of 14°C (between projected sea level MAT 27° and Florissant MAT 13°) is multiplied by 150 meters (the reciprocal of the inferred regional lapse rate 6.7°C/km) to give a result of 2100 meters. This is calibrated to modern sea level by adding 200 meters, providing an estimated paleoelevation of 2300 meters for the Florissant flora.

Comparison of Previous Results
The first estimate of paleoelevation for Florissant was that of MacGinitie (1953), who used qualitative comparisons to infer a paleoelevation of about 300-900 meters. This estimate has served as an elevation benchmark used in tectonic and geomorphic studies dealing with the timing of the region's uplift (e.g., Epis and Chapin, 1975).

The first use of a quantitative method to estimate high paleoelevation at Florissant was by Meyer (1986, 1992), suggesting 2450 meters, although other recent studies using variations in methodologies have also derived high paleoelevation estimates. Wolfe has applied his methodology (using a lapse rate of 3.0°C) for estimating paleoelevation of the Florissant flora and obtained estimates of 2700-2900 meters (Wolfe, 1992a) and 4133 meters (Wolfe, 1994). Gregory and Chase (1992) derived estimates of 2300 ± 400 meters to 3200 ± 800 meters based upon modifications of both the Meyer and Wolfe methodologies. Variation between the results of different workers is due to differences in the applied paleotemperature estimates, lapse rates, sea level floras along the west coast, sea level calibrations, paleolatitudinal corrections, and corrections for the effects of continentality and elevated interior land surfaces.

Conclusions

The application of these methods indicates a high paleoelevation for the Florissant flora. The methodologies for estimating paleoelevations are problematical and conjectural because they integrate a number of variables and assume the validity and precision of paleotemperature estimates, lapse rate estimates, paleolatitude corrections, sea level fluctuations, and geochronology. Certain aspects of the models are based upon known patterns of modern lapse rate and temperature variability, yet inferences must be made when applying these to the late Eocene. Although estimated paleoelevations are consequently speculative, they nevertheless provide a useful framework for comparison with other interpretations regarding late Eocene elevation in the southern Rocky Mountain region.

The results reached by the data applied in this paper suggest a paleoelevation of about 2300 meters. Other recent models also indicate a high paleoelevation at Florissant, ranging from about 2300 meters to over 4000 meters. The high values estimated by these different applications should provide a stimulus for studies reconstructing the tectonic history of this region. High late Eocene elevation may be due to Laramide compressional tectonism, crustal thickening, or local or regional uplift related to magmatic emplacement. Late Tertiary uplift is not needed to explain the present elevation of 2500 to 2550 meters at Florissant.

References

Axelrod, D. I., 1965, A method for determining the altitudes of Tertiary floras: The Paleobotanist, v. 14, pp. 144-171.

Axelrod, D. I., and H.P. Bailey, 1976, Tertiary vegetation, climate, and altitude of the Rio Grande depressi[on], New Mexico - Colorado: Paleobiology, v. 2, pp. 235-254.

Berggren, W. A., D.V. Kent, J.D. Obradovich, and C.C. Swisher III, 1992, Toward a revised Paleogene geochronology, in Prothero, D. R., and Berggren, W. A., eds., Eocene-Oligocene climatic and biotic evolution: Princeton, Princeton University Press, pp. 29-45.

Epis, R. C., and C.E. Chapin, 1975, Geomorphic and tectonic implications of the post-Laramide, late Eocene erosion surface in the southern Rocky Mountains: Geological Society of America Memoir, v. 144, pp. 45-74.

Gregory, K. M., and C.G. Chase, 1992, Tectonic significance of paleobotanically estimated climate and altitude of the late Eocene erosion surface, Colorado: Geology, v. 20, pp. 581-585.

Haq, B. U., J. Hardenbol, and P.R. Vail, 1987, Chronology of fluctuating sea levels since the Triassic: Science, v. 235: pp. 1156-1167.

MacGinitie, H. D., 1953, Fossil plants of the Florissant beds, Colorado: Carnegie Institution of Washington Publication 599, 198 pp., 75 plates.

Meyer, H. W., 1986, An evaluation of the methods for estimating paleoaltitudes using Tertiary floras from the Rio Grand rift vicinity, New Mexico and Colorado [Ph.D. thesis]: Berkeley, University of California, 217 pp.

Meyer, H. W., 1992, Lapse rates and other variables applied to estimating paleoaltitudes from fossil floras: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 99, pp. 71-99.

Smith, A. G., A.M. Hurley, and J.C. Briden, 1981, Phanerozoic paleocontinental world maps: Cambridge, Cambridge University Press, 102 pp.

Wolfe, J. A., 1968, Paleogene biostratigraphy of nonmarine rocks in King County, Washington: U. S. Geological Survey Professional Paper, v. 571, 33 pp.

Wolfe, J. A., 1978, A paleobotanical interpretation of Tertiary climates in the northern hemisphere: American Scientist, v. 66, pp. 694-703.

Wolfe, J. A., 1979, Temperature parameters of humid to mesic forests of eastern Asia and relation to forests [of] other regions of the northern hemisphere and Australasia: U. S. Geological Survey Professional Paper,

v. 1106, 37 pp.
Wolfe, J. A., 1981, A chronologic framework for Cenozoic megafossil floras of northwestern North America and its relation to marine geochronology: Geological Society of America Special Paper, v. 184, pp. 39-47.
Wolfe, J. A., 1992a, An analysis of present-day terrestrial lapse rates in the western conterminous United States and their significance to paleoaltitudinal estimates: U. S. Geological Survey Bulletin, v. 1964, 35 pp.
Wolfe, J. A., 1992b, Climatic, floristic, and vegetational changes near the Eocene/Oligocene boundary in North America, in Prothero, D. R., and Berggren, W. A., eds., Eocene-Oligocene climatic and biotic evolution: Princeton, Princeton University Press, pp. 421-436.
Wolfe, J. A., 1994, Tertiary climatic changes at middle latitudes of western North America: Palaeogeography, Palaeoclimatology, Palaeoecology, (in press).

Figure 1. Temperature climagraph illustrating the calculation of paleoelevation for the Florissant flora using inferred paleotemperatures, latitudinal corrections, and known patterns of modern temperature variability (Meyer, 1992) between coastal and interior locations (points 2 to 3) and with elevational change (points 3 to 4). The thermal gradient shown between points 2 and 3 assumes that the late Eocene gradient was about half that of modern conditions. Projected sea level temperature (point 3) is essentially a correction factor for the effects of continentality and elevated base level (Meyer, 1992). The difference in MAT (14°C between points 3 and 4) is multiplied by the reciprocal of the inferred lapse rate (150 m/-1°C), deriving a value of 2100 meters. Adding 200 meters for calibration to modern sea level (based on Haq et al., 1987) results in an estimated paleoelevation of 2300 meters.

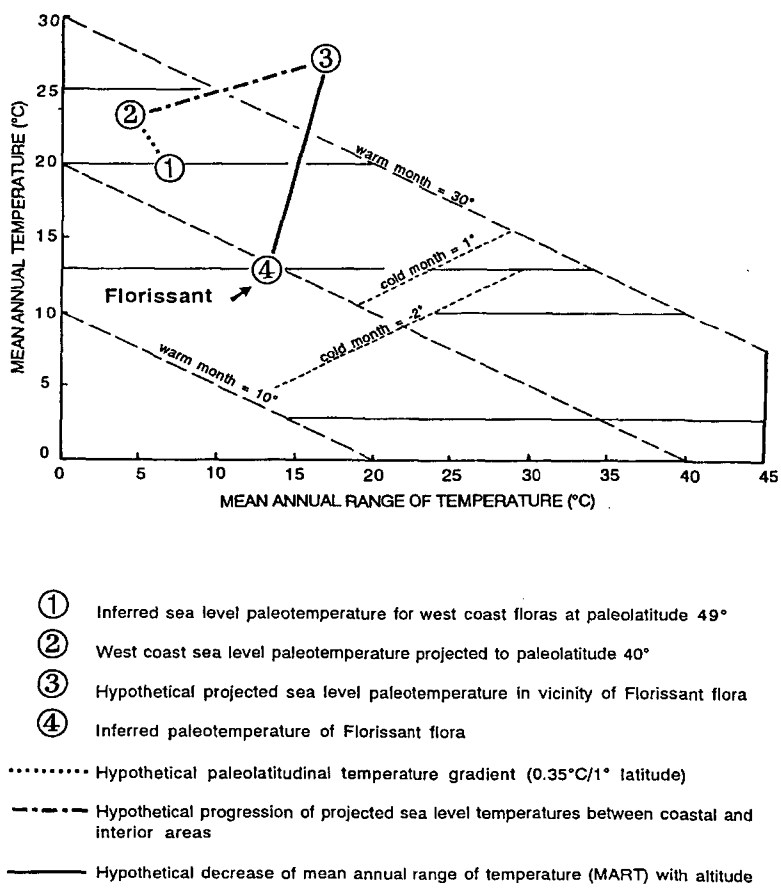

FIGURE 1

Dinosaur Ridge: Preserving and Enhancing the Paleontological Heritage of Denver's Backyard

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Dinosaur Ridge is the newly adopted name for a 4 mile section of the Dakota hogback north of Morrison, Colorado. It was the site of one of the first (1877) major dinosaur discoveries in the western U.S. (type locality for *Apatosaurus*, *Stegosaurus*, *Diplodocus*, and *Allosaurus*), and more recently has been the subject of research on its Cretaceous dinosaur trackways. The Friends of Dinosaur Ridge, founded in 1989, exists to enhance the educational potential of Dinosaur Ridge, and to make the Denver public more aware of its nearby paleontological heritage. It strives to protect and preserve the still visible bones and trackways, to support paleontological, historical, and archaeological research, and to establish permanent visitor and interpretive facilities.

The Friends led tours for more than 15,000 visitors during 1993, and an equal number are estimated to have toured the site on their own. The location of the Ridge on a public highway just outside Denver makes it an attractive site for large numbers of visitors, including school classes. At the same time, busy road traffic and narrow shoulders make visitation inconvenient and potentially hazardous. The roadside outcrops containing dinosaur fossils are State Highway property, and most of the rest of the ridge is Jefferson County Open Space land.

The history and accomplishments of the Friends are a story of hard volunteer effort and extensive cooperation between government agencies, nonprofit institutions, and private corporations. In the spring of 1994, Jeffco Open Space purchased the 1½ acre Wagner Ranch property, including a house and barn, for use as a visitor center for Dinosaur Ridge. The center will be run by the Friends of Dinosaur Ridge in cooperation with the Town of Morrison and the City of Lakewood, under the supervision of a consortium representing four other public museums (Colorado School of Mines, Morrison Natural History Museum, Lakewood's Historic Belmar Village, and Jefferson County Nature Center). Preparation of exhibits and upkeep of the buildings will be the responsibility of the Friends, through fees collected by guiding field trips, merchandise sales, and solicitation of government or private grants.

Other activities in progress at the Ridge include:

- Excavations to expose new trackways (with the University of Colorado, Denver).
- A survey of archaeological resources (with the State Historical Society).
- Preparation of Stegosaur bones, collected here in 1877, and now on loan from the Yale-Peabody Museum to the Morrison Natural History Museum and Colorado School of Mines.
- Classes for teachers (taught through Colorado School of Mines).
- Scientific and Cultural Facilities District grants ($25,000 in 1994) to fund buses for school class visits.

A series of 17 permanent interpretive signs was installed along Alameda Parkway in 1992. " A Field Guide to Dinosaur Ridge," by Martin Lockley, was published in 1990, followed by "Fossil Footprints of the Dinosaur Ridge Area" in 1994; other publications and numerous other projects are in preparation, including ramps and walkways for access to the fossil sites, a self-guided audio tape tour, and more. The unique resource of Dinosaur Ridge affords both the opportunity and the challenge to develop an outstanding outdoor classroom for use by residents of the metropolitan area.

Geoteach: A Hands-on Geological Education Experience for Teachers

Peter J. Modreski, Geologist, and Marilyn E. Tennyson, Geologist, U.S. Geological Survey, Denver Federal Center, Box 25046, MS 905/940
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Geoteach is a five day course designed to give secondary school science teachers a first hand knowledge of Colorado geology, and ideas about how and where to lead a geologic field trip for a school class. It is offered as a 2 credit graduate recertification class through the Colorado School of Mines Office of Continuing Education.

Geoteach is taught by geologists from the US Geological Survey, in combination with one or more teacher/facilitators and guest leaders. The course outline and field guidebook were prepared in 1991 with funding from the Excellence in Education Initiative of the US Department of Interior. Two science teachers from Adams County Schools, Joe Beydler and Wayne Pound, worked with USGS mentors Pete Modreski and Lynn Tennyson to prepare the first version of the guidebook. The course was given in 1991, 1992, and 1993 to a total of about 120 teachers. It is not being offered in 1994, but is planned again for 1995. The field guidebook/class notebook is being reworked into an educational field guide in a form that will be generally usable by anyone, whether or not they have taken the Geoteach course.

The trip route begins at the Denver Federal Center and leads from Lakewood through Central City and Idaho Springs to Leadville, down the Arkansas Valley to Cañon City, and back to Denver via Florissant and Colorado Springs. Side trips include sites in Morrison, Golden, Boulder, Trout Creek Pass, and Garden Park. A wide range of themes is covered:

- Geologic principles.
- The geologic history of Colorado.
- Mineral resources and mining.
- Geologic hazards.
- Water pollution and the environment.
- Paleontology (including visits to Dinosaur Ridge, Garden Park, and Florissant Fossil Beds National Monument).
- Preservation, protection, and utilization of natural history resources.
- How to make connections with other sources of earth science educational information.

The emphasis of the class is hands on, experiential learning; observing, touching, testing, collecting samples for class use, and posing and answering questions. Questions and answers, and suggested activities which can be done in the field or later in a class, are integrated into the guidebook. A set of some 150 class activity ideas, prepared by teachers who have taken Geoteach in the past, has been collected and is made available to teachers who take the course. These activity plans and the Geoteach field guidebook are available to any teacher through the "GEO" (Geoscience Education Outreach) Center at the USGS Library (303 236-1015), Denver Federal Center, Lakewood, CO.

Plans for the Dinosaur Discovery Center.

Pat Monaco and Donna Engard, Garden Park Paleontology Society, Route 1 Box 9A, Wetmore, CO 81253

The date is August 14, 1992 and the setting is the Garden Park Fossil Area (GPFA). The mining company of Colorado Quarries is working feverishly to complete the welding of a frame that had been constructed under the 13,000 pound *Stegosaurus* skeleton. The Denver Museum of Natural History field crews are busy doing last minute preparations and the advance army crew from Ft. Carson is surveying the situation for their first ever dinosaur airlift with a Chinook helicopter. Local citizens have gathered on the horizon and positioned themselves to see an unequalled event. It was not surprising that news people from every major newspaper, TV and radio station in Colorado were there, which resulted in international press coverage!

That August day, a world class *Stegosaurus* skeleton was successfully lifted out of the narrow canyon where it had waited for 150 million years to be discovered, and placed onto a waiting flat bed truck. The local community, the Garden Park Paleontology Society (GPPS), and the Bureau of Land Management (BLM) provided coordination and assistance at every turn.

Later, mail was received from around the world expressing excitement and wanting to learn more. The local community was sparked with excitement and this spark remains as intense today as it was in 1992.

This year (1994) the Garden Park Paleontology Society will open its doors to the public in downtown Canon City. The Dinosaur Depot at the River Station will be the first time that Canon City has had the opportunity to share its wealth of fossil resources with the American public and will be a major step in realizing the dream of the Dinosaur Discovery Center.

Last year Governor Roy Romer stated, "The Garden Park Fossil Area offers a unique site to celebrate our nation's paleontologic resources. With hard work and broad participation, The Dinosaur Discovery Center can become an important center for education and enjoyment. I encourage all interested Americans to join me in support of this dream."

Significance of the Garden Park Fossil Area (GPFA)

In 1989, Dr. Richard Stucky, Curator of Paleontology at the Denver Museum of Natural History stated, "The Garden Park Dinosaur localities are among the most important sites in the world. The area was one of three sites to be discovered in Western North America in 1877 that provided paleontologists with the first knowledge of the giant sauropod dinosaurs, some of the carnivorous dinosaurs and the stegosaurus of the Jurassic: their existence was virtually unknown prior to the discoveries at Garden Park. More type or original specimens of these dinosaurs are known from Garden Park than from any other site in North America."

The following are statements of significance pertaining to the Garden Park Fossil Area:

- Many of the best examples of Jurassic dinosaurs in the world come from the GPFA, with many specimens on display in our nation's most prestigious museums.
- The GPFA provides unique specimens of many species, and current surveys show enormous potential for new discoveries that can provide insights into the history of life on earth.
- The GPFA represents one of the world's most important late Jurassic locations, where millions of years of continuous fossil records showing evolutionary change and diversity of plants and animals during the Jurassic period are present.
- The historic dinosaur discoveries in the GPFA triggered intense international interest in paleontology. This interest has never let up.
- The GPFA is the site of historic excavations by two rival and world renowned scientists. Their competition for the best specimens later became known as the "Great Dinosaur Race", and

is a colorful and important component of our national heritage.

- The GPFA is located within a region of complex geologic formations and has a fascinating geologic history. It is complemented by the Florissant Fossil Beds National Monument, the Picketwire Dinosaur Trackway, the Indian Springs Trace Fossil Area, and the Denver Museum of Natural History.

In 1989, Dr. Emmett Evanoff stated, "The Garden Park Fossil Area is unique not only for its abundant dinosaur remains but also for its historical significance concerning the early days of vertebrate paleontology in the United States. No where else in Colorado, and few places in North America, does one area have so much importance both paleontologically and historically."

The Garden Park Fossil Area National Visitor Center

The discussion of a visitor or discovery center has occurred off and on, but officially began in 1990 when the GPPS submitted a preliminary site plan to the BLM. Initially the facility was termed a visitor center but as we looked at it more intensely, we learned that it was anything but a visitor center and later the title changed to **the Dinosaur Discovery Center**.

To assess the initial proposal, four alternative site locations, four alternative facility sizes, and three alternative access routes were analyzed. A community based planning team was formed to guide this assessment and participated in various aspects of the plan. Additionally, alternative sets of objectives were looked at to fully flesh out the proposal.

Following completion of the proposal document, the Environmental Assessment (EA) confirmed that the original GPPS submission was on the right track and worthy of further work. Because of the excellent choice of site location and access route, the EA concluded that the facility could be built with only minimal impacts and, in fact, would result in a lot of positive environmental benefits.

The BLM, in partnership with the GPPS, went the next step in 1992 and developed a project plan based on the preferred alternative. This document again involved a wide variety of members of the community in addition to GPPS volunteers and BLM staff. The purpose of this document was to fully document the significance of the resources, identify goals and objectives, describe the interpretive themes, and provide an initial description of what the facility would look like.

Within that document, the following facility goals were identified:

- To manage, interpret, and preserve the internationally significant Garden Park Fossil Area.
- To foster public awareness, appreciation, and interest in geological, paleontological, and other natural resources.
- To improve understanding of multiple use management of public lands, instill a land use ethic, and promote wise use of natural resources.
- To instill community and regional pride and a sense of ownership in the GPFA.
- To encourage scientific excavation and research for the benefit of the public.
- To foster economic development and tourism.

The Dinosaur Discovery Center

The project plan itself did a good job of describing in words what the project was all about, but we only had a vague idea of what the actual facility would look like. Because of the size and complexity of the proposal, the organization decided to hire a professional architectural firm to prepare a preliminary design package so that the words could be put into pictures and shared with the public.

In order to pay for this package we needed to find a quality architectural firm to do the work, and obtain funding to pay for it. Our best estimates were that these types of packages ordinarily cost about $250,000 but, because of the significant amount of work that had already been done, we felt we could get it done for less.

We established **a goal of $100,000** that we wanted to raise in a one month local fund raising drive. A committee was formed and we were told more than once that it was impossible in a small and conservative community to raise that kind of money, particularly for a design package that would be prepared by a firm outside the community. We didn't let that discourage us. In June of 1993, the citizens of Canon City raised over $120,000 in a local fund raising effort.

Simultaneously while the fund raising effort was going on, a second committee was going through proposals trying to determine which architectural firm was going to prepare the package. Six excellent architectural firms were interviewed.

Topping out the list was the design firm of Anderson Mason Dale of Denver which was in the process of designing the Tropical Discovery Exhibit at the Denver Zoo. In addition to other factors, their teamwork and enthusiasm were felt to be outstanding. Once the firm had been selected and the money put in the bank, Anderson Mason Dale went to work.

The goals developed for the design of the Dinosaur Discovery Center are as follows:

- To develop a world class paleontological research center.
- To provide a unique and stimulating educational experience which will draw visitors from many locations.
- To take advantage of the natural site and environmental characteristics, the building should be designed to complement the site and have minimal impacts.
- To develop a building which can become a model for sustainable development and has long range positive cost implications.
- To reinforce the sense of "discovery."
- To design a totally accessible facility.
- To design a building which can adapt to change and can be easily expanded.

The project was completed in October of 1993 with a full narrative, 22 artist renderings, and a scale model.

The Garden Park Paleontology Society will present this package at the Partners in Paleontology Conference and encourage you to look for yourself and determine if you think the goals were met.

Summary of the Proposal

The Garden Park Fossil Area is well recognized as an internationally important site for paleontological resources and heritage. The educational and recreational programs proposed for the Discovery Center are consistent with a variety of national laws, programs, and strategies.

The Dinosaur Discovery Center will be a beehive of activity and educational programs, yet it will be only one part of a regional geological educational package featuring major educational opportunities not only at the Dinosaur Discovery Center, but in the Picketwire Dinosaur Trackway, Indian Springs Trace Fossil Area, and Florissant Fossil Beds National Monument.

The facility is planned to serve as a **model of sustainable design concepts** using minimal energy and environmental disturbance both in its construction and in its long term operations. It will provide a unique, hands on facility that provides learning opportunities by doing rather than by looking!

The facility would provide a unique combination of benefits in a cost effective manner, minimizing the need for exclusive long term federal expenditures.

The first major on-the-ground step in the realization of the Dinosaur Discovery Center in the Garden Park Fossil Area will be the opening of the Dinosaur Depot at the River Station. The Dinosaur Depot will be the first opportunity the city of Canon City has had to share its wealth of fossil resources with the rest of the world. Once the Dinosaur Discovery Center is built, the Dinosaur Depot will continue to serve as an introduction to the larger facility and will be an ongoing and important component of the overall master plan.

Managing the Garden Park Fossil Area Using Partnerships

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The purpose of this paper is to provide a look at how things sometimes really work, not just the things that we want to talk about. Although partnerships are the buzz word, a wide variety of formal and informal partnerships have already been operating in the Garden Park Fossil Area (GPFA) for over a hundred years. Along the way we have discovered that what we hope to accomplish, and what we are actually able to accomplish, are two different things, considering the constraints we sometimes place on ourselves.

This program will describe some of these real life situations that are designed to help both partners improve the way they do business and, maybe, use these ideas to improve the way we do business on a wide scale.

Background of the Fossil Area

The GPFA is one of our country's premier locations for the discovery of upper Jurassic dinosaur fossils. The discoveries occurred in 1876, followed by 10 years of initial excavations. In those early years of dinosaur exploration, known as the Great Dinosaur Race, the Garden Park Fossil Area, Dinosaur Ridge west of Denver, and Como Bluffs, Wyoming, were the three principal locations where Professors Cope and Marsh sponsored skeletal excavations. Much of the Marsh excavation materials from Garden Park ended up in the Smithsonian, while the Cope materials eventually arrived at the American Museum of Natural History. Excavations in the Garden Park Fossil Area have continued until today, resulting in an interesting and colorful history.

The Garden Park Fossil Area was first formally recognized for its significance in 1953 when the local community erected a commemorative plaque near the Marsh Quarry. In 1972 the GPFA was recognized as a National Natural Landmark by the National Park Service (NPS). In the mid 1980s, an organized group of scientists studied various geologic features on public lands around the state of Colorado and recommended that the Bureau of Land Management (BLM) develop a plan to manage the GPFA and that it be used for research and educational purposes. This plan was completed in 1988 and has been used as a spring board to pursue many of the activities that have occurred since that time. For example, in 1990 the GPFA was recognized as a Research Natural Area by both the BLM and the state of Colorado.

The Garden Park Paleontology Society (GPPS)

Although the local community has maintained a strong interest in the GPFA, it did not possess an organization to pursue educational and research goals until 1990 when the Garden Park Paleontology Society was formed. The GPPS is a 501(C)(3) nonprofit corporation recognized both by the state and federal government. The GPPS now includes about 500 members and has received two national awards and one state award for outstanding volunteer service, primarily for public education, resource care, and assistance with scientific research. The GPPS is currently an all volunteer organization but has begun discussions about hiring paid staff to further the goals of the organization. The GPPS will have a permanent operating location in the River Station Visitor Center, and is openly pursuing the development of the Dinosaur Discovery Center, which would be designed to carry forward the goals of public education, stewardship and scientific research to a much larger public.

The Bureau of Land Management

The BLM has taken many steps towards implementing partnerships and encouraging volunteerism. These steps are documented in countless reports and position papers. Some of this information will be covered in other papers presented at this conference. It is a relatively safe statement to say that, in general, the BLM will support quality volunteer projects and that the agency will work towards developing partnerships. The BLM is actively involved in restructuring its organization to reflect new ideas in managing resources and in working with others in implementing these ideas.

The BLM and GPPS Relationship
The BLM and the GPPS have developed a working partnership to further their respective goals in public education, stewardship, and research. The goals and objectives developed in the BLM management plan are very similar to the goals and objectives listed in the bylaws of the GPPS. This similarity in view points has allowed the two organizations to formalize their partnership with both a volunteer guidebook developed specifically for the GPPS organization and a cooperative agreement developed between the two organizations. These documents lay out a foundation for cooperation and provide an example for structuring other partnerships.

Recent GPFA Partnerships
There are other partnerships which focus on managing the GPFA.

In 1993, the BLM and the NPS completed a Memorandum of Understanding that defined roles and responsibilities of each agency in regards to the regional paleontology resources with emphasis on the Florissant Fossil Beds National Monument and the Garden Park Fossil Area.

The GPPS has initiated discussions to involve regional tourism partners in providing quality visitor services at the River Station Visitor Center.

The BLM and the US Forest Service (USFS) have put together an informal partnership revolving around the fossil resources in the Picketwire Canyon Lands and Garden Park. The relationship between the USFS and the BLM is growing rapidly and numerous specific examples could be provided.

The GPPS and the BLM have developed educational partnerships involving the local school districts.

The GPPS, BLM, and the Denver Museum of Natural History have had informal relationships for several years.

The GPPS and the Rocky Mountain Nature Association are discussing a potential partnership revolving around the sales outlet at the River Station Visitor Center.

The GPPS has established strong relationships and "partnerships" with a wide variety of organizations in the scientific community, museum field, and the nonprofit community.

The BLM and the state of Colorado, through the Natural Areas Program, have established a formal partnership focused on the GPFA.

Historic GPFA Partnerships
A wide variety of partnerships have existed for over a hundred years that have been focused on fossil excavations in the Garden Park Fossil Area. Some of these include:

- Early partnerships and relationships between fossil excavators and the scientists that sponsored the excavations.
- Partnerships between the community and fossil excavators.
- Early partnerships between excavators and their rivals.

Dinosaurs as Tools for the Investigation of Science

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From preschool to college, students enjoy learning about dinosaurs because of their mystery, their uniqueness, and often, their sheer size. Announcing to students that, "we are going to learn about dinosaurs" will usually elicit an enthusiastic response. A similar announcement about learning science is generally less well received. Since their extinction more than 60 million years ago, dinosaurs have never been regarded more fondly than they are today. They appear as cookies, cake icing designs, gummy candies and breakfast cereals, and on student lunch boxes, rental trucks, postage stamps and T-shirts; they even have a weekly, prime time television series.

Younger students already know about dinosaurs. They know the sizes, they know the names, they know the spelling of the names, they know the carnivores, and they know the herbivores. They can probably name as many dinosaurs on sight as they can animals in a zoo. What the students don't know is **how** we know about dinosaurs. Zoo animals can be observed in a zoo. What they look like, how tall they are, what they eat, what sounds they make, how they move, whether they live alone or in groups are all readily available from even a casual visit. With dinosaurs, no such observations are possible. None of the animals we call dinosaurs has ever been seen by a human being, yet we believe we know what they looked like, what they ate and how they moved. Everything we know (or think we know) about dinosaurs has been determined by application of the processes of discovery, analysis, synthesis, and testing of theories.

I have chosen dinosaurs as a vehicle for explaining science to children because their discoveries have rarely followed a slow, step-like progression so often associated with scientific investigation. The history of our knowledge of dinosaurs is a detective story, full of plots and subplots Arthur Conan Doyle or Robert Parker would be proud of; tantalizing clues, mysterious footprints, fragmentary evidence and surprise discoveries. The scientist/detectives were, and still are, intensely excitable people who thrilled to the hunt for knowledge, became both rivals and friends, concocted imaginative explanations for their discoveries, made mistakes, and corrected them.

Science involves more than memorization of exotic animal names and statistics. The examination of dinosaurs allows students to exercise the methodology of science, extrapolating from the known to the unknown. Being wrong is as much a part of the process as finding the correct solution to a problem. Unfortunately, being wrong is generally anathema to students. Systematic and repetitive testing has taught students that being correct is all that counts. In science, they must be taught the discovery process is sacred and 'rightness' or 'wrongness' are merely parts of the process.

A History of the Relationship Established by the Memorandum of Understanding between the Western Interior Paleontological Society and the Bureau of Land Management/Colorado

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In June 1992 the Western Interior Paleontological Society (WIPS) and the Bureau of Land Management/Colorado (BLM/CO) entered into a Memorandum of Understanding (MOU) to explore the practical methods of cooperation that could be mutually beneficial. Since then, three projects have been completed or are currently on-going. These projects illustrate some practical experience and learning on the part of both organizations.

A brief history of WIPS will clarify how WIPS and the BLM came to a working understanding with the MOU. WIPS was founded as a nonprofit corporation in 1985. The Statement of Purpose dedicates WIPS to all aspects of scientific paleontology, with a special interest in education. WIPS members now number over 200 and have a primary interest in field work. Currently, WIPS has a personnel base to draw from which include at least 8 Ph.D's in Earth Sciences or Biology with an equal number of other advanced degrees in the Earth Science fields. At least 25 WIPS members are also members of The Society of Vertebrate Paleontology, including a vice president-elect. WIPS conducts approximately 4 classes and about 10 field trips per year. WIPS also has 7 lectures per year, delivered by noted members of the paleontological community. All WIPS activities are conducted under the jurisdiction of an oversight committee called the Science Committee.

The Board of Directors of WIPS created the Science Committee to insure that all WIPS classes and field work be of the highest professional standards. The Science Committee must qualify all instructors and principal investigators of field work and insure that scientific ethics are maintained in both the classroom and in the field. With the Science Committee and the talents of its membership, WIPS was able to enter into a MOU with the BLM allowing for permitted WIPS projects with WIPS members acting in a paraprofessional capacity.

Two successful ongoing projects
First is a study of insect fauna from the Green River Formation. This project has been in progress for two field seasons. The data being gathered is both taxonomic and statistical. It is hoped that it will lead to a more refined understanding of the paleoecology of the Green River Formation.

The second project involves the Chinle Formation of southwestern Colorado. While this project is still in its infancy, it has identified a first occurrence in the state of Colorado, a Temnospondyla amphibian species. Other specimens have been identified that may allow a tentative dating of this part of the Chinle Formation to Norian-Rhaetian age. This was reported at the Western Area Vertebrate Paleontological Conference at the Denver Museum of Natural History in April 1994.

Another project which has been completed is of a more problematical nature. At the BLM's request, WIPS did a study of paleontological resources on lands involved in an exchange between the public and private sectors. While this project was conducted with the highest professionalism, it is believed that this might not represent an appropriate venue for WIPS/BLM interaction. The Board of Directors of WIPS has discussed this project and the possibility of others like it. WIPS feels that legally sensitive and time restrictive projects might be beyond the current scope of an amateur organization. It would be better if these projects were handled by professional organizations with the dedicated (costly) resources that these projects require.

To date the MOU has accomplished the following:

- The scientific understanding of project areas is increasing.
- Recovery and curation of important scientific specimens from BLM lands has been increased.
- Education of individuals has been enhanced by WIPS/BLM cooperation.
- Members of the public with an interest in paleontology are enjoying these resources on BLM land in an ethical and scientific manner.
- There will be a rich future to be built on this solid foundation.

Significance of Plant Microfossils from Ancient Lake Florissant, Florissant Fossil Beds National Monument, Colorado

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Lake beds and associated sedimentary deposits of volcanic origin preserved at Florissant Fossil Beds National Monument are world famous for their fossils, especially huge petrified tree stumps, leaves, and insects. Few people know that the fossil flora of the Monument also includes microscopic pollen grains, spores, and algal cysts. In addition to the better known wood, leaves, and other plant megafossils, the plant microfossils represent the vegetation in and around the ancient lake. They provide unique insights into the geologic history of the region and the development of the Rocky Mountain flora.

The Florissant lake beds and associated rocks occupy an ancient stream valley near the town of Florissant in central Colorado, west of Colorado Springs. The valley was carved into the same mass of Precambrian Pikes Peak Granite that forms Pikes Peak to the east. The valley and the deposits that filled it were formed in latest Eocene time. At this time the region to the south and west of this area was occupied by several active volcanic fields. One of these was the Thirtynine Mile volcanic field. About 36 million years ago this area underwent a series of eruptive events. Eruptions ranged from massive pyroclastic debris flows that blanketed the landscape and those that deposited thick beds of air-fall tuff to smaller, periodic rains of volcanic ash and pumice. One of the larger flows blocked the southern end of the stream valley in the area where the fossil beds now exist. A lake formed behind the natural dam; ancient Lake Florissant. Mudflows caused by recurring volcanic activity flowed into the valley as the lake level rose. The lake itself gradually filled with clay and silt, as well as volcanic ash that periodically fell from the sky as eruptions persisted in the Thirtynine Mile field. Intermittent larger eruptive events resulted in deposition of more pyroclastic debris flows such as the unit locally known as the "caprock," which lies above the main interval of lake beds. The lake endured for some time, and ash and pumice continued to rain into it. Eventually, however, it was completely filled and finally covered by volcanic deposits.

Despite the ongoing eruptions, debris flows, and rains of volcanic ash, during the time that Lake Florissant existed, its valley and the surrounding hills were covered with vegetation. There were conifers including huge sequoia trees in the valley and ancient pines on nearby slopes. Several kinds of hardwood trees also grew on the nearby slopes. Many kinds of smaller plants grew in the area as well. Along the lake shore and in the lake itself, aquatic plants thrived. Fish swam in the lake, exotic mammals roamed through the forest, and a myriad of insects flew about. Many of these plants and animals ultimately were preserved in sediment that accumulated in the lake, especially in the layers of shale that formed from clay and volcanic ash. The gentle settling of these fine sediments into the water provided an exceptionally good medium for preserving the delicate structure of leaves and insects.

Plant microfossils also were becoming part of this rich legacy of ancient life. Pollen grains and spores, which were produced in prodigious numbers by the wide variety of plants in the area, were washed into the lake and buried, along with microscopic cysts of algae that lived in the lake itself. The lake deposits and the fossils they contain lay buried for 34 million years. They are now protected in large part within Florissant Fossil Beds National Monument (figure 1). Geologic and paleontologic studies of these rocks and fossils provide glimpses into the fascinating history of the region.

Several years ago, we collected samples of the Florissant Lake Beds in collaboration with National Park Service geologist Ralph Root, who was conducting stratigraphic studies associated with plans for construction of a new Visitor Center at the monument. The samples were collected from two trenches excavated at sites within the monument that fully exposed the main interval of lake beds (figure 1). We also collected samples from other lake beds recently discovered stratigraphically above the caprock (figure 1). These samples were collected in collaboration with

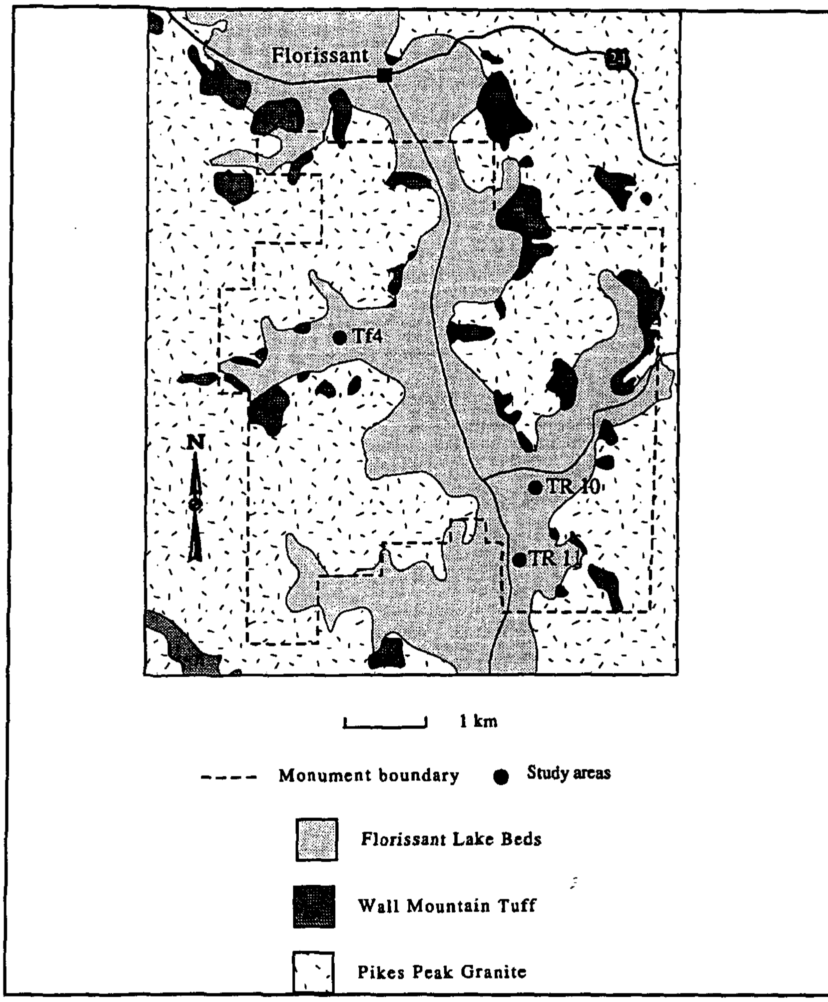

Figure 1. Generalized geologic map of Florissant Fossil Beds National Monument. Study areas are trenches TR 10 and TR 11 (the main interval of lake beds) and Tf4 (lake beds above the caprock).

University of Colorado geologist Emmett Evanoff, who has just completed new mapping and geologic studies within the Monument. Samples were processed according to standard procedures used in palynology (the study of plant microfossils), and the specimens of pollen, spores, and algal cysts were prepared for analysis under the microscope.

Palynologic analyses revealed the presence of about 130 species. Their botanical affinities have been ascertained as closely as possible, and their abundances within each sample have been determined. Assemblages from most samples are numerically dominated by pollen of the pine family (Pinaceae) and bald-cypress family (Taxodiaceae, which includes sequoia). Pollen from flowering plants is diverse, encompassing about 100 species, although specimens of many species are rare. The numerically most abundant flowering plant pollen species belong to the elm family (Ulmaceae), the walnut family (Juglandaceae), and the beech family (Fagaceae). All of these kinds of pollen likely were produced by trees living on hills and slopes near the lake. Lake and lake-margin plant communities are represented by pollen of the water lily family (Nymphaeaceae) and the cattail family (Typhaceae), and others (Pandanaceae). Drier habitats in the vicinity are indicated by pollen of the jointfir (Ephedraceae) and either the goosefoot family (Chenopodiaceae) or pigweed family (Amaranthaceae). Spores of several families of ferns are present, indicating that moist conditions also prevailed among the mosaic of environments that existed in the region. The varied environments evidently were inhabited by several plant communities during latest Eocene time.

Most of the plant families present in the Monument area are well known in the fossil record of Colorado and the Rocky Mountain region in general. They present a picture of a regional vegetation rather different from that of today, but one not unexpected for the time. However, some pollen records from Florissant indicate that a few flowering plant families had evolved earlier than was previously known. The Florissant fossil beds are especially important because the associated volcanic rocks are so well dated geologically. Their radiometric ages bracket the moment in time at which the new plant families appeared. Thus pollen from the Florissant fossil beds documents the stratigraphically oldest known records of the sunflower family (Asteraceae), the mallow family (Malvaceae), and the phlox family (Polemoniaceae). This information contributes to knowledge of the evolution of the modern flora of the Rocky Mountain region, and is also useful to palynologists for determining the geologic age of other pollen bearing deposits in western North America.

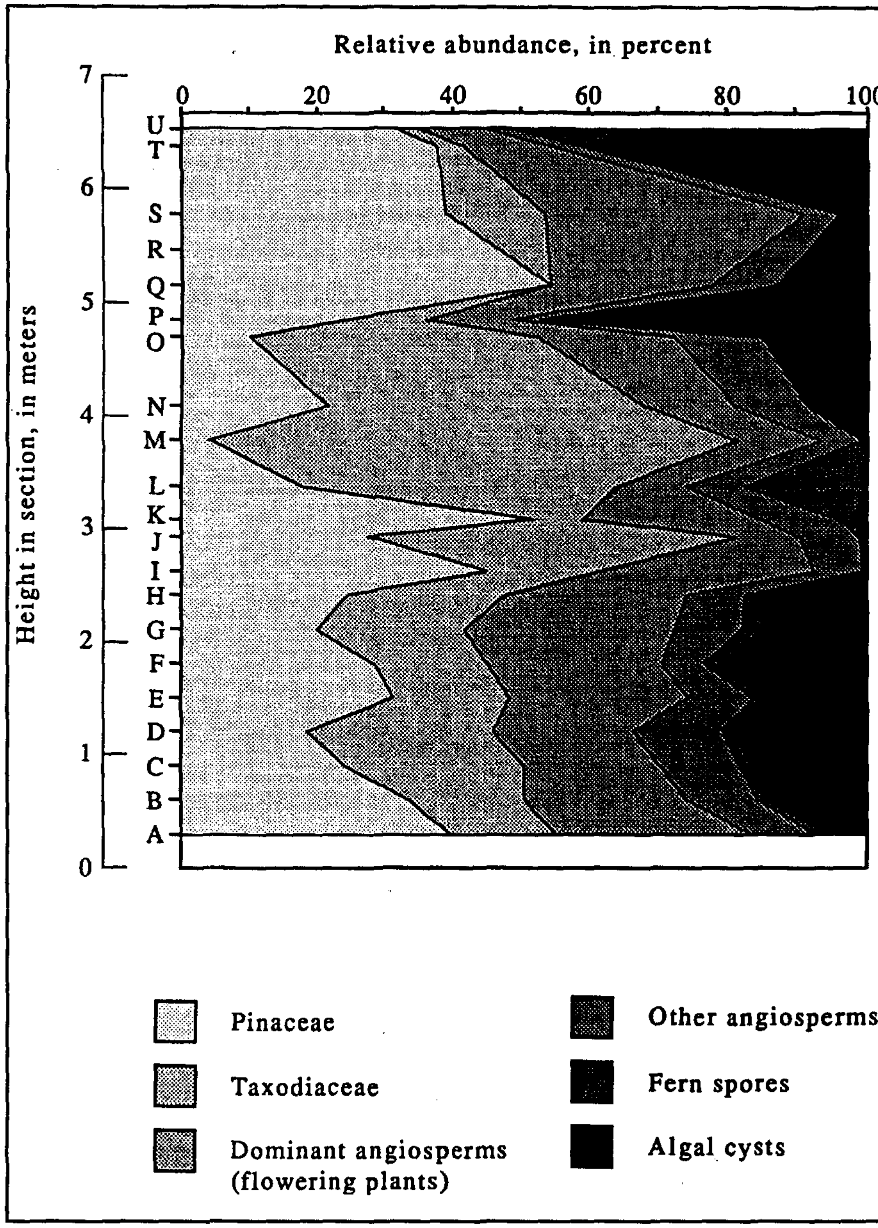

Figure 2. Percentage relative abundances of plant microfossils in samples from trench TR 10. Sample positions are indicated by lettered tic marks. A major turnover in relative abundances between samples K and P correlates with a major eruptive event.

Percentage abundance data on pollen, spores, and algal cysts from the main lake beds (figure 2) can be used to reconstruct some of the history of the lake and the vegetation of the Florissant area. The fossil sequoias are the best known part of the flora, but the pollen record indicates that during most of the time represented by the lake beds, fossil pines dominated the landscape. Among hardwood trees, fossil elms persisted in great numbers throughout this time, and fossil species of the walnut and beech families varied in abundance but were always prominent. The relative abundance of algae fluctuated during the lake's history. We interpret this to be the result of changing water chemistry in response to influxes of volcanic ash, or perhaps to changing water depth (however, we concur with Evanoff that the lake always had much the same size and shape indicated by the present outcrop pattern). There is no evidence that minor ash falls on the surrounding landscape affected the conifers or flowering plants. However, about midway through the section, there is a strong turnover in relative abundances of pollen, spores, and algal cysts. In this interval, the two dominant kinds of conifer pollen reverse in abundance, algal cysts are greatly reduced in number, and fern spores reach their peak abundance within the section. This interval correlates with stratigraphic evidence of the beginning of a major eruptive event (represented by an unusual influx of pumice in the lake) that culminated with deposition of a pyroclastic conglomerate. We conclude that, although the frequent minor ash falls had little or no effect, major eruptive events did have a disruptive effect on the plant communities in and surrounding the lake.

The fossil pollen and spores can be related to the leaves and other plant megafossils from the Florissant beds. However, the correspondence between the microfossil and megafossil components of the flora is not as close as might be expected. Certainly the same plant communities that were producing pollen and spores were producing leaves that could be fossilized as well. Nonetheless, lists of species and even families based on the different kinds of fossils show differences in composition. One reason is fossilization potential. Many species produce millions of fossilizable pollen grains from a single plant each season, yet their leaves may be too thin to be similarly preserved. Alternatively, many plants have robust and easily fossilized leaves, but they may produce pollen grains that are thin and not easily preserved, or they produce pollen only in low numbers. For example, plants pollinated by insects tend to produce low numbers of pollen grains (which can be efficiently carried to other flowers by insects) in contrast to wind pollinated plants (which produce vastly greater numbers released into the air). Such variations in productivity and fossilization potential result in great contrasts in relative numbers of kinds of plant fossils. Fortunately, the palynological and paleobotanical records complement one another. Combining palynological with paleobotanical studies of ancient floras like that at Florissant gives a more complete picture of the nature of the total flora than would the study of one kind of fossil alone. Integrated studies of fossil pollen, spores, leaves, cones, and flowers can reveal much about the botanical affinities, geologic history, and evolution of ancient plants.

In somewhat parallel fashion, integrated research investigations in which Federal agencies cooperate to develop data and interpretations can contribute much to public understanding and appreciation of the paleontological heritage protected on public lands. This study is an example. Plant microfossils themselves may not be a resource requiring protection, but their scientific significance enhances interpretations of the better known fossils at Florissant Fossil Beds National Monument.

Rocky Mountain Paleontological Tourism Initiative

Robert M. O'Halloran, Associate Professor, Andrea Nyquist, Lucy Osius, Jennifer Wheatley, Eric Frolich, and Diego San Ramon, School of Hotel, Restaurant and Tourism Management, University of Denver, Denver, CO 80208

The Rocky Mountains and the surrounding regions are said to contain some of the world's largest known deposits of rare and unique dinosaur fossils (Walsh and McKean, 1994). This study focuses on a Regional Paleontological Initiative, including Colorado, South Dakota, Nebraska and Wyoming. The key issue in this project is the preservation of natural heritage resources while providing public access. The Picketwire Canyon, part of the Comanche National Grasslands managed by the United States Forest Service, is central to this project and the least developed and one of the more remote sites included in the initiative. Two other sites, Florissant Fossil Beds National Monument, a National Park Service site near Florissant, Colorado, and the Garden Park Dinosaur Discovery Center, a Bureau of Land Management site near Canon City, Colorado, were also reviewed.

In determining how to allow access to valuable and scientifically significant heritage resources and still control development, a set of objectives were developed. The objectives of the study were to:

- Assess the resource for potential development keeping in mind the need for preservation and conservation of the resource;
- Assess the generalizability of conclusions for natural heritage sites in the region;
- Make development recommendations that can be applied to other paleontological sites.

The Rocky Mountain initiative is an interagency partnership effort involving the United States Forest Service (USFS), the National Park Service (NPS), the Bureau of Land Management (BLM), and the U.S. Geological Survey (USGS). Additionally, state and local governments, private organizations such as museums, universities, chambers of commerce and paleontological societies are involved.

Background of the Study

The need to protect and preserve attractions while providing a tourism or recreation experience makes the development of natural heritage areas difficult. Heritage tourism is a new concept that has developed alongside the growth of a paleo tourism industry (Millar, 1991) and involves both conservation and tourism as well as public accountability of heritage management.

To make or develop these sites into tourism destinations means that society must put a value on them (Millar, 1991). One could argue that the success of the film, "Jurassic Park," has heightened the public's awareness and made dinosaurs and fossils of great interest to the general public. Local communities must get involved to make these projects realities. Community interpretation encourages an awareness of, and pride in, the natural and cultural heritage of a community and, at the same time, enables that community to be proactive in promoting what it sees as unique in terms of developing an appropriate tourism strategy (Millar, 1991).

In addition to preservation issues, there are also political issues to be addressed. For example, the Picketwire Canyon is located on USFS land and they must manage the resource. However, because these resources are fossils, the USGS should have input into the decision making process. Additionally, access to the Picketwire Canyon involves Department of Defense (DoD) land, further complicating matters.

The NPS and, more specifically, Dinosaur National Monument offer the Paleontological Initiative a successful model to follow. However, different mandates and enabling legislation for various agencies will determine the direction taken by each.

Methodology

Data were collected by attending planning meetings held by agencies officials and conducting interviews with representatives of the USGS, the USFS Regional office, the Comanche National Grasslands management team, and managers from the BLM at Garden Park. Research also included a review of the literature on subjects relating to heritage tourism, ecotourism, comparable paleontological tourism development experiences and site interpretation. Additionally, field visits to the Picketwire Canyon, Florissant Fossil Beds National Monument and Garden Park were made.

Data collected were assessments of paleontological tourism resources (i.e. size, use, location, and sustainability) and cultural resources (e.g. hiking, picnic areas etc.). Current attendance and visitor use figures were also collected. Planning strategies for each area in the region, objectives for development of each site, and lists of potential partners in the project were also compiled. During personal interviews qualitative data were collected from representatives of the different agencies by asking what their ideal development of each area should be. Field visits to each of the three sites also provided data on location, access and infrastructure. Socio-economic data were collected on each market area near the sites, i.e. Pueblo, Colorado Springs, La Junta, and Canon City.

Conclusions
The main consideration for paleontological development is planning. **Most environmental damage is caused by lack of plans, policies and actions to prepare for growth** (Gunn, 1993). Planning and development must stress the value and significance of the resource. Tourism or recreation experiences must be managed carefully. Based on data collected in the study, conclusions were drawn and recommendations made for the best use of the resources concerning market segments to target, protection of the resources, physical access, infrastructure, communication and marketing efforts, and partnership programs beneficial to the initiative.

The three sites that the study centered on are at different stages of development. Florissant Fossil Beds is the most developed site and has a track record for visitor use. It is easily accessible, near a major market (Colorado Springs), and has plans for future development. Garden Park has extensive plans for a Dinosaur Discovery Center. It is located near a major Colorado tourism area (Canon City and Royal Gorge). It is easily accessible, has an infrastructure in place, and will benefit from the synergy of an existing tourist area. Each site can offer the Picketwire Canyon some insights for development. Ideally the three sites in reasonable proximity to each other should work collaboratively to market and educate the public concerning paleontological tourism resources.

Recommendations
Market segments for the regional initiative will differ by site. For the least developed, the markets should be educationally based, i.e. these segments should focus on schools and universities, scientific groups, families, day trips, and weekend visitors. By activity, these groups could be classified as recreationists, hikers, sightseers, and tourists. By focusing on educationally based segments, visitor numbers can be controlled. The issues associated with attracting these market segments are described below. It should also be noted that marketing and educational efforts for the three sites should be collective, therefore saving money and using resources more efficiently.

Access to the Picketwire Canyon is the most difficult of the three sites and will require road improvements. Use of DoD land for access through Minnie Canyon would greatly assist this effort. It is recommended that the DoD, through its recreation section of the U.S. Army Corps of Engineers, be invited to participate in the partnership.

It is also recommended that concessionaires and/or outfitters be used to provide access and control access and visitation. The NPS has great experience with concession operators and could be a resources in these efforts. Recommendations are for hiking by permit only, and group tours, i.e. mountain bikes, jeeps and horses, conducted by licensed concessionaires. Concession operators should be selected based on their record of environmental concern and, perhaps, on criteria established by the International Eco-tourism Society. Permits should also be issued for scientific research. Additionally, staging areas should be developed at the entrance to Picketwire and in Pueblo to control traffic congestion. Partners, including government agencies, concessionaires and interest groups, should communicate the needs and benefits of the attraction. A collaborative brochure, focusing on a site, but also providing information on the regional initiative is recommended. These brochures could be distributed through Chambers of Commerce, information centers, and outdoor stores such as REI and Eastern Mountain Sports. The continued development of educational outreach programs is recommended with the possibility of attracting corporate sponsors and fund raising through private partner groups that are interested in the preservation of the resources.

Ultimately, development should stress the protection of the resources and allow access in stages focusing on the concept of visitor ethics. The sites must be developed and marketed to potential visitors while balancing preservation and access needs.

This paper was prepared by students Andrea Nyquist, Lucy Osius, Jennifer Wheatley, Eric Frolich, and Diego San Ramon.

References

Frohlich, R., A. Nyquist, L. Osius, D. San Roman, and J. Wheatley, 1994, Regional Tourism Paleontological Initiative Project, HRTM 4400 Tourism Policy and Planning, School of Hotel, Restaurant & Tourism Management, University of Denver in conjunction with the U.S. Forest Service and Regional Paleontological Partners, Spring.

Gunn, C., 1993, Tourism Planning: Basic Concept Cases, Third Edition, Taylor and Francis, Washington, D.C.

Millar, S. 1991, Heritage management for heritage tourism, pp. 115-121, in Managing Tourism, Medlik, S. (ed.), Butterworth-Heinemann Ltd, Oxford, England.

Walsh, R.G and J.R. McKean, 1994, Economic benefits study of preserving fossil sites: Garden Park fossil area dinosaur discovery center, A preliminary report to the Garden Park Paleontology Society, Colorado: Colorado State University.

History and Development of the Ashfall Fossil Beds State Historical Park

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The steep, grass covered hills of the lower Niobrara River drainage in northern Nebraska are being eroded by creeks and seasonal runoff that expose the surrounding rock layers. Heavy rains in 1971 exposed the jaw bone of a juvenile rhinoceros in a gully bank that was discovered by paleontologist Michael Voorhies. The dentary was embedded in pure volcanic ash, and proved to be part of a complete, articulated skeleton. Further excavation revealed several more complete rhino skeletons buried in an eight foot thick bed of airfall volcanic ash.

The National Geographic Society provided funding for an excavation to reveal the extent of the assemblage. During 1977, 1978, and 1979 over 200 articulated skeletons of 16 species of animals, mainly the barrel-bodied rhino *Teleoceras major*, five species of horses, four species of camels and a previously undescribed species of crowned crane. All fossil material was removed and reposited in the University of Nebraska State Museum Research Collections.

Excavation and research revealed that the animals died in a sequence according to body size during a storm of volcanic ash. Skeletons of birds and small deer are at the lowest layers of the ash bed. Horses and camels are positioned above the smallest animals. The hefty barrel bodied rhinos are situated at a level above the medium sized animals. Lung capacity was apparently a factor in the demise, and most skeletons exhibit an abnormal, crusty growth on the bone which is indicative of **Marie's Disease**, a malady associated with lung failure.

The sediment, which accumulated as a powdery dust to depths of 10 feet, was responsible for the deep, "rapid" burial of the animal carcasses. Most carcasses remained undisturbed except for the occasional displacement of rib or limb elements by scavengers such as the bone-crushing dog *Aelurodon*.

Particles of volcanic ash, which are shards of shattered glass bubbles, do not fit tightly together and therefore do not compress the skeletons, allowing for three dimensional preservation of the carcasses. Rarely preserved skeletal material such as side-toes of three-toed horses, tendons, fetal remains, and cartilage are common. Microfossils are in evidence as well: preserved grass seeds (some within the mouths and gullets of rhinos), tree seeds, and diatoms. Trace fossils include animal tracks, feather impressions, plant impressions, and coprolites.

In 1986, donations by the Burlington Northern Railroad Foundation, Michael and Gail Yanney of Omaha, and Ed Owen of Omaha brought the prospect of an Ashfall Park to reality. Funding was donated to the Nebraska Game and Parks Commission Foundation, which proceeded with development with the intent of turning the facility over to the Game and Parks Commission itself. A contract for management aspects of the Park was negotiated with the University of Nebraska State Museum. Management of the fossil site, program development, hiring of staff, and future physical development is the responsibility of the University of Nebraska.

The park was developed with the intent of preserving the unique fossil skeletons in situ, protected by an enclosed structure. The skeletons would be excavated during times of visitation, allowing the public a first hand view of fossil recovery processes, along with a glimpse of the well preserved image of a prehistoric catastrophe.

The Park opened in June of 1991 with an Orientation Center that includes interpretive materials and fossils recovered from the previous dig, a painted mural of the pre-ashfall landscape and it's inhabitants, and a preparation lab where students engage in fossil bone preparation demonstrations. The Rhino Barn has been constructed on the fossil producing bed of volcanic ash. The Barn has eight overhead doors to control winds, yet allow visitor access to within a few feet of the skeletons. A total of 30 skeletons have been exposed inside the current Barn, with a portion of the interior yet to be excavated.

The Ashfall Fossil Beds is currently open to the public five months of the year, not including a spring and autumn school tour season in which 4,000 students are presented programs annually. Pending the hard surfacing of the county access road, the park will expand its operating schedule.

An Initiative for Management of Paleontological Resources on National Forests and National Grasslands, U.S.D.A. Forest Service

Mary H. Peterson, Forest Supervisor, U.S. Forest Service, Nebraska National Forest, 270 Pine St. Chadron, NE 69337

One responsibility of the US Forest Service (USFS) as a land and resource management agency is to preserve, protect, and manage the rich cultural and natural resource heritage of our nation for its citizens. The places and material things that constitute heritage are a vital resource for our modern society. They provide a sense of orientation and place for individuals and local communities and have a wider role in fostering pride in our legacy as Americans. Wise stewardship of our resources in a future that includes increasing demand for their use and more vulnerability to damage is a key concern for agencies managing America's public lands. Both archeology and paleontology provide insight into the past and, while these two resource areas sometimes overlap, they are scientifically different. Archeology is the study of historic and prehistoric mankind, while paleontology is the study of any evidence of past life. As stewards of public lands, The USFS must protect both paleontological and archeological resources and provide opportunities to help fulfill the individual, social, and spiritual needs of all Americans.

One important component of our natural resource legacy is the surviving record of the biological past preserved as fossil remains of plants and animals. The Rocky Mountain Region (RMR) has many locations where rich and diverse nonrenewable fossil remains are preserved. Increasing demands for these finite resources for scientific research, recreational opportunities, and commercial development have raised public awareness and concern. If wisely managed, they offer valuable opportunities to meet those needs. As stewards, we must manage these resources for the best public benefit for current and future generations. A reasonable and responsible management program for these resources has become a critical need. Our management must be based on an adequate knowledge of the resource and related issues, so that we are aware of associated opportunities and vulnerabilities. The program must include a balance between support activities for the agency and public opportunities. To meet our agency responsibilities to effectively manage all publicly owned resources within its jurisdiction, the RMR proposes this initiative.

Vision

We envision a future where the USFS is recognized as a leader in managing paleontological resources. It is a future in which our field personnel know where the significant resources are and what conservation treatments are needed. USFS regulation and policy regarding the resource is clear and easily implemented. This future also includes the USFS as one member in an effective network of public and private partners working together for stewardship and providing challenging and enriching experiences to the public regarding the value of fossil resources.

Objectives Conceived as Desired Future Conditions

- The locations of prominent paleontological resources in Region 1 (North Dakota and Montana) and Region 2 (Colorado, Kansas, Nebraska, South Dakota, and Wyoming) are known and their significance from a scientific and educational standpoint has been assessed. This knowledge is used to integrate specific fossil management objectives into our land and resource management plans.

- Field personnel understand the importance of managing paleontological resources. They have a practical working knowledge in recognizing fossils and the geologic units where they might be expected to occur. They are aware of the situations that require special assistance and know how to obtain the help of various agency specialists.

- Significant resources are protected for the present and future, including implementation of active and passive protection measures. This includes, but is not limited to, providing law enforcement to assist in protection of fossils resources.

- Public education programs are available and presented to interested groups. These programs discuss the fossil resource, its scientific and educational values, and management of fossil resources on public land for public benefit. The public is provided with a number of locations where opportunities to experience and appreciate paleontological resources are available. These experiences include tours, interpretation with a positive message about resource protection, and guided hands on experiences such as collection and excavation. Hands on experiences are also available to educational groups such as colleges and universities. These public use sites have been developed to provide educational media, visitor safety, and protection of the resource.

- The USFS has created partnerships with other agencies, educational and research institutions, state geologists, state paleontologists, and other appropriate public and private sector entities, such as qualified amateur paleontological groups, to further public stewardship goals for education, protection, and interpretation of fossil resources.

- The USFS has created clearly defined special use permits, regulations, and policies regarding paleontological resources. Law Enforcement Officers have practical working knowledge to prevent or deter vandalism to paleontological resources located within designated areas of significant fossil resources.

Strategies

In developing strategies, the intent is to accomplish each in balance with the others. In order to provide the best service to the public in managing the fossil resource it is important that one strategy not be financed to the detriment of another. The program levels proposed in this section maintain a balance between various strategies.

Inventory and Evaluation

- Identify exposed fossil bearing formations on National Forest System lands.

- Inventory areas of anticipated sensitivity.

- Develop extensive and intensive survey techniques.

- Develop mapping procedures.

- Determine salvage intensities for various sites.

- Determine value and significance of exposed fossil sites.

- Develop appropriate databases and storage for fossil resource information.

Conservation and Protection

- Develop conservation strategies that recognize which fossil resources are vulnerable to natural forces, agency activities, wear and tear of sanctioned public use, and unauthorized use or vandalism.

- Develop general education programs concerning the fossil resource management on public lands.

- Develop conservation plans for significant paleontological resources/sites.

- Develop law enforcement strategies for the protection of fossil resources and investigation of vandalized sites.

- Develop demonstration projects on several forests. (Demonstration Areas are areas of unique fossil resources to be developed for their education and scientific significance. Sites such as Picketwire Canyon, Dry Mesa Dinosaur Quarry, mastodon dig on Routt NF, Hudson-Meng Bison Kill Site, and Toadstool Geologic Park would be utilized to conduct educational-interpretive programs and provide hands on opportunities for exploration, excavation, curation, and preservation strategies for these resources.)

- Conduct employee education programs on fossil resource identification and significance.

- Survey and post interior land boundaries where fossil resources are located adjacent to private lands.

- Develop a signing program for the protection of important fossil sites.

Policy Development and Application

- Work with the Washington Office (WO) geology staff and US Department of Interior agencies to recommend and develop regulations for fossil management on National Forest System and other federal multiple use lands.

- Work with WO geology staff to recommend and develop policy for fossil management.

- Work with WO geology staff and Bureau of Land Management (BLM) to recommend and develop special use clauses and Memorandum of Understanding (MOU) wording for permitting fossil inventory, excavation and collection on public lands to provide for consistency of the permitting process and agreements.

- Provide training and guidance to resource managers on the importance and management of fossil resources.

- Provide guidance to resource managers in the development of Forest Plan standards and guidelines during the Forest Plan revision process.

- Develop criteria for the designation of Special Areas.

- Determine how fossils will be considered in the National Environmental Protection Act effects analysis process.

- Determine if, when, and how we would permit commercial fossil use.

Interpretation and Education

- Provide general education regarding the fossil resource and management on National Forest System lands both internally and externally. Utilize the Natural Resource Conservation Education program as one way to provide public education.

- Develop opportunities for public experiences and appreciation by commissioning demonstration projects on several forests.

- Provide articles to various media such as general readership magazines and newspapers regarding fossil resources and opportunities to enjoy them on public lands.
- Provide a range of experiences for people to learn more about the fossils and their significance. These can include self guided trails, site interpreters, excavation sessions, and exhibits in federal or nonprofit organization buildings.

- Use educational programs as law enforcement management tools to reduce destruction and theft of the resource.

Partnerships

- Utilize partnerships and other programs, whenever possible, to accomplish strategies listed for Inventory and Evaluation, Conservation and Protection, Policy Development and Application, and Interpretation and Education.

- Develop a multi-agency task force to create Federal policy using an interdisciplinary approach (including line officers).

- Develop partnerships with universities, museums, magazines, amateur groups, professional societies, and commercial interests to carry out demonstration projects, conservation programs and educational programs.

- Form a Paleontology Resource Council similar to the National Wilderness Council. (To make the Paleontological Initiative a success, it is critical that we work closely with other Federal agencies that play a role in management of the paleontological resources, ie., US Geological Survey, BLM, National Park Service, Department of Defense, etc.) We need to be consistent in the management of the resources and provide support to one another whenever possible. An Advisory Council would help lead the Paleontological Initiative. The council would include representatives from the involved agencies. The purpose of this council would be to provide an interagency approach to paleontological resource management. This is not an attempt to change authorities or responsibilities of the involved agencies, but would serve to guide a coordinated federal approach to paleontological resource management.

- Develop a basic MOU for partnerships with some standard wording that could be used service wide for paleontology partnerships.

What are the benefits of this initiative to the public?

- It provides enriching recreational experiences.
- It provides opportunities for personal growth and a sense of shared heritage among people.
- It encourages the public to have a sense of ownership concerning natural heritage resources.
- It fosters a knowledgeable, enlightened public through opportunities for natural resource conservation education.
- It ensures paleontological resources will be available for the future.
- It broadens the natural history of any geographic location.
- It introduces people to scientific exploration.
- It prompts respect for public lands and publicly owned resources.
- It contributes to economic development of rural communities.

What are the benefits to the agency and resource?

- It is relevant to resolving contemporary natural and human resource issues.
- It will provide direction to manage a threatened nonrenewable natural resource.
- It will increase awareness and sensitivity among agency staff for paleontological resources.
- It will display to the public the agency's role in responsible management of a natural resource.
- Knowledge acquired can be applied to future individual forest planning efforts and some information should be timely for Forest Plan revisions.
- It contributes to our knowledge of ecosystem management and animal behavior by preserving ancient ecosystems in the rock units that contain paleontological resources.

United States Geological Survey Branch of Paleontology and Stratigraphy

John Pojeta, Jr., Past Chief, Branch of Paleontology and Stratigraphy, U.S. Geological Survey, National Center, MS 970, Reston, VA 22092

US Geological Survey Organic Act
The law creating the US Geological Survey (USGS) was enacted and approved on March 3, 1879. The Survey's Organic Act makes specific reference to fossils and paleontology. As far as I can determine, the USGS is the only Federal agency specifically directed by legislation to deal with fossils. The Survey's Organic Act is short and in part reads:

"For the salary of the Director of the Geological Survey, which office is hereby established under the Interior Department...: **Provided**, That this officer shall have the direction of the Geological Survey, and **the classification of the public lands**, and examination of the geological structure, mineral resources, and products of the national domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey...; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys west of the one hundredth meridian, under the War Department, are hereby discontinued... . And all collections of rocks, minerals, soils, **fossils**, and objects of natural history... made by the... the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum. ...

The publications of the Geological Survey shall consist of the annual report of operations, geologic and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and **paleontology** ..." (Rabbitt, 1979).

Introduction
Paleontologists have been a part of the USGS since its founding and, by 1894, paleontologist C.D. Walcott, of Burgess Shale fame, was Director of the Survey. Some of the classics of American paleontology were published by the USGS including Marsh's Dinocerata, David White's paleobotanical studies, Newberry's Paleozoic fishes, Marsh and Lull's Ceratopsia, Osborn's Titanotheres, and many papers on invertebrates by Ulrich, Reeside, Stephenson, Gardner, and others.

The modern Paleontology & Stratigraphy Branch (P&S) dates back to about 1950, when Preston Cloud gathered almost all of the paleontologists in the USGS into one administrative unit and added to this a number of new hires. Cloud is probably most famous for studies and theories about Precambrian life and the Precambrian-Cambrian transition.

At present, the P&S Branch has 51 research paleontologists, a support staff of 38, several dozen volunteers, and a few Research Associates. The support staff includes administrative, secretarial, and technical help. At least 10 of the technicians have advanced training in paleontology and, in addition to providing laboratory and field support, they conduct research programs of their own.

P&S is a national branch with staff in the East (Reston, VA; Washington, DC; and Woods Hole, MA), Center (Denver, CO); and West (Menlo Park, CA). The branch headquarters are at the USGS National Center in Reston, VA, where the Branch Chief is located.

At present, the branch forms part of the Office of Regional Geology within the Geologic Division. The Office includes the regional geologic mapping branches and the Branch of Isotope Geology, which is the other geochronologic arm of the USGS.

Onboard Expertise
The P&S Branch is the largest grouping of research paleontologists in one administrative unit in the world, and it has an enormous diversity of expertise.

Several of the paleontologists work with more than one major taxonomic group and they are listed more than once. (Figure 1.)

Megapaleontology

BRACHIOPODS
- R.B. Blodgett
- J.T. Dutro, Jr.
- T.W. Henry
- R.B. Neuman
- R.J. Ross, Jr.

CORALS
- W.A. Oliver, Jr.
- W.J. Sando

GRAPTOLITES
- Claire Carter

MAMMALS
- T.M. Bown
- C.A. Repenning
- F.C. Whitmore, Jr.
- P.A. Holroyd

MOLLUSKS
- R.B. Blodgett
- W.A. Cobban
- W.P. Elder
- T.G. Gibson
- L.N. Marincovich
- John Pojeta, Jr.
- N.J. Silberling
- G.L. Wingard
- E.L. Yochelson

DINOSAURS
- T.R. Holtz, Jr.

TRILOBITES
- R.J. Ross, Jr.
- M.E. Taylor

VERTEBRATE ICHNOLOGY
- R.J. Litwin

Micropaleontology

CALCAREOUS
- J.M. Berdan
- E.M. Brouwers
- J.D. Bukry
- L.M. Bybell
- Claire Carter
- T.M. Cronin
- H.J. Dowsett
- T.G. Gibson
- S.E. Ishman
- Kristin McDougall-Reid
- C.W. Poag
- I.G. Soh
- W.V. Sliter

PHOSPHATIC
- A.G. Harris
- J.E. Repetski
- B.R. Wardlaw

PALYNOLOGY
- D.P. Adam
- T.P. Ager
- L.E. Edwards
- R.F. Fleming
- N.O. Frederiksen
- R.M. Kosanke
- R.J. Litwin
- D.J. Nichols
- R.S. Thompson
- D.A. Willard

SILICEOUS
- G.W. Andrews
- J.A. Barron
- C.D. Blome
- J.P. Bradbury
- B.L. Murchey-Setnicker

Figure 1

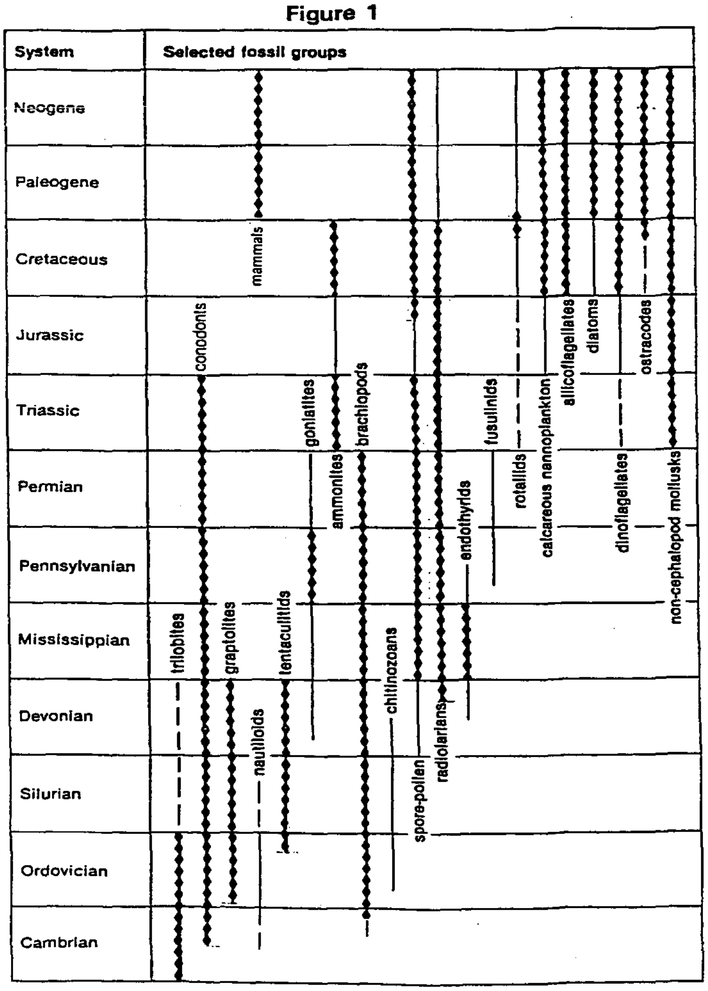

Figure 1. Adapted from the American Geological Institute Data Sheet 66.2 - Major Fossil Groups Used for Correlation of Phanerozoic Strata in North America. Thin lines show the biostratigraphically useful range of the fossil group. Dashed thin lines indicate limited biostratigraphic utility of the group. The lozenge patterns show the distribution of present in-house USGS paleontological expertise by stratigraphic interval and taxonomic group.

Laboratories
As a national branch, P&S has laboratories across the nation for the preparation of a great variety of fossils including facilities for the use of mechanical, chemical, and thin section techniques. In addition, all centers (Reston/Washington, Denver, and Menlo Park) have computer/computer graphics, photographic, SEM, taxonomic library storage laboratories, and facilities for casting larger specimens. The USGS has unrivaled paleontological library facilities available at Reston, Denver, and Menlo Park.

Reston/Washington
For the 26 USGS paleontologists in the east, the following laboratory facilities are available:
- Two HF preparation labs
- A thin section lab
- A CH3COOH/HCL preparation lab
- Three chemical nonacid prep labs
- Three mechanical preparation labs
- Two SEM labs
- Two photographic labs
- Two computer/computer graphics labs
- A rock crushing lab
- A clean lab

Denver
For the 16 USGS paleontologists in the Denver Federal Center, the following laboratory facilities are available:
- Four HF preparation labs
- A thin section lab
- A CH3COOH/HCL preparation lab
- Two chemical nonacid preparation labs
- Five mechanical preparation labs
- A SEM lab
- Two photographic labs
- A computer/computer graphics lab
- A rock crushing lab

Menlo Park
For the nine USGS paleontologists in Menlo Park, California, the following laboratory facilities are available:
- Two HF preparation labs
- A rock slabbing lab
- A chemical nonacid preparation lab
- A mechanical preparation lab
- A SEM lab
- A photographic lab
- A computer/computer graphics lab
- A frozen core storage facility

Field Areas
Most paleontologists are also biostratigraphers, because it is necessary to know the succession of biotas to understand evolution and Earth's geologic history. Stratigraphy is carried out on a worldwide basis by correlating biotas because no complete succession of biotas is present on any one continent. In this sense, the Earth is a paleontologist's field area. However, in a practical sense, most paleontologists limit their field areas to a part of a continent and depend on colleagues from other places to provide information that is integrated into understanding the full succession of biotas. USGS paleontologists conduct field studies throughout the United States; the center at which someone is headquartered is not necessarily near their field area.

In the past four years USGS paleontologists have conducted fieldwork in most of the USA, including: the Appalachian and Illinois Basins, Florida, Virginia, Oklahoma, Arkansas, Mississippi, Kansas, Ohio, the Great Basin, the Bighorn Basin, California, the Basin and Range Province, Kentucky, the Colorado Plateau, the Gulf Coastal Plain, New York, the Atlantic Coastal Plain, New Jersey, the Western Interior, South Carolina, Georgia, the Pacific Northwest, Texas, Alaska, Montana, Maine, and Michigan. (Figure 2.)

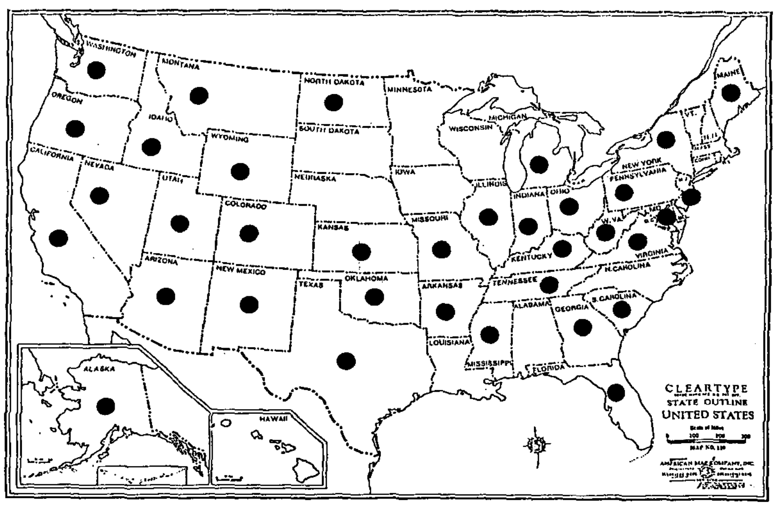

Figure 2. The dots indicate the States in which USGS paleontologists have conducted field work in the 1990's.

In the past four years field work by USGS paleontologists has been conducted in various parts of the world, including: the North Atlantic Ocean, the Arctic Ocean, the Southern Ocean, Chile, Pakistan, Japan, China, Bangladesh, Yukon, Egypt, Argentina, Venezuela, Spain, the United Arab Emirates, Panama, Costa Rica, Germany, Belgium, and Newfoundland.

All of the new collections add to the massive paleontological data base maintained by the P&S Branch.

Programs, Projects, and Funding
Funding for paleontological research in the USGS comes from a variety of sources. Congressionally appropriated funds that come directly to the USGS are called SIR dollars and support a variety of programs for which the USGS is responsible; SIR funds are distributed to researchers through a project proposal system. In the past decade, paleontological research has been funded through a number of programs, including: Geological Framework and Synthesis, Evolution of Sedimentary Basins, Earthquake Hazards Reduction, National Geologic Mapping, Coastal Erosion and Wetlands Processes, Global Change and Climate History, National Minerals Resources Assessments, Onshore Oil and Gas Investigations, Cooperative Geologic Mapping, Strategic and Critical Minerals, Coal Investigations, Offshore Geologic Framework, Gilbert Fellowships, Radioactive Waste, and Water Resources Division Programs. In the past few years about 75% of the P&S funds for paleontological research have come from the Geologic Mapping and the Global Change and Climate History programs.

Funds coming from other agencies are called OFA dollars. Such funding sources can be arranged for at any level from the Director's Office to the Branch Chief's Office. In the past decade, OFA funds have come to P&S from a variety of sources, including: the Department of Defense (Eniwetok), USAID (Bangledesh and Pakistan), Department of Energy (Yucca Mountain and Savannah River), NSF (Japan), National Geographic Society (Egypt), University of Kansas, University of Alaska, National Oil Company of Venezuela, United Arab Emirates, and the US Forest Service. Depending on the year, OFA funds have comprised up to 10% of the P&S budget.

Scientific Outreach
P&S paleontologists regularly present information about their current research at the meetings of the Geological Society of America, the American Geophysical Union, the several North American paleontological societies, and various foreign venues. In addition, USGS paleontologists have served as officers and/or committee persons in a number of paleontological societies including: Paleontolgical Society, Society of Economic Paleontologists and Mineralogists (SEPM), Paleontological Research Institution, Paleobotanical Section of the GSA, Society of Vertebrate Paleontology, Cushman Foundation for Foraminiferal Research, American Association of Stratigraphic Palynologists, North American Micropaleontological Section of SEPM, and the International Paleontological Union. P&S research is published in all the internal USGS outlets and in many outside peer reviewed journals. The table exhibit at "Partners in Paleontology" showed the list of P&S publications from 1983-1993. This listing will be issued as an USGS Open-File Report.

P&S paleontologists also provide a service to the scientific and general public by identifying fossils. This is done through a process called the Examination and Report (E&R) on referred fossils. The sample(s) is submitted to the Branch Chief who gives it to the appropriate specialist. E&R reports are provided to geologists and hydrologists throughout the USGS, to other agencies such as State Geological Surveys, the Bureau of Land Management, company and academic geologists and paleontologists, and to the public at large. Over the past several years E&R reports have covered an average of about 600 samples per year. The submitter understands that the information provided is in the public domain (not proprietary) and that the USGS scientist has the right to retain the specimen to document his/her identification and age determination.

Educational Outreach
In addition to research activities, the P&S Branch carries on outreach to educators, amateur collectors, and the general public. Outside of the scientific arena, P&S paleontologists regularly give talks about fossils in a number of venues, including schools, churches, scout troops, amateur fossil collectors' societies, etc. The USGS has also added paleontological literature to its General Interest Publications (GIP). In Colorado, the USGS makes a hands on experience with fossils available to the

schools through the circulation of its fossil kits. Bob O'Donnell created these kits and they were exhibited at the "Partners In Paleontology" meeting.

In the GIP series is the 25 page booklet entitled "Fossils, Rocks, and Time" (Edwards and Pojeta, 1993). This booklet discusses the basic concepts of biostratigraphy, the relative and numeric time scales, formation of sedimentary rocks, evolution, and correlation. It also shows photographs of paleontologists at work both in the laboratory and the field, and includes a basic bibliography for various age and interest groups.

A second GIP is the poster entitled "Fossils Through Time" (Pojeta and Edwards, 1994). This is a collage of photographs of fossils providing a visual impression of the diversity and evolution of life on the "Blue Planet" during the Phanerozoic. First appearances, dominant organisms, and extinctions are stressed in the short accompanying texts for each time period. Both of these publications are intended for teachers, Earth Science students, and anyone interested in learning the basics about fossils and biostratigraphy.

Both the booklet and the poster are available at **no charge** from: Mr. P. Guss, Chief, Earth Sciences Information Center, U.S. Geological Survey, National Center, MS 507, Rm 2C130, Reston, VA 22092; or from U.S. Geological Survey, Branch of Distribution, P.O. Box 25286, Denver, CO 80225.

A third paleontological GIP entitled "Dinosaurs: Facts and Fiction" will soon be available. This pamphlet answers 20 commonly asked questions about dinosaurs.

Interactions with Land Managing Agencies
The USGS has a history of working with other agencies; the Survey providing the scientific expertise needed by the other agencies to solve their mission problems. Because the USGS mission is geological research, it has a reputation for providing factual and unbiased scientific information relevant to the Nation's geological, land management, and other problems where data from or about geology are needed. Joint hosting of this meeting by the USGS reinforces that history.

On May 4, 1992, a memorandum of understanding (MOU) entitled "Management of Fossils on Public Lands" became effective. Copies were available at the "Partners In Paleontology" meeting, and can be had by mail from: B.R, Wardlaw, Chief, Branch of Paleontology & Stratigraphy, U.S. Geological Survey, National Center, MS 982, Reston, VA 22092. The MOU is a mechanism for the USGS to provide scientific expertise in paleontology to the Bureau of Land Management (BLM), National Park Service (NPS), Department of the Interior, and the US Forest Service (USFS), Department of Agriculture. Like his two predecessors, the current Secretary of Interior has endorsed the MOU.

The USGS has a cooperative project with the USFS in the Picketwire Canyon Lands on the dinosaur trackway, which was one of the field trips for this meeting. This cooperation is being augmented through the negotiation of an MOU specific to the Rocky Mountain Region.

The USGS has done cooperative work with the NPS on the Chinle Formation at Petrified Forest National Park, and on the Morrison Formation and its upper unconformity in and around Dinosaur National Monument. In the past, the P&S Branch has also worked with the NPS in the Newark Supergroup at Manassas National Battlefield. The branch was also helpful to NPS at Guadalupe Mountains National Park.

Working with BLM, the P&S Branch has provided several Examination and Report studies of fossils from various western localities.

NOTE
For an update on the disposition of these USGS functions and collections, see Addendum on page 2.

References
Edwards, L.E., and J. Pojeta Jr., 1993, Fossils, Rocks, and Time, 25 pp., U.S. Government Printing Office 353-390.
Pojeta, John, Jr., and L.E. Edwards, 1994, Fossils Through Time, Poster (U.S. Government Printing Office does not assign numbers to posters).
Rabbitt, M.C., 1979, Minerals, Lands, and Geology for the Common Defence and General Welfare, Volume 1, Before 1879, pp. 283-284, U.S. Government Printing Office 024-001-03151-5.

Conducting a Systematic Paleogeology Resource Inventory of Natural Features: A Case Study from Anza-Borrego Desert State Park, California

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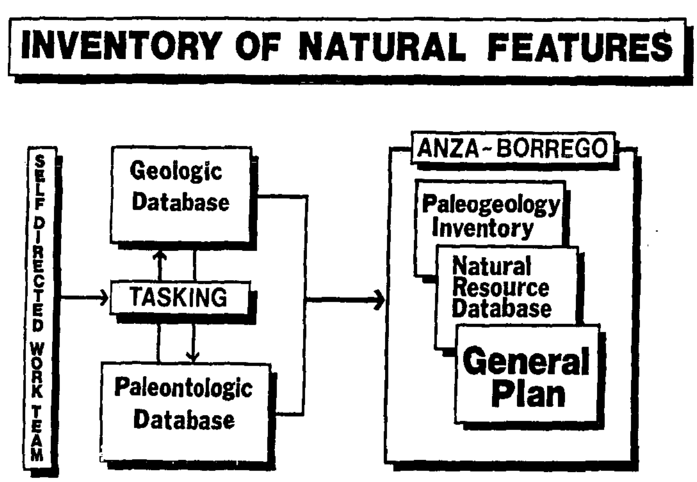
Anza-Borrego Desert State Park (ABDSP), ranked as the largest state park (620,000 acres) in the United States, rivals many paleontological parks with National Park Service status and serves as a major repository of natural and cultural history collections within the State of California. The specimen collections represent a multitude of disciplines, including geology, paleontology, biology, botany and archeology and constitute a significant portion of the resources that the California Park Service (CPS) is charged to preserve and protect for the public trust.

ABDSP's scientifically important paleogeology resources comprise the largest collections within the CPS and form an integral part of Neogene biostratigraphy within the dynamic Salton Trough-Gulf of California (STGC) structural depression (White et al, 1991; Remeika and Lindsay, 1992; Remeika and Jefferson, 1993; Reynolds and Remeika, 1993). The documented record represents a nationally and internationally recognized reference section (Downs and White, 1968), including over 170 vertebrate taxa with 17,000 cataloged specimens (recovered from 2,500 localities) belonging to five local faunas (Downs and White, 1968; Remeika, 1992a; Remeika and Jefferson, 1993), 1200 invertebrate taxa (nonmarine and marine), a paleobotanical assemblage (Remeika et al, 1988; Remeika, 1994), and an increasing ichnogenera (Stout and Remeika, 1991) recovered from thick (5,000m) vertically superimposed Mio-Pleistocene (Hemphillian-Rancholabrean LMA) epicontinental tectonostratigraphic deposits.



Pathways to development of an Inventory of Natural Features. Self Directed Work Teams, made up of paleo volunteers and park staff who have expertise in areas covered by the resource inventory, acquire geologic and plaeontologic task assignments. These carry through into the paleogeology general planning inventory process. Once completed, the paleogeology portion is systematically incorporated with other natural resource databases that provide the basis for the formulation of Anza-Borrego Desert State Park's General Management Plan.

The seismogenic San Jacinto and Elsinore Fault Zones divide the fossiliferous, syndepositional succession into prominent, structurally controlled paleobasins, referred to as the Vallecito-Fish Creek Basin (VFCB) in the south and the Borrego-San Felipe Basin (BSFB) in the north.

In order to responsibly manage and protect this large heritage-preservation resource (Jorgensen, 1991; Remeika, 1992c), ABDSP paleontologists are conducting a systematic Inventory of Natural Features (INF) for General Plan (GP) compilation (Remeika,1992b, 1993). The GP is a workable legal document legislatively mandated by the Public Resources Code of the State of California. It is based on quantitative collection inventories, field salvage recovery, identification, preparation and curation, cataloging and accountability of ABDSP's natural and cultural resource features. Upon completion, the GP becomes the major planning tool for regulating public usage, resource management, development, and future goals. The first step of the GP is an INF within and proximal to ABDSP.

The preparation of the GP utilizes a multifaceted approach with Self-Directed Work Teams (SDWT) designated to facilitate data acquisition for the INF. The SDWT is recruited from staff personnel and thirty paleo volunteers who have successfully completed ABDSP's Certification Training Program in Paleontology. This innovative program, modeled after the Denver Museum of Natural History's docent training program, consisted of 40 hours of regimented classroom instruction, 40 hours of laboratory training, and 30 hours of field exercises, with advanced curriculum in laboratory methods, field surveying and reconnaissance. Under the direction of a Park Paleontologist and District Archeologist, specific paleogeology INF strategy goals and objectives completed or planned by SDWT include:

- Compilation and publication of a comprehensive bibliography (3,000 entries) on the geology and paleontology of ABDSP with a regional STGC component applicable to ABDSP (Jefferson and Remeika, in press).

- Establish stewardship with the Bureau of Land Management (BLM), similar to the interagency agreement between John Day Fossil Beds National Monument and the BLM, for long term procurement and management of paleogeology resources of common concern (Remeika, 1994). Public collecting has depleted significant marine fossil bearing deposits on BLM administered lands neighboring ABDSP. ABDSP's Paleontology Program is equipped with the mandate, technical staff, equipment, and established facilities to provide scientific research, field salvage, and curatorial/conservation services. It is also dedicated to the responsible exploration for recovery, study, and research of paleogeologic resources in and beyond Park boundaries for the purpose of educating the scientific community and the public, and increasing the knowledge of paleogeology resources.

- Draft an interagency agreement, jointly sponsored as part of the State of California Division of Mines and Geology and the United States Geological Survey's Southern California Areal Mapping Project (SCAMP), to produce a detailed 1:100,000 scale metasedimentary and plutonic bedrock/basement geological map coverage of ABDSP from 33 1:24,000 scale USGS quadrangle sheets.

- Concurrently initiate limited term Planned Experience Training Assignments to accurately field map and compile comprehensive 1:24,000 scale stratigraphic/geologic base maps of the VFCB and BSFB. Phase I, just completed, includes a detailed 1:5,000 scale black and white lithostratigraphic treatise (Remeika, 1994) of the Borrego Badlands to establish stratigraphic control critical for the paleontological resources recovered from the area. Continuation of additional phases is still pending. Once completed, the revised geologic, stratigraphic and paleontologic mapping information will be digitized on 7.5 minute USGS quadrangle sheets to the GIS system for addition to SCAMP.

- Measure lithostratigraphic sections and apply biostratigraphy (Remeika and Jefferson, 1993), magnetostratigraphy, palynology (Fleming, 1993; Fleming and Remeika, 1994) and tephrochronology to the BSFB rock unit stratotypes in order to understand paleobasin evolution and structural history along the western STGC. Correlate database to the VFCB which already has a documented magnetostratigraphic (Opdyke et al, 1977; Johnson et al, 1983) and vertebrate biostratigraphic zonation (Downs and White, 1968).

- Compile a comprehensive specimen database and generate hard copy locality and taxonomic catalogues for analyses and reports. At present, the successfully recalled Imperial Valley College Museum Collection (IVCM) is reorganized sequentially by locality number. Twenty-seven new Lane-style Steel Fixtures storage cabinets intended to hold vertebrates, petrified wood and marine invertebrates, are installed. Computerization of the collections data continues. Editing of the IVCM fields (taxonomic and location) has been completed. 1,200 records from the Borrego Local Fauna have been manually entered. A 486DX2/66 computer has been purchased as a budgeted line item from the Stewardship Grant Program. It will be used to run ARC View with the GIS database as well as integrate images of specimens and/or localities for the INF.

- Transfer paleontological field locality positions (coordinates, taphonomic data, stratigraphic resolution) from black and white aerial photographs (10" x 10" contact prints and 24" x 24" enlargements) to GIS topographic base via PG2 optical plotter and annotate with locality numbers.

- Assist in a feasibility study for the planning and development of an interdisciplinary Colorado Desert Research Center which will feature a major paleogeology component. Such a facility will exist to formally support ABDSP's mission by providing the public a safe repository and interpretive arena for examples of the natural and cultural environment commemorated by the 1933 establishment of the state park. The facility automatically advocates ABDSP to become involved in a long range procurement program to guide present and future direction of managing and exhibiting its specimens collections. Internal elements of the facility include a scientific research wing, a laboratory/preparation wing, a collection storage/repository wing, and a public education/park interpretation exhibit hall.

- Reacquisition of ABDSP paleontological specimens presently on loan to other institutions. ABDSP asserts ownership of all specimens collected from its properties and maintains the right to recall and relocate collections as/or when necessary to insure their safety and/or for the development of important CPS policies and programs. At present, ABDSP is recalling its 5,741 specimen vertebrate collection temporarily housed at the National History Museum of Los Angeles County (LACM). As expected, LACM is disputing ABDSP's claim and wishes to retain the collection as a part of its holdings. ABDSP continues to investigate this matter to determine an appropriate course of action.

Project completion of INF resource management phase for the GP is projected for 1997.

References

Downs, T. and J.A. White, 1968, A vertebrate faunal succession in superposed sediments from Late Pliocene to Middle Pleistocene in California: Proceedings, 23rd International Geol. Congress, 10:41-47.

Fleming, R.F., 1993, Palynological data from the Imperial and Palm Spring Formations, Anza-Borrego Desert State Park, California: U.S. Geological Survey open-file report 93-678:1-29.

Fleming, R.F., and P. Remeika, 1994, Pliocene climate of the Colorado Plateau and age of the Grand Canyon - evidence from Anza-Borrego Desert State Park, California: 4th National Park Service Conference on Fossil Resources, Partners in Paleontology, Colorado Springs, Colorado.

Jorgensen, M. 1991, Paleontology Resource Management Plan. Draft on file, California Park Service, Color[illegible] Desert District, Anza-Borrego Desert State Park, Borrego Springs, California. 21 pp.

Johnson, N.M., C.B. Officer, N.D. Opdyke, G.D. Woodard, P.K. Zeitler, and E.H. Lindsay, 1983, Rates of Late Cenozoic tectonism in the Vallecito-Fish Creek Basin, western Imperial Valley, California: Geology 11:664-667.

Opdyke, N.D., E.H. Lindsay, N.M. Johnson, and T. Downs, 1977, Paleomagnetism and magnetic polarity stratigraphy of the mammal-bearing section of Anza-Borrego Desert State Park, California: Quat. Research 7:316-329.

Remeika, P., 1992a, Preliminary report on the stratigraphy and vertebrate fauna of the Middle Pleistocene Ocotillo Formation, Borrego Badlands, Anza-Borrego Desert State Park, California: Mojave Desert Quaternary Research Center Symposium. Abstracts of Proceedings, San Bernardino County Museum Association Quarterly 39(2):25-26.

____, 1992b, Paleontological program development at Anza-Borrego Desert State Park, California, Abstract with programs: Third Conference on Fossil Resources in the National Park Service,

Fossil Butte National Monument. 14-17 September, Kemmerer, Wyoming. p. 25.
____, 1992c, Paleontology Collection Management Policy. Draft on file, California Park Service, Colorado Desert District, Anza-Borrego Desert State Park, Borrego Springs, California. 46 pp.
____, 1993, Achieving paleogeology resource management strategies for General Plan development - a progress report on Anza-Borrego Desert State Park, California. Abstract with programs, Paleontological Resource Management Symposium, Society of Vertebrate Paleontology fifty-third annual meeting, Albuquerque, New Mexico. 13(3):53A.
____, 1994, Lower Pliocene angiosperm hardwoods from the Vallecito-Fish Creek Basin, Anza-Borrego Desert State Park, California - Deltaic Stratigraphy, Paleoclimate, Paleoenvironment, and Phytogeographic Significance: Mojave Desert Quaternary Research Center Symposium, Abstract from proceedings, San Bernardino County Museum Association Quarterly 41(3):26-27.
Remeika, P., I.W. Fischbein, and S.A. Fischbein, 1988, Lower Pliocene petrified wood from the Palm Spring Formation, Anza-Borrego Desert State Park, California: Review of Palaeobotany and Palynology 56:183-198.
Remeika, P., and L. Lindsay, 1992, Geology of Anza-Borrego - Edge of Creation, Dubuque, Kendall/Hunt Publishing Company.
Remeika, P., and G.T. Jefferson, 1993, The Borrego local fauna - revised basin-margin stratigraphy and paleontology of the western Borrego Badlands, Anza-Borrego Desert State Park, California: Ashes, Faults and Basins, edited by R.E.Reynolds and J. Reynolds, San Bernardino County Museum Association special publication 93-1:90-93.
Reynolds, R.E., and P. Remeika, 1993, Ashes, faults and basins - the 1993 Mojave Desert Quaternary Research Center field trip: Ashes, Faults and Basins, edited by R.E. Reynolds and J. Reynolds, San Bernardino County Museum Association special publication 93-1:3-33.
Stout, B.W., and P. Remeika, 1991, Status report on three major camelid tracksites in the Lower Pliocene Delta Sequence, Vallecito-Fish Creek Basin, Anza-Borrego Desert State Park, California: Abstract with programs, Symposium on the Scientific Value of the Desert, Anza-Borrego Foundation, Borrego Springs, California. p.9.
White, J.A., E.H. Lindsay, P. Remeika, B.W. Stout, T. Downs, and M. Cassiliano, 1991, Society of Vertebrate Paleontology field trip guide to the Anza-Borrego Desert: Society of Vertebrate Paleontology fifty-first annual meeting and field trip, San Diego, California.

Dino Fest: A Scientific Conference for Everyone

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The Problem

There is a growing recognition that science in our nation is in trouble. The public's interest in science is waning. Fewer young men and women are studying for science careers in college, while increasing numbers are planning for more lucrative futures in business administration. I find it a remarkable coincidence to hear colleagues from around the country report that students are impatient with having to take even a single rigorous science course if they deem it irrelevant to getting a job. With the success rate for proposals submitted to the Paleontology/Stratigraphy section of the National Science Foundation down to 20%, it seems that government funding of pure science research is dwindling. For one thing, the fear of Soviet hegemony in technology, initially aroused by Sputnik, and which was a continuing, powerful stimulus for subsidizing science for more than two decades, is becoming a distant memory with the end of the cold war. The private sector is putting less money into "research and development" in order to appease stockholders who want immediate returns in the form of increased dividends.

Paleontology, in particular, is hard hit. Employment of paleontologists has always been cyclic, but the present nadir seems especially prolonged and broad based across academia, museums, government, and industry. Paleontologists in the petroleum industry have become so scarce due to lay offs and hiring freezes over the last decade that survivors of the decimation have formed an advisory group (the Industry Paleontology Managers Group, or IPMG) to find ways to make paleontologists employable in the oil patch once again. Paleontology collections in universities are being orphaned as geology departments decline to replace retiring paleontologists with young paleontologists. The collections are being offered to "foster" museums (themselves laying off personnel) or are being thrown out, if museums refuse them.

Ironically, the public's fascination with paleontology has never been greater. The 1993 movie, "Jurassic Park," aroused the public's attraction for dinosaurs to a frenzy. You could have sworn those dinosaurs were real, but they were fun because they were celluloid and safe. Courses about dinosaurs attract huge numbers of students at many universities. But those courses are safe too, because students really don't have to take them seriously. For the most part, they are not rigorous laboratory science courses.

In a word, the public has ceased to be a partner with scientists in the agony and ecstasy of scientific discovery, specifically paleontologic discovery. What to do about it? How to involve the public in science? How to nurture science literacy? How to show the public that science careers are fulfilling and that new scientists are needed to make the scientific breakthroughs that will make our lives better?

Dino Fest

One answer that the Department of Geology, Indiana University/Purdue University at Indianapolis (IUPUI) developed, was Dino Fest. Dino Fest was probably the first scientific conference - certainly the first paleontological conference - ever organized for the general public. It was also unique because its participants included commercial and amateur collectors and even a few artists, as well as scientific researchers themselves.

Dino Fest was held March 24-26, 1994 on the IUPUI campus. It evolved as it was organized over an eight month period from a plan to have a couple of guest lecturers talk about dinosaurs into a major three day conference with major exhibits, requiring the continual readjustment and expansion of design.

During the summer of 1993, Dr. Robert Hall, the Geology chairman, asked the faculty to invite a couple of dinosaur workers to campus to capitalize on the enthusiasm that "Jurassic Park" had generated. I decided to call Don Wolberg, Secretary of the Paleontological Society, first. Don had led a Geological Society of America field trip out of Santa Fe in which I had participated, and he had offered to come to campus to talk to our students about dinosaurs and other fossils he had dug up in New Mexico. Before I knew it, Don had invited some 20 of his vertebrate paleontologist friends to campus as well. Then Jim Farlow, Department of Geosciences, IUPU/Fort Wayne, suggested another dozen or so. Soon, we had 40 dinosaur hunters and researchers, Mesozoic paleoecologists, and molecular biologists committed to giving three days of talks on dinosaur origins, evolution, habits and habitats, cloning, and extinction. A steady 400 people, ranging from grade schoolers to advanced researchers and interested laypersons, attended the lectures.

One day in October, Don Wolberg called to ask if we would like to show a "few" dinosaur bones on campus during the conference. I said yes and, before I knew it, several truckloads of dinosaur bones and other fossils from around the country were headed to IUPUI's "Dino Bones" exhibit that ultimately filled two-and-a-half floors of the new campus library. Our head librarian, Barbara Fischler, didn't know what she was getting the library into when she agreed to let us display a "few" bones in the building. But she was steadfastly supportive and, along with everyone else, was thrilled when the exhibits were finally installed in beautifully illuminated halls that seemed to be designed for just such displays. (Edward Larabee Barnes, architect of the library, knows light.)

The Dino Bones ensured the success of the public outreach. We estimate that at least 40,000 people, including babes in arms and grandparents who could barely walk, students of all ages, and their teachers and parents, came to campus specifically to see the exhibits. Twenty thousand came during the four days of the Dino Fest conference alone, most in buses from the Indianapolis Public School System, and from school systems in the surrounding counties. A total of 75 thousand people, including library patrons who primarily came to use the book collection, were exposed to at least some fossil displays during their three week stay.

Dino Fest also included a Dino Feast, in which diners ate fiddleheads of fern, seaweed in the form of sushi, a salad of exotic greens including flowers and oak leaves, chicken with pine nuts, and an iridium layer cake with Pleistocene icing - while learning what dinosaurs did and did not eat, how birds evolved from dinosaurs, and why dinosaurs are not found along the Wabash. The hit of the evening was John Ostrom who riveted even the youngsters in the audience to their seats with the story of *Archaeopteryx*, the link between dinosaurs and birds. Another measure of the Feast's success was the fact that tickets, costing $10 for adults and $5 for children, were being scalped for $250 just before the performance.

Partners

The organization of, support for, and the participation in Dino Fest was an unprecedented partnership. The students, alumni, secretary, and faculty of the Department of Geology, IUPUI, devoted huge numbers of hours to the project. It was an especially challenging undertaking because, as previously stated, the originally intended couple of guest lectures grew over an eight month period into a major conference, and so required immediate responses to unfolding events as they happened; for example, the need to have a score of students on site to help unload and set up exhibits, when given only a few hours' advance notice of the fossils' arrival.

IUPUI is actually a confederation of two state universities, or parent campuses, more typically known for their academic and extracurricular rivalries. The faculty at IUPUI feel a little schizophrenic towards the parent campuses. (For example, our department awards Indiana University degrees, but administratively is in the Purdue School of Science at IUPUI.) Yet six campuses of the Indiana University and Purdue University systems and five schools at IUPUI (Science, Medicine, Dentistry, Engineering, and Liberal Arts) participated in Dino Fest. As a measure of Dino Fest's successful integration of competing campuses, a faculty member from one of the parent campuses wrote to our department after the conference to say that educational innovations such as Dino Fest could probably not originate at the parent campuses because they are too entrenched with tradition.

The Children's Museum of Indianapolis and the Indiana State Museum of Natural History also agreed to participate on very short notice. Their support consisted of loans of important specimens, assistance with set up and dismantling of exhibits, and the participation of two curators, Karol Bartlett of the Children's Museum, and Ron Richards of the Indiana State Museum, in presentations to the public.

The Indianapolis Zoo and two nurseries also loaned specimens and expertise to the Biology and Geography Departments which created a "Mesozoic Forest" in the Biology greenhouse where plants with relatives alive during the Age of Dinosaurs were shown.

Big conferences require big funding. Fortunately, Bob Hall convinced David Stocum, Dean of the School of Science at IUPUI, to guarantee funding for the conference. Indiana and Purdue University sources, in addition to the School of Science at IUPUI, included the IU President's Council, Purdue University North Central, and the Dean of Faculty Development at IUPUI. We received additional funding from the Geological Society of America (North Central Section), the alumni of the Geology Department (IUPUI), West Publishers, Wm. C. Brown Publishers, and Geraghty and Miller Corporation. Mayflower Movers transported many of the fossils to campus at cost.

The Paleontological Society agreed to help fund and publish the proceedings volume. The book will be approximately 300 pages and will have contributions by 35 of the participants.

Ameritech heard about the conference and, in addition to a generous grant, offered to broadcast a live interactive session to the Indianapolis Public Schools (IPS) via their fiber optics network and with the liaisonship of Dorothy Crenshaw, Distance Learning Coordinator of the IPS. Then NASA Lewis Research Center in Cleveland, learned of our efforts, and offered to transmit the broadcast via satellite to schools across the continent to demonstrate the future of teaching and learning via the "information skyway." Thus, the conference spread across campus, then across the city, the state, and the continent. We do know that several thousand students and teachers in schools in Montana, Idaho, Minnesota, Michigan, Ohio, New York, and Washington D.C. saw the broadcast. We can only guess at the total size of the audience.

Conclusions

Dino Fest was a success because the general public responded to it in droves and because the general public participated in it. They sat in on scientific lectures. They heard scientists debate hot topics and discuss their recent break-throughs. They brushed shoulders with scientists in the exhibits, talked to scientists, ate with scientists, and learned that scientists were just like them. Perhaps, too, Dino Fest was a success because it took place in Indianapolis, where there are few dinosaurs on display to satiate the public's appetite for them, and where such a diversity of distinguished researchers, commercial collectors, and artists had never before assembled.

Rather than the last word in scientific conferences for the general public, Dino Fest is only the first. And there is much room for improvement. For example, increased student and teacher involvement in scientific presentations and interactions with researchers would be desirable. The School of Science at IUPUI is already at work in this area. The School sponsors research mentorship programs which bring young scholars to work in labs, especially during the summer. Moreover, the School of Science has submitted proposals for funding a science learning center, which will involve the public in science as it happens, for a long time to come.

One thing is for certain; public involvement in science is essential to public understanding of it and public support for it. Everyone benefits from being a partner in science. Everyone benefits from being a partner in paleontology.

Acknowledgment

I thank Arthur Mirsky, Department of Geology, IUPUI, for his review of this manuscript.

Paleontological Initiatives and Morrison Research In The Rocky Mountain Region

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Four National Park Service (NPS) units within the Rocky Mountain Region were established primarily for their nationally significant paleontological resources, while an additional five NPS units contain paleontological and quaternary resources of worldwide significance. Paleontological resources have only been partially located, evaluated, and mapped. Research initiatives have been extremely limited and almost exclusively accomplished apart and in addition to normal duties. The following discussion and actions attempt to rectify a number of on-going problems in the Rocky Mountain Region.

The Morrison Formation of the Rocky Mountain Region is one of the most important windows scientists have into the world of dinosaurs and their associated ecosystems. Because of its varied environments, rich fossil deposits, extensive rock exposures, and broad geographic distribution, the Morrison offers an outstanding opportunity for a multipark, multi-institutional, interdisciplinary approach to the evolution of vertebrates, habitats, communities, and climate through some 10 million years of Mesozoic earth history.

The Morrison Formation has significant exposures in a number of NPS units, including: Arches NP, Bighorn Canyon NRA, Black Canyon of the Gunnison NM, Capitol Reef NP, Colorado NM, Curecanti NRA, Dinosaur NM, Glacier NP, Glen Canyon NRA, and Yellowstone NP.

Based on unpublished data and the scientific literature, there is a high probability that the Morrison in some of these units contain previously undiscovered significant fossil assemblages. Most exposures have been studied in a cursory manner. We lack the data needed for managing and protecting these resources. As a result, significant resources are likely being damaged or lost through vandalism, theft, and erosion.

Within this proposal, four related efforts are directly associated with the ecosystem level approach toward investigating the Morrison Formation and are discussed as follows:

1. A major effort to reconstruct the extinct Morrison Ecosystem will be initiated through a cooperative research effort between the NPS, US Geological Survey, and university cooperators. The scope of this effort includes Morrison Formation outcrops spread from Glacier National Park to Glen Canyon National Recreation Area.

2. Arches National Park is presently evaluating a potential boundary adjustment to incorporate a potentially significant site primarily consisting of Morrison Formation outcrops in order to more adequately protect the resources. The potential incorporation of this property is presently supported by the Bureau of Land Management and the State of Utah (State School Lands). The area presently lacks a comprehensive evaluation of the significance of the site and its potential eligibility and inclusion into the Park.

3. Curecanti National Recreation Area and Black Canyon of the Gunnison National Monument contain significant Morrison Formation outcrops, an extremely well documented Geographic Data Base, and an extremely well qualified GIS programmer and data manager. As yet stratigraphic and paleontological data have never been incorporated into a GIS data base such that spatial data can be analytically evaluated and extrapolated into a decipherable paleotopography that reveals origination and depositional

features. This work should be accomplished by means of a Geographic Positions System (GPS)/Geolink/PC combination to gather spatial information in a high-to-continuous frequency. This work will be conducted in cooperation with the Museum of Paleontology, University of California at Berkeley, California.

4. The paleontology lab at Dinosaur National Monument is the major scientific facility in a 300 mile radius around the lab. As such, it is used by park staff to provide limited technical preparation services to other state, federal, and private sector agencies and organizations. The lab suffers from equipment and facility shortages which reduce the effectiveness of preparation and presents threats to employee health and safety. Along with other laboratory facilities at the US Geological Survey and university labs, the Dinosaur lab will be utilized extensively for analytical support of the Reconstruction of Extinct Ecosystems.

Other paleontological initiatives include the following:

- In Badlands National Park, a routine followup to a visitor report of an intact fossil vertebral column soon expanded into a major paleontological discovery and emergency salvage dig throughout the summer. Located next to the road, the paleontological material was in jeopardy of being destroyed by heavy rains and runoff and was vulnerable to visitor disturbance. One complete and one incomplete subhyracodon, two or three archaeotherium, one mesohippus, one scute of a peltosaur, and two unidentified partial skeletons were soon discovered. The site has become a significant find because of the excellent preservation of the materials, the completeness of the individuals, and what may be the largest concentration of early oligocene mammals ever uncovered.

- In Fossil Butte National Monument, most research activity has occurred outside of the Monument boundaries within commercial quarries. Researchers depend heavily on the work of commercial quarriers outside the monument for both fossils and exposed stratigraphy. The development of a research quarry and interpretation within or adjacent to the Monument would provide all future scientists a stable environment to study the geology and paleontology directly associated within the Monument and provide a valuable interpretive site for visitors.

Additional items include the following:

- Partial support of the Fourth National Conference on Fossil Resources scheduled for October 31-November 4, 1994.

- Parkwide paleontological survey at Theodore Roosevelt National Park conducted in cooperation with the State Paleontologist from North Dakota.

- Support of interpretive materials oriented towards conserving and protecting paleontological resources.

- Support for continued litigation associated with loss and protection of paleontological resources.

- Paleogeological Mapping in Canyonlands National Park.

Cooperators

Active participants include research cooperators at about 19 different academic institutions as well as three different federal and three state agencies. The number of cooperators is dynamic as word of the project spreads, but for the present time a partial list includes the following institutions, consultants, and cooperators, and their contributing disciplines:

- University of Arizona - Timothy M. Demko, Field Investigator
- University of Nebraska - George F. Engelmann
- University of Utah - Thure E. Cerling
- Weber State College - S.R. Ash (Paleo plant taxonomy)
- State University of New York - S.C. Good (Freshwater bivalve taxonomy)
- Brigham Young University - B.J. Kowallis (Argon isotopic dating)
- Wesleyan University - J.S. McIntosh (Sauropod taxonomy)
- Brigham Young University - W.D. Tidwell (Fossil plant paleoecology)
- University of California - K. Chin (Coprolites)
- University of California - A.L. Deino (Argon isotopic dating)
- Carnegie Museum - A. Henrici (Amphibian taxonomy)
- University of Colorado - M.G. Lockley (Vertebrate tracks)
- Memorial University of Newfoundland - P. Ostrom (Bone isotopic analyses)
- Freie Universitat, Berlin, Germany - M.E. Schudack (Charophyte and ostracode biostratigraphy and paleoecology)
- Loma Linda University, California - P. Buchheim (Biostratigraphy, Ichthyology)
- University of California - C.L. May (Stratigrapher, GIS specialist)
- University of California - A.R. Fiorillo (Stratigrapher)
- South Dakota School of Mines - P. Bjork (Paleontologist)
- Denver Museum of Natural History - R. Stucky (Paleontologist)
- Denver Museum of Natural History - Emily Bray (Paleontologist)
- US Geologic Survey, Denver:
  Christine Turner, Project Chief and Co-investigator
  Fred Peterson, Co-investigator
  William M. Aubrey, Co-investigator
  S.T. Hasiotis (Non-marine trace fossils and tracks)
  R.M. Forester (Charophyte and ostracode paleoecology)
  Janet Brown (Research Geologist)
  Russell Dubiel (Research Geologist)
- US Geological Survey, Reston, VA - Palynologist
- Bureau of Land Management
- US Forest Service
- State of North Dakota, State Paleontologist
- State of Utah
- State of Wyoming

National Natural Landmarks: Tool for Protection of Paleontological Resources

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The 23 designated paleontological National Natural Landmarks (NNL) in the western states epitomize two conference themes: "Partners in Paleontology" and "Strategies for Protection."

As partners in paleontology, the National Park Service (NPS), through 10 regional coordinators, administers the NNL program. Regional coordinators meet with landowners (other Federal, state, county, or private), visit the NNLs and discuss any threats or damages to the sites. Through the annual "Section 8" report to Congress, the NPS has a vehicle to bring attention to actions that may adversely affect these nationally significant sites. The annual report, resulting from site inspections, "Damaged and Threatened National Natural Landmarks," is a major tool in the strategy for protecting these significant resources.

An NNL is a nationally significant natural area that has been designated by the Secretary of the Interior. To be nationally significant, a site must be one of the best examples of a type of biotic community or geologic feature in its physiographic province; for example, fossil evidence of biological evolution. It is a goal of the program to identify, recognize, and encourage the protection of sites containing the best remaining examples of ecological and geological components of the nation's landscape. Landmarks are designated on both public and private land, with the program designed to have the concurrence of the owner or administrator. As of June 1990, 587 sites had been designated as National Natural Landmarks; 23 of these are paleontological resources in the western states.

The United States, Puerto Rico, the Virgin Islands, and the Pacific Trust Territories were divided into 33 natural regions or physiographic provinces. Contracted ecological and geological theme studies of these regions (generally completed by qualified university scientists) have produced an inventory of more than 3,000 potential sites for further evaluation. This inventory is maintained by the NPS National Natural Landmarks Program. Additional sites can be added through the initial recommendation of outside groups or individuals.

The NPS then contracts with other scientists to conduct on-site evaluations of those sites which are ranked highly in the theme of studies, or from other recommendations. The evaluations gather more information and comparatively evaluate the site in question against other similar sites, using the NPS NNL national significance criteria. The determination that a site is one of the best examples of a particular feature in a given natural region is based on the primary criteria of illustrativeness and condition of the specific feature, and secondary criteria of rarity, diversity, and values for science and education. Completed on-site evaluation is then made by NPS staff, based on all available information, as to whether the site appears to qualify for NNL status.

Following a 60 day comment period, NPS reviews all information on the site to determine if it still qualifies for NNL designation and that all procedural requirements have been met. The Director of the NPS then nominates those sites which he/she believes are qualified to the Secretary of the Interior for designation. Areas which the Secretary designates as NNLs are listed on the National Registry of Natural Landmarks.

Under current NNL program regulations, owners of sites being considered for NNL status should be contacted at three points in the process. Prior to the on-site evaluation, owners are notified that the area is being considered for study for possible NNL designation. When the NPS has determined, following the review of the on-site evaluation, that the site appears to qualify for designation, the owners are notified again. In addition, notice is given to State officials, Congressional representatives, and other individuals or organizations that have expressed interest in the site. In addition, general public notice of the proposed action is also placed in the Federal Register for a 60 day comment period.

Management and Protection of National Natural Landmarks
NNL designation is not a land withdrawal, does not change the ownership of a site, and does not dictate activity. Landmark preservation is made possible through the long term, voluntary commitment of public and private owners to protect an area's outstanding values.

Report on Damaged and Threatened Natural Landmarks
The NPS monitors the condition of designated NNLs and each year is required by law to prepare a report for the Secretary to transmit to the Congress identifying all designated NNLS with known or anticipated damage or threats to the integrity of their resources and the sources of such threat or damage. NNLs which are determined to have lost the values which originally qualified them for designation may be removed from the National Registry of Natural Landmarks. To date, no site has been removed from the Registry due to listing in this report.

Research au Temps Perdu: Keeping the Past for the Future

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Problems of Fossil Specimen Conservation
Poor treatment, documentation, storage, and handling of fossil material have caused significant losses to the discipline and to the public. Many methods and materials in common use are untested and cause serious deterioration of fossil material over time. Preventive conservation of fossil resources and the information they represent begins at the time of exposure and continues, ideally, forever. With the heightened interest in the biogeochemical nature of fossils, as well as in their morphology, workers responsible for the care of these materials should be taking a hard look at what they are doing and why, in order to prevent destroying some aspects of a fossil in order to save others which may be less important. This presentation reviews the principles of preventive conservation, including suggestions for treatment, storage, consolidation, archival protection and handling, and sources of technical information.

Terminology
In this presentation, **preservation** refers to the natural substances and processes of fossilization. **Conservation** refers to the methods and materials used to ensure and extend the existence of the fossil, from first exposure through its tenure in a collection. Conservation can be further divided: **preventive conservation** refers to the approaches used to eliminate or mitigate problems with the fossil; **interventive conservation** refers to the processes used to repair or restore the fossil in response to problems which have already occurred.

Preparators and conservators both use the term "reversible," but not in the same way, leading to some misunderstandings. Preparators use the term to mean that a treatment can simply be undone; this is not the same as true reversibility for conservators, who use the term to mean that a treatment can not only be undone, but will leave no trace of chemical contamination or physical change. In this presentation, **reversibility** is used in the conservator's sense.

MATERIALS
Many materials are commonly used in fossil conservation, often without good understanding of what they are or what effects they may have on the material. Preparation/conservation techniques can in many cases be traced back to a time when all fossils were routinely prepared as if they were going on exhibit, the exhibition function of the museum being its main or only function. Today, some 85-95% of specimens are never intended for exhibit, yet they are still treated with materials which have, at best, only a short term cosmetic function and no long term value at all. Detailed materials lists will be available as handouts at the presentation.

Adhesives and Consolidants
The most commonly used materials in fossil conservation, these are natural or synthetic polymers used to adhere or cohere parts of a fossil together. They may have a solvent base or carrier to aid penetration and speed setting time. Many adhesives in common use are proprietary compounds purchased off the shelf, an approach which has led to very inappropriate compounds being used.
Characteristics to check:
- Potential for cross-linking and shrinkage.
- Potential for yellowing and staining.
- Embrittlement over time.
- Glass transition temperature for thermoplastic materials
- Chemical and physical reactivity.
- Solubility.
- Volatility.
- Ease of application and removal.

Recommended: Adhesives in pure form which can be mixed to specifications at the time of use.

Surface Coatings
Again, natural or synthetic polymers used to seal, cohere, or affect the appearance of a surface, including lacquers and varnishes, paints, waxes, and the like. May also have solvent bases or carriers.
Characteristics to check:
- Same as listed for adhesives and consolidants. May also be thinned down solutions of adhesives.

Gap Fillers
Materials combining adhesion with bulk, used to fill in missing parts of a fossil in order to recreate an interpretation of appearance in life. Most valuable for exhibition purposes; for research material, valuable as enhancement, but may be damaging as new information changes interpretations. May be pigmented or painted.
Characteristics to check:
- Weight.
- Brittleness.
- Ease of application and removal.
- Other characteristics as listed under adhesives.

Recommended: Lightweight, inert materials which can be easily removed without damaging the specimen.

Acids, Bases, and Other High-grade Chemicals
Used in laboratory preparation and development to remove a fossil from a tough matrix of differing composition, or to treat a fossil. Require good training and protective equipment. Potential for serious damage to human health and safety is high, as is threat to specimen integrity. Improper use or inadequate neutralization can destroy fossil material.
Recommended: Training, good safety precautions, and limitations on use.

Supports and Armature
Overlapping to some extent with storage materials, these are the materials used to support a specimen and/or to secure it in a desired position. Characteristics to check: chemical reactivity; long term aging characteristics (including corrosion); and intrusiveness.

Molds and Casts
A wide variety of materials may be used in the production of molds and casts including polymers, solvents, plaster, fiberglass, and other materials alone or in combination.
Characteristics to check:
- Nature of the separator compound directly applied to the fossil.
- Potential for heat liberation during reaction.
- Long term aging characteristics as listed under adhesives.

Mold making almost always leaves chemical traces behind in the original fossil.

METHODS
All the procedures used to get a fossil from the stratum to the collection storage system are grouped under this heading.

Field Exposure
Dependent on nature of matrix; may be very gentle or may require explosive or percussive work. The specimen may be weathered at the surface already and thus vulnerable.
Considerations:
- Fragility of material.
- Induration of matrix.
- Training of staff and crew.
- Access.
- Safety.

The most intrusive and destructive methods should be reserved only for the situations which cannot otherwise be resolved.

Packaging and Transportation
The suite of processes including jacketing, overturning, and hauling. Jacketing materials may double as long term storage materials and so should be carefully selected.
Considerations:
- Weight
- Durability and ease of use of jacketing materials.
- Training.
- Careful planning.

Laboratory Preparation-Development
General heading for all processes associated with matrix removal and specimen exposure. Often inappropriate use of materials here.
Considerations:
- Research use of material.
- Storage limitations on size and weight.

Should not, but often does, include restoration of missing areas or appearance.

Restoration
The processes, including adhesion/consolidation, gapfilling, and surface application, used to recreate an interpretation of life appearance. Should never be permanent or irreversible. Often unnecessary unless cosmetic enhancement is sought. May adversely affect research uses.

DOCUMENTATION

A specimen should have a complete information history permanently associated with it through files or databases. Increasingly, a specimen without key information is considered scientifically worthless. There are two considerations here: **type** and **storage** of information.

Types of Information - Data Required

- Site and stratigraphic setting with coordinates.
- Collecting and collector information.
- Copies of permits and authorizations.
- Maps, graphs, sketches.
- Field notes.
- Identification; photographic records.
- Taphonomic and biotic associations.
- Treatment history, including changes to specimen whether deliberate or accidental.
- Collection and institution records numbers.

Also valuable are original labels and other holographic records.

Storage

The materials commonly used for records have very different characteristics from those of fossils and should, for the sake of both permanence and security, NEVER be stored with the specimens. While magnetic media (disks, videos, tapes) may be used and copied, they are not archivally durable. Hard copy on acid-free paper has no substitutes. Photographic material also has a limited life; color prints are very fugitive. Color slides persist best in very cool and dark storage. Black-and-white prints last longest but are still sensitive. It is wise to set up off-site fireproof storage of all original records and documents, and to use good quality copies in day-to-day collections management. Field notes are the property of the institution sponsoring the work and archivally sound copies should always be accessible. Records should be stored in nonacidic conditions.

STORAGE SYSTEMS

Ideal storage starts with the ideal building and works inward. In the absence of the ideal building, good storage starts with the materials directly in contact with the fossil and works outward.

The Drawer

The drawer and any dividing trays or boxes should be nonacidic. This usually means no wood or wood products, though old wood may be made acceptable through surface coatings. Fossils should be padded with an inert, closed-cell foam, never directly in contact with a drawer or box surface, never allowed to roll around or to abrade other specimens. Labels should be displayed so that they can be read without moving or handling specimens. Holographic labels of historical value should be removed to off-site document storage. Volatile plastics should be avoided.

The Case or Shelf System

Ideal: steel case with powder paint finish, excellent gaskets. Not advised for very large and/or heavy material. Surface coated metal is generally preferred over wood systems. Open shelving should have dust protection, as acidic particulates can contaminate fossil surface coatings and set up damaging reactions. Steel cases are expensive but worthy investments.

The Room

Considerations:

- Control of temperature and relative humidity.
- Control of UV radiation.
- Amount of unnecessary light.
- Ease of cleaning under as well as around cases.
- Isolation of eating, preparation, and office machine areas from collections storage.
- Pest monitoring and management.
- Safety equipment and ease of evacuation.
- Floor loading capacity.
- Security and access.

The Building

Considerations:

- Security and access.
- Internal environmental control systems.
- Safety of lab equipment venting and control systems.
- Pest access.
- Isolation of functions.

Enduring Stories: Themes, Goals, and Objectives for Fossil Resource Interpretation

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I can remember being approached by a visitor while working at the front desk on a slow afternoon at John Day Fossil Beds National Monument. He inquired about the size of our staff, and, when I replied, he scowled and stepped back, stunned and confused. Who else did we need besides me at the front desk, the maintenance worker mowing the lawn, and, perhaps, an extra person to answer the mail and step in while I had lunch? We have all experienced the challenge. While this vacationer was an extreme example, most visitors to a managed paleontological resource have a very vague idea of the work that gets done, the continuing responsibilities involved in managing the resource, and the people necessary to do it.

Confronted with this lack of understanding by the public that supports us, public contact staff and resource managers can find themselves in a defensive, reactive, and adversarial position unless organizational goals, interpretive themes, and program objectives have prepared them to present the resource message in a clear, coherent, and cost effective way to the diversity of publics that interact with the resource.

Interpreters in the National Park Service specifically define **"goals, themes, and objectives"** in an effort to ensure that:

- We clearly understand internally what values we associate with our resources.
- We understand what key messages we mean to convey to the public regarding those values.
- We can articulate what new competencies the recipients of our interpretive services could demonstrate as a result of our efforts.

We define "goals" as general statements of what we intend to accomplish as a result of our public service program.

This program includes not only exhibits, displays, publications, and personal services, like guided walks and interpretive talks but also more subtle components of communication, such as how we respond to criticism, how we design and manage our physical plant, and how and to what degree we provide outreach services to the community, such as our relations with schools, service organizations, and neighbors. Goals are expressed in general terms addressing broad concepts we hope to convey to the public and the influence such changes may have on public opinion, attitude, and outlook. Often, goals express our desire for the public to understand, appreciate, value, and protect resources by supporting, communicating with, and even participating in the management of those resources.

The management unit as a whole articulates goals regarding public information and interpretation. Individual services also have goals. Examples of individual service goal statements for an exhibit or a live program, for instance, might include:

- To instill an understanding of the necessity of methodical, scientific excavation.
- To inspire an appreciation for the history of life ascertained by fossil study.
- To stimulate a desire to protect and preserve fossil resources.

These are valid goals, but without more tools it would be challenging to quantitatively test how successfully a program or individual service is accomplishing such goals.

Theme statements are defined as single, declarative sentences that express a central idea we are trying to convey. Once again, a set of interpretive theme statements is developed for each management unit, so as to clarify the core body of information we wish to relate to the public. Each interpretive service is built around only one single theme statement. (Themes should not be confused with topics, which are usually one or a few words indicating the general area or subject addressed in a program. Any topic can suggest a number of theme statements.) Whether for a display or a guided walk, building an interpretive service around a single clear interpretive theme has many advantages. Foremost, it provides direction towards a meaningful target. We enjoy considerable depth of knowledge about our resources. When communicating with the public, we can easily drift into a prolonged stream of consciousness that may be entertaining to visitors, but may not be particularly interpretive. Hewing to a sound theme guides the design and preparation of interpretive services so that they address goals and accomplish objectives, rather than just conveying reams of data. When presented with theme based interpretation, it is much easier for visitors to come away with a clear grasp of the seminal meaning and value of the resource. This encourages them to explore and develop their own feelings of relatedness to the resource, rather than overloading them with "factoids." Examples of themes around which services could be built include:

- The "life history" of a fossil consists of three sets of events.
- The fragile fossil deposits here were preserved by layers of harder rock.
- The scientific value of fossils is strongly dependent on associated data.

One of the most challenging aspects of resource interpretation is objective analysis of the effectiveness of the program. How do we know which of our programs truly succeed in affecting the visitor and to what extent? Other disciplines are more clear cut. If we close a trail, there are direct methods we can use to document the rate and nature of revegetation. If we establish parking regulations, it is a simple matter to check citation records to document public compliance. Interpretation, with more ambitious goals relating to enriching the lives of visitors and cultivating their personal sense of resource stewardship, faces a more sophisticated challenge in effecting and documenting change.

In the National Park Service, we have borrowed the techniques of developing and measuring behavioral objectives from the field of education. **We define behavioral objectives as measurable changes in the competencies of visitors experiencing our programs**; competencies we could actually test for and measure, though in fact we seldom do so directly. **Objectives differ from goals in that they are action oriented and result in concrete, observable changes.** They are usually written employing the form, "After experiencing this program/service, visitors will be able to..." Wording is specific and clear, rather than broad and general. A program's goal might be, "To instill an understanding of the necessity of methodical, scientific excavation." With no more specific direction than that, it would be quite challenging to determine to what degree this "understanding" is instilled, or even what we mean by "understanding." Specific, measurable objectives for this same program might be as follows.

After having experienced this exhibit, visitors will be able to:

- List at least three kinds of data important to collect with specimens at an excavation.
- Describe how specimens and data are collected and preserved at this site.
- State at least two scientific questions being investigated and/or hypotheses currently being tested using the data and specimens that have been collected here.

In a post-visit interview, we could actually test for these behavioral objectives and quantify the success of our program based on achievement. If the objectives are sound and meaningful, their achievement should be a strong indicator that we are moving towards the accomplishment of our goal. Some have criticized programs designed to accomplish a few simple, measurable objectives. These, they argue, trivialize and oversimplify truly complex messages. They trivialize, I think, only to the extent that the stated objectives are poorly written and fail to relate to goals. As for oversimplification, I will hold with John Ruskin who said in 1843, "The greatest thing a human soul ever does in this world is to **see** something, and tell what it saw in a plain way... To see clearly is poetry, prophesy, and religion, all in one."

In this way, themes, goals, and objectives provide a methodology for stating what we hope to accomplish, measuring our success, and evolving our program over time to improve effectiveness. The fact that we seldom confront our visitors with pop quizzes does not weaken the logic of the approach. That we have done our homework and developed a diverse program beforehand with specific goals and objectives in mind will go a long way towards making secondary evaluation relatively easy. Good teachers can successfully predict test grades for their students long before they sit down with their red pencils. Similarly, interpreters can measure program success by observing subsequent visitor behavior, listening to their questions, and noting their responses both oral and written. Without such mileposts, it is impossible to measure success, since you have never defined it.

I believe effectiveness in interpretation of paleontological resources can be significantly enhanced if those of us involved in the management of such resources look for common and meaningful goals, themes, and objectives. Such an exchange of ideas between each site's administrators, interpreters, scientists, and law enforcers, as well as between areas and agencies, will help us develop visitor experiences fostering an environmentally and socially responsible evolving world view. That will have positive consequences far beyond the appreciation and protection of fossil deposits. One needs to look no further than the evening news to conclude that human society is not in tune with some simple physical principles, like the first two laws of thermodynamics. While we may be excused from shouldering full responsibility for "Saving the Earth" (a euphemism for pulling our own hominid hides back from the edge of the cliff), there is no question that the exhilaratingly long view we are privileged to study affords us the opportunity to significantly enhance the perspectives of our fellow travellers. It is cliche, but axiomatic, that, "You can't know where you're going if you don't know where you've been." Paleontology is a singularly descriptive science. By sharing our stories, and strategizing how best to share them with those outside the profession, we maximize our likelihood for survival personally, professionally, and societally. Peter Steinhart wryly observed in 1985, "Science is taught as if its aim were to produce scientists, not citizens who must mediate complex conflicts between biology and culture." That is the challenge of interpretation.

Themes, Goals, and Objectives for Fossil Resource Interpretation - What Do We Mean By That?

Topic

The general subject of your program. Usually one or two words.

Examples

- Fossil Fishes
- Volcanic Ash
- Fossil Leaf Prints

Theme

- The central idea of your program.
- Expressed as a single, declarative sentence.
- The "take home" message you want to convey to the public.
- Guides the design and preparation of your program.
- Eliminates trivia and extraneous material.

Examples

- The "life history" of a fossil consists of three sets of events.
- The fragile fossil deposits here were preserved by layers of harder rock.
- The scientific value of fossils is strongly dependent on associated data.

Goal

- What you hope to accomplish with your program.
- Changes you hope will occur in visitors' minds (their opinions, attitudes, philosophy).
- Broad concepts, expressed in general terms.
- Usually not communicated verbatim directly to the audience.

Examples

- To instill an understanding of the necessity of scientific excavation.
- To inspire appreciation for the history of life ascertained by fossil study.
- To stimulate a desire to protect and preserve fossil resources.

Objective

- A statement of specific measurable changes in the visitor resulting from your program.
- A statement that measures whether you are moving towards your goal.
- Usually uses the format: "By the end of this program, visitors will be able to:"

Examples

"By the end of this program, visitors will be able to:"

- Name three stages in the "life histo[ry]" of a fossil.
- Define the term "taphonomy."

"By the end of this program, visitors will be able to..."

- Generally describe the fossiliferous and non-fossiliferous strata here.
- Discuss how the former were protected from erosional loss by the latter.

"By the end of this program, visitors will be able to..."

- List at least three types of data collected with specimens.
- Generally describe the process of specimen and data collection here.

The Fossil Collections in the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution: Content and Use

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The National Collections housed in the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, constitute a vast resource both for science and for public programs.

The origins of the Department of Paleobiology go back to at least 1858 when the Smithsonian Institution acquired specimens of the United States Exploring Expedition (Wilkes, 1838-1842). This was also the year that the great paleontologist F.B. Meek came to Washington to live in the "Castle", the Smithsonian headquarters building constructed between 1847 and 1855.

The paleontological collections (consisting primarily of specimens received from the Wilkes Expedition, General Land Office, and later the National Institute) were first housed in the Castle, but it soon became apparent that more space was needed. In 1882, the collections were shifted to the new US National Museum (now the Arts and Industry Building), where they stayed from 1881 to approximately 1910. In 1897, the US National Museum (USNM) was organized into three Departments, Anthropology, Biology and Geology. The new Department of Geology was responsible for paleontology, petrology, and mineralogy collections of the Smithsonian. It was not long before the collections again became too crowded and money was allocated to build a new museum. The new building was completed in 1909. By the close of 1910, the Department of Geology, with its paleontology, mineralogy, and petrology collections, had been moved in. After a new wing was added to the National Museum of Natural History in 1963, the Department of Geology was split into two new departments, Paleobiology and Mineral Sciences.

Paleobiology's current holdings are estimated to be in excess of 40 million specimens. Collections are maintained to house type, reference, stratigraphic, research, field, and teaching specimens. In all, there are more than 450 separate collections, mostly arranged taxonomically. In addition, the Department maintains a collection of over 50 thousand sediment samples collected primarily from the United States. Most Department collections are housed at the National Museum on the Mall, but some are also stored at the Museum Support Center in Suitland, Maryland.

The Department's rate of acquisition fluctuates, but collections continue to grow steadily. Some growth is generated internally as our scientists participate in active field work. But, in large part, the growth results from our serving as a nationally recognized repository. Certainly from our earliest years, many U. S. Government agencies have used the Smithsonian as a repository.

Since its founding in 1879, the US Geological Survey has transferred a large volume of collections to the Smithsonian and their paleontologists have served as affiliate curators. Under the Organic Act (1879), Congress designated the Smithsonian Institution as the national repository for all specimens no longer needed for current research collected by US Government agencies.

Our collections also grow from the acquisition of orphaned collections, private donations, and as a result of providing 6,000 to 8,000 new catalogue numbers annually for type specimens awaiting publication. It should be noted that the majority of the newly designated type specimens were collected within the United States and represent the work of scientists at universities as well as US Government agencies.

Providing accessibility to, and accountability for the National Collections is a prime responsibility of the Museum and Department Collections Management Programs.

Access to specific collections can be arranged by contacting the staff member with collection responsibility or the Collections Manager of the Department. Indeed, Paleobiology annually hosts between 250 to 300 or more professional investigators, ranging from senior foreign scientists to graduate students. Individual visits can last from a single day to a full year.

Another important avenue for providing access to collections is our loan program. From the period October, 1992, to the present (1994), 277 loans consisting of 11,666 specimens were lent to scientific organizations for the purpose of study. Many of them were type specimens.

Access to collections is also provided by outreach programs such as exhibits and the identification of fossils.

On average, the National Museum welcomes 8.5 million visitors annually. The first stop for the vast majority of the visitors are the paleontology halls. The Associate Director for Public Programs estimates that at least 80% of all Museum visitors, 6.8 million people, tour the various permanent exhibits featuring vertebrate, invertebrate, and paleobotanical fossils. Temporary exhibits that feature staff preparing fossil vertebrates out of the matrix or exceptional specimens recently acquired by the Museum also offer the public opportunities to view fossil specimens in the National Collections.

Paleobiology also provides service to the public through staff examination of specimens sent in for identification and report. From October, 1992, to the present (1994), Paleobiology received 748 specimens in a total of 64 separate transactions for identification and return. Additional paleontological specimens were received by the Museum's Naturalist Center and identified either by trained volunteers or by Department of Paleobiology staff.

Other public outreach efforts include, but are not limited to, active participation in local and regional fossil and career opportunity fairs. Such events afford Paleobiology staff the opportunity to share knowledge about the Museum, its collections, and paleontology in general with the community.

- The principal method to provide accountability for collections is through the requirement that all st visitors, interns, and volunteers strictly adhere to the Smithsonian Institution, National Museum of Natural History, and Department of Paleobiology Collections Management Policies. These regulations, guidelines, and protocols were developed with the intention of providing the proper level of care and documentation for all specimens and objects housed in the National Museum. Paleobiology's Collection Management Policy provides specific guidelines for:

- Accessioning.

- Documenting and tracking outgoing loans.

- Documenting and tracking incoming loans borrowed by our staff.

- Recording and tracking incoming unsolicited specimens or objects (e.g. specimens sent for identification).

- Staff and visitor access to the collections.

- Care and control of collections.

- Deaccessioning specimens and objects.

- Building and maintaining specimen inventories.

- Handling requests for destructive analysis.

- Staff conduct.

In the situation where no guidelines exist, the Office of the General Counsel, Smithsonian Institution is consulted.

Accountability as well as access is provided through the building and maintaining of automated collection databases. Currently, 7.3 million specimens housed in either type, reference, or stratigraphic collections have been catalogued at the item or itemized lot level in more than 500,000 computerized records. For type and reference collections, the amount of information (e.g. stratigraphic, detailed locality) associated with each specimen's record varies depending on when the specimen was catalogued into the automated system.

The Department began to automate type specimen information in 1969 and, until around 1980, scientific, stratigraphic, and locality data was also captured. In the early 1980's there was a great push to inventory all type and selected non-type collections. Because the large job was to be completed in three years, the Museum's emphasis shifted to capturing a subset of the information associated with each specimen or specimen lot, rather than all the data available. As a result, approximately one-third of our type and reference collection data base consists of "short" records, having at a minimum the USNM catalogue number, scientific name, author of the species/subspecies, type designation, number of specimens, and the name of the collection housing the specimen(s), but no stratigraphic or locality data. Now the Department is in the process of fleshing out the "short" records and will continue to do so until all the records have been amended. In the meantime, we continue to enter new specimens into the database. In 1993 we added in excess of 11,000 records, capturing scientific, stratigraphic, and locality data for more than 40,000 specimens.

To summarize, the Department of Paleobiology serves as the repository for the taxonomically diverse National Collections of fossils. It has served in this function since April 28, 1859 when the first specimens were officially catalogued. We have enjoyed a very cordial and reciprocal relationship with other government agencies, especially the US Geological Survey, housing their paleontologists from 1882 to the present. This relationship has allowed our collections to grow and, in turn, provided an incalculable resource to the outside scientific community and the public.

The Upper Jurassic Morrison Formation at Dinosaur National Monument, Utah and Colorado: The Geologic Setting for Vertebrate Paleontological Resources

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A multidisciplinary research project was focused on the Upper Jurassic Morrison Formation in and near Dinosaur National Monument (DINO) to gain a better understanding of the Monument's vertebrate paleontological resources. The study was undertaken by the US Geological Survey in cooperation with the National Park Service (NPS) and was directed toward understanding the geologic setting of the dinosaur remains at DINO and their relation to other Late Jurassic dinosaurs. The research objectives were to establish the stratigraphic, sedimentologic, and geochronologic framework for the Morrison Formation within the Monument and to relate the vertebrate fossils there to the biostratigraphic framework of other important vertebrate fossil bearing localities in the Morrison elsewhere in the Western Interior of the US (Turner and Peterson, 1991, 1992). The study was done concurrently with a paleontological survey of the Morrison in DINO by G.F. Engelmann.

Stratigraphy

The **Morrison Formation** is 182-218 m thick at DINO and consists of four members described below in ascending order.

The **Windy Hill Member** is a thin basal unit 0.5 to 6.4 m thick consisting of glauconitic sandstone. The regional J-5 unconformity at the base separates it from the underlying Redwater Member of the Stump Formation.

The **Tidwell Member**, about 2-13 m thick, consists of gray mudstone and minor thin sandstone. Important features are a marker zone of authigenic red chert (called "welded chert") that is widespread throughout the southern part of the Western Interior, and a thin bentonite bed below the chert.

The **Salt Wash Member** is largely a sandstone unit about 56-96 m thick that is pebbly or locally conglomeritic in the upper half of the member in the western part of the Monument. Thin beds of red or green mudstone or rare gray mudstone are also present. Most of the sandstone beds in the eastern part of DINO are better sorted and lack pebbles.

The **Brushy Basin Member** consists of red or green mudstone and is divided into two parts. The thin lower part, about 12-22 m thick, consists largely of nonswelling clays (illite) and scarce sandstone beds. The upper part, about 88-134 m thick, consists largely of swelling clays (smectite) and includes scattered sandstone beds in about the upper half. The abrupt vertical change in dominant clay minerals is an important stratigraphic marker horizon found throughout most of the southern Western Interior. At DINO, the quarry sandstone interval is about in the middle of the upper part of the member and consists of superimposed fluvial channel sandstone beds, one of which is the main dinosaur bone bearing bed at the Carnegie Quarry. The regional K-1 unconformity separates the Brushy Basin from the overlying Lower Cretaceous Cedar Mountain Formation.

The Morrison at DINO is correlated with the Ralston Creek and Morrison Formations at their type localities near Denver by stratigraphic markers and similar lithologies and sequences of beds.

Sedimentology

The Morrison Formation was deposited in a variety of continental environments, although the basal beds were deposited in marine waters. Sandstone beds of the Windy Hill Member contain bivalves, dinoflagellates, and glauconite, all of which suggest deposition in marine environments. Some of the scarce, thin sandstone beds in the lower part of the Tidwell Member contain glauconite, suggesting marine deposition, whereas mudstone beds higher in the member contain spores and pollen that suggest nonmarine depositional environments. In southeastern Utah, the Tidwell contains scarce fluvial sandstone beds or interfingers with fluvial strata of the Salt Wash Member. These features suggest that the Tidwell was deposited on broad mudflats crossed by rare streams or, at the base, in marginal marine environments. The Salt Wash Member in western DINO was deposited by braided streams on a broad alluvial plain. The streams flowed roughly southeast across DINO and originated in a highland source area in northwestern Utah and nearby areas. A few gray mudstone beds contain plant fossils suggesting deposition in small ponds or lakes in abandoned stream channels. Red or green mudstone beds were deposited on floodplains adjacent to the stream channels, and rare thin limestone beds containing charophytes (green algae) and ostracodes were deposited in small lakes or ponds on the floodplain. At Deerlodge Park in eastern DINO, most of the sandstone beds contain textural features suggesting deposition by eolian processes. Several beds at the base of the Salt Wash in this area were deposited by streams, and fluvial strata completely replace the eolian beds a few km south of Deerlodge Park.

The abundant mudstone beds in the lower part of the Brushy Basin Member reflect a stratigraphically upward change to depositional environments dominated by mudflats and scarce streams. During deposition of the thick upper part of the member, explosive volcanic eruptions became common 1,000 km or more to the southwest along the southwest margin of North America. Abundant ash from the volcanos was carried by wind to the Colorado Plateau where it was devitrified and altered to smectite, a clay mineral that swells when wet. Numerous thin beds of bentonite in this part of the member represent beds of nearly pure volcanic ash. Lacustrine fossils suggest deposition in small scattered lakes and ponds, whereas locally common root impressions and paleosols suggest subaerial exposure on an alluvial plain. The uppermost part of the member contains fluvial sandstone beds, suggesting that streams became somewhat more common toward the end of deposition of the member. Scattered vertebrate remains and a recently discovered dinosaur embryo (Chure and others, 1994) suggest well established animal communities and, perhaps, dinosaur nesting grounds.

Geochronology

The Late Jurassic Epoch extends from 141 to 157 Ma and is divided into three parts; from oldest to youngest these are the Oxfordian, Kimmeridgian, and Tithonian Ages. Feldspar grains separated from bentonite beds were analyzed using $^{40}Ar/^{39}Ar$ dating techniques. J.D. Obradovich (in Peterson, 1992) obtained a date of 154.9±1.5 Ma from a bentonite bed in the Tidwell Member. Kowallis and others (1991) obtained five dates ranging from 145.2±1.2 to 149.4±0.7 Ma from several bentonite beds 30 m or more below the top of the Brushy Basin Member in southeastern Utah. Using these dates as guides, the formation is about 145-155 Ma in age. Studies of age diagnostic plant microfossils indicate that the formation ranges from the latest Oxfordian, through the Kimmeridgian, and probably into the early Tithonian (M.E. Schudack and R.J. Litwin, oral communications, 1994).

Biostratigraphy

Over a hundred dinosaur quarries in the Western Interior were examined and positioned stratigraphically to determine the biostratigraphy of Morrison dinosaurs. Most of the quarries are just above or just below the change in dominant clay minerals in the Brushy Basin Member. These studies show that the dinosaur fossils recovered from the Carnegie Quarry at DINO are younger than most, but not all, of the Morrison dinosaur fossils recovered from elsewhere in the Western Interior.

Paleontological Resource Management

In this research endeavor we took advantage of new discoveries to contribute to NPS resource management and inventory needs as well as public education programs. The study also supported the broad program goal of preserving and protecting all the fossil resources in DINO.

Detailed sedimentologic studies revealed two other localities within 2 km of the Carnegie Quarry that should also yield abundant fossilized vertebrate bones. Our studies also suggest that no significant amount of fossils will be found below the level of the floor of the quarry building. Earlier workers thought that the bones at the Carnegie Quarry were originally deposited on a sand bar on the side of a stream channel. However, this study demonstrated that most of the bones were deposited on the bottom of the stream channel. This changes previous concepts and adds new information for public education programs. Interpreters advise visitors of the on-going research and new discoveries as soon as they occur, resulting in a positive experience as the visitors feel that they are in a park where exciting research is in progress. Other interpretive impacts of this project are the necessity to revise museum exhibits to reflect the new knowledge, improved accuracy of NPS interpretive programs, and a planned interpretive trail that will provide visitors with greater insight into the dinosaur bearing Morrison Formation.

As a result of this research, DINO contains some of the best studied exposures of the Morrison Formation in the Western Interior. This will attract researchers to do additional work in and near the Monument. The area will be a critical reference locality for future researchers working on Upper Jurassic strata in the Western US, or studying Late Jurassic paleontological problems on a national or global scale. Thus, the project was important to NPS resource management objectives and to the international scientific community.

References

Chure, Daniel, C. Turner, and F. Peterson, 1994, An embryo of *Camptosaurus* from the Morrison Formation (Jurassic, Middle Tithonian) in Dinosaur National Monument, Utah: Carpenter, Kenneth, Hirsch, K.F., and Horner, J.R., (eds.), Dinosaur Eggs and Babies: Cambridge University Press, Cambridge, pp. 298-311.

Kowallis, B.J., E.H. Christiansen, and A.L. Deino, 1991, Age of the Brushy Basin Member of the Morrison Formation, Colorado Plateau, western USA: Cretaceous Research, v. 12, pp. 483-493.

Peterson, Fred, 1992, Chronology of the Jurassic System in the Western Interior Basin: Society for Sedimentary Geology, SEPM 1992 Theme Meeting, Mesozoic of the Western Interior, Abstracts volume, p. 53.

Turner, C.E., and F. Peterson, 1991, Sedimentology and stratigraphy of the Morrison Formation in Dinosaur National Monument: Plumb, G.E., (ed.), 15th Annual Report, University of Wyoming-National Park Service Research Center, pp. 91-93.

Turner, C.E., and F. Peterson, 1992, Sedimentology and stratigraphy of the Morrison Formation in Dinosaur National Monument, Utah and Colorado: U.S. Geological Survey, Annual Report for the National Park Service, 80 pp.

Colorado Natural Areas Program: Geologic Features and Paleontological Resources

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In contributing to the protection of Colorado's natural heritage, the Colorado Natural Areas Program (CNAP) has incorporated sites with unique geologic features and paleontological resources into Colorado Natural Areas. Once designated, these areas are managed to protect their natural features and to promote scientific research and educational opportunities.

Program Mission

CNAP was created by an act of the Colorado Legislature in 1977 and reauthorized in 1988. The Colorado Natural Areas Act directs the Board of Parks and Outdoor Recreation to administer CNAP with the advice of the Colorado Natural Areas Council. Under the Act, CNAP's mandate is to:

- Identify, evaluate and protect examples of Colorado's natural heritage.
- Maintain an inventory and registry of qualified natural areas.
- Establish a system of designated natural areas.

Natural Area Identification, Registration and Designation

The Act defines a "natural area" as "a physical and biological area which either retains or has re-established its natural character, although it need not be completely undisturbed, and which typifies native vegetation and associated biological and geologic features, or provides habitat for rare or endangered animal or plant species, or includes geologic or other natural features of scientific or educational value."

Information on potential natural areas is collected during on-site inventory and background research, a process which utilizes a broad network of natural resources professionals, members of diverse organizations, and individuals. Public and private lands are eligible for nomination as Colorado Natural Areas. The Natural Areas Council reviews reports prepared by CNAP and considers sites for registry as Colorado Natural Areas.

High priority sites approved for registry may be selected for possible designation as Colorado Natural Areas. In addition to assessing ecologic and physical attributes of the site, CNAP staff review specific management criteria in preparing Draft Articles of Designation. Steps involved in designating a natural area include:

- Negotiating a voluntary agreement with the landowner.
- Obtaining approval and recommendation from the Colorado Natural Areas Council.
- Presenting material for review by the Board of County Commissioners.
- Conducting public hearings upon request.
- Gaining approval from the State Parks Board.

Once approved, designated Colorado Natural Areas are formally recognized under the provisions of the Natural Areas Act, resulting in a voluntary legal agreement between landowners and the State of Colorado for their management.

Natural Areas with Significant Geologic Features and Paleontological Resources

Of the 81 designated and registered Colorado Natural Areas, 22 exhibit unique geologic attributes. Five of the designated natural areas have significant paleontological resources:

1. Fruita Paleontological Locality;
2. Garden Park Fossil Locality;
3. Indian Springs Trace Fossil Locality;
4. Kremmling Cretaceous Ammonite Locality;

5. Rabbit Valley Research Natural Area.

These areas represent a range of geologic formations, with paleontological resources corresponding to Jurassic outcrops in the Grand Valley containing some of the oldest mammal fossils found in the western hemisphere; an outcrop of the Harding formation, including fossils of species that lived 450 million years ago; and a section of the Uncompahgre uplift, where on-going excavation continues to uncover large dinosaur specimens. Quarries at the Garden Park Research Natural Area exhibit a range of dinosaur and early mammal fossils and are recognized in the history of paleontological research as a site of the Marsh-Cope rivalry. In addition, a rare fossil assemblage of giant ammonites and many other groups of marine invertebrates occurs at the Kremmling Cretaceous Ammonite Locality Natural Area.

Among areas identified for further study as potential natural areas, about 15 exhibit outstanding paleontological resources. These include areas important to research on plant evolution, local paleoecological reconstruction, vertebrate specimens (including primates and numerous dinosaur records), and marine invertebrates. The Jimmy Camp Creek/Corral Bluffs site offers a continuous sequence of continental rocks which cross the Mesozoic-Cenozoic boundary.

Interagency Coordination and Resource Management

CNAP staff prepare cooperative agreements with private, state, and federal landowners to preserve sites for the use and benefit of present and future generations. Interagency cooperation and agreements with private landowners continue during site selection, registry, designation, monitoring, and management of the natural area.

Appropriate use categories for Colorado Natural Areas are determined by landowners and CNAP staff based on ecologic/physical features and management factors. Staff coordinate with resource professionals and landowners to determine management strategies which take into account the scientific, interpretive, scenic and buffer qualities of an area.

The Kremmling Cretaceous Ammonite Locality Natural Area serves as a recent example of cooperative management for paleontological resources on a Colorado Natural Area. As part of its management strategy for the site, CNAP staff developed a Cooperative Agreement among the Division of Parks and Outdoor Recreation, the State Land Board and lessee, and the Bureau of Land Management (BLM) and lessee providing protective fencing and educational signage to deter the illegal collection of rare marine fossils.

Scientific Research

As part of its management strategy for Colorado Natural Areas, CNAP encourages long term monitoring of significant natural features and ongoing scientific research. Designated natural areas represent a rich reserve of topics for scientific study, including research on geologic phenomena and paleontological resources. Expertise on the scientific investigation of these resources is represented on the Colorado Natural Areas Council by Dr. Richard Stucky, long time associate of the Denver Museum of Natural History.

CNAP coordinated the development of the Geologic Advisory Group (GAG) in 1983 to help identify and evaluate significant geologic and paleontological features on Colorado's public lands. Designed to support the BLM, GAG emphasized interaction among numerous professionals with expertise on geology and paleontology. CNAP has been instrumental in planning, organizing, sponsoring, and publishing the results of projects undertaken by GAG, and has incorporated GAG recommendations into the management of many of the State's natural areas. In 1989, the BLM published "Faults, Fossils, and Canyons: Significant Geologic Features on Public Lands in Colorado," a product of the cooperative efforts of GAG members.

In addition, CNAP sponsors Colorado Natural History Grants, which fund research on Colorado Natural Areas. This program has sponsored more than 50 research projects since its inception in 1985.

Educational Opportunities

CNAP has specific objectives for promoting educational opportunities on Colorado Natural Areas. Staff encourage an awareness of the natural features characteristic of each site, which serves an important role in identifying and protecting Colorado's natural heritage. Interpretive sites provide signage in areas of public access, while involvement in group presentations and the preparation of resource materials add to the educational value of natural areas. These strategies supplement ongoing scientific research to provide unique educational experiences for a diverse group of visitors.

Protection Strategies
Under the Colorado Natural Areas Act, CNAP provides for the protection of natural features representing the natural heritage of the state. Use categories appropriate to each site are incorporated into the long term management of natural areas. Activities related to diverse uses, including scientific study and interpretation, are evaluated for their compatibility with program goals for preserving the state's natural heritage. Restricted access to sensitive areas and interpretive signage are two of the strategies used in promoting these objectives.

Participation in Natural Areas Selection, Research, and Management
CNAP encourages input and feedback from resource professionals and individuals in the nomination and review of candidate sites, natural area evaluation, long term monitoring, and resource management. The efforts of individuals and cooperating agencies support the identification, registration and designation of natural areas, and contribute to the development and implementation of site specific management strategies.

Fossil Resources Involving Federal Lands in California

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Paleontologic localities of significant scientific value occur on public lands in California. Some localities on private land are administered by the Bureau of Land Management (BLM) and the US Forest Service (USFS) for their mineral resources. The opportunity to protect these resources through establishment of Areas of Critical Environmental Concern or through cooperative agreements with private institutions and other public agencies is quickly being lost as these localities are vandalized or developed for nonpaleontologic purposes. On the other hand, cooperation between government agencies and private institutions have resulted in the preservation and appropriate curation of many paleontologic resources from public lands.

Paleontologic localities involving public lands in California are invariably associated with private or military lands. These complications in land ownership provide easy access to some localities which have resulted in their near total destruction. Land ownership and management patterns have led to the preservation of other localities. Table 1 is a partial summary of some of the more important localities in California. Several of these localities have provided time-rock correlations that have world wide stratochronographic and paleoecological ramifications.

Specific Localities

Alverson-Coyote Mountain: An Area of Critical Environmental concern was established for this locality in 1988. The Alverson locality has had heavy use due to its location near a dump and gravel quarry. The Coyote Mountain localities are in a mountainous area near a military ordnance range and retains a pristine condition due to limited vehicular access.

Avawatz Mountains: This locality contains the best Clarendovian terrestrial mammalian assemblage in the Mojave desert.

Badlands-Soboba Hot Springs: Identified as nationally important in the 1992 South Coast Draft Resource Management Plan, these localities involve separate facies of the Soboba Formation. The Badlands locality contains terrestrial vertebrates whereas the Soboba locality contains an important fossilized chaparral and woodland plant community.

Basset Point-Lake Manix: Containing a wide variety of plant and animal fossils, this locality is one of many which extend for 25 miles along the Mojave River. This recreational corridor provides access to the localities and also has resulted in some degradation of them due to off road vehicles. Much of the resource is contained in the Manix Basin Area of Critical Environmental Concern.

Bena Forest: One of the few known occurrences of petrified wood of Miocene age in the San Joaquin Valley. Negative impacts to the locality are mostly associated with cattle ranching.

Calico Mountains: This agate bed preserves exquisite silica casts of insects, larva and spiders. The preservation is so perfect that details of compound eye structures and leg hair follicles are seen in SEM micrographs. Much of this locality has been harvested by rockhounds for the making of belt buckles and other rock jewelry. In 1994 the locality was identified as an Area of Critical Environmental Concern.

Caliente Mountain-Horse Canyon: These localities contain rare vertebrate specimens from the California Coast Ranges. Some of them are within the Caliente Mountain Wilderness Study Area. Others are in the vicinity of Quatal Canyon which has been identified as a special management area for fossils by the USFS.

China Lake: Within a military reservation, these deposits have been essentially undisturbed and unstudied for 20 years.

Comanche Point: A unique assemblage of Miocene terrestrial vertebrates is known from this locality, a portion of which is within the Tejon oil field.

Cuyama Phosphate Beds: A rich assemblage of phosphatized invertebrates and fish fossils occur in a unique series of depositional environments which prograde from deep water to shallow water facies. The locality is a wonderful outdoor educational laboratory because students can walk upsection and collect fossils from a sequence of deepening depositional environments.

Democrat Hot Springs-Heald Peak: A roof pendant preserves rare Triassic marine fauna at these localities and is critical in the dating of metamorphic rocks in the Southern Sierra Nevada.

Dutch Flat: This locality has been vandalized for over 100 years. It contains one of the few remaining petrified forests of lower Eocene age in North America in an unnamed fluvial unit stratigraphically equivalent with the Ione Formation. Informal discussions are underway for BLM to acquire the portions of this locality which are on private land. BLM acquisition would be followed by establishment of an interpretive center at the locality through a Recreation and Public Purpose lease to a local consortium of nonprivate foundations.

Kettleman North Dome: Giant oysters, barnacles and other marine invertebrates occur in great quantity and variety at this locality which lies in the heart of the Kettleman oil field. Some degradation of the paleontologic resource has occurred from oil and gas development.

Lindsay: Rare microfossils in this ophiolite sequence are important for reconstructing plate tectonic history of central California.

Lucerne Valley: Fossils from this area give important paleospastic information about the date of rise of the central San Bernardino Mountains.

McKittrick and Maricopa Brea Pits: Two of four important tar pits in southern California (the others are La Brea and Carpenteria) are either in or adjacent to oil fields. Portions of the tar pits were destroyed in the 1870's-1890's by asphalt mining operations. The McKittrick locality has been almost totally excavated. The Maricopa locality has not been fully studied and several thousand tons of material remain undisturbed. The Caliente Resource Area Draft Resource Management Plan of 1994 identifies these localities as having high paleontological value. Informal discussions for having BLM acquire the locality from Mobile Oil Company and, then, for its administration through the West Kern Oil Museum, have occurred since 1992.

Paradise Cove: A rare assemblage of calichefied leaves has provided important paleoecological information about the evolution of the Sierra Nevada.

Rainbow Basin: Recently, camel fossil trackways were stolen from this Area of Critical Environmental Concern. The locality is important because it occurs interbedded with a set of thin volcanic layers which can be dated by K/Ar analysis. Several index fossils are found at this locality and have world wide chronostratigraphic implications. This is the type locality for the Barstovian land mammal ages.

Red Rock Canyon: This locality is partially within a state park. The surrounding BLM lands have extensive vertebrate finds. Some of the most impressive are from Dove Springs, which is also an open area for off road vehicles. This recreational activity continues to degrade most of the Dove Springs fossil locality. An uninterrupted seven million year sequence of sediments provides important details about the evolution of life in this time period and is the most continuous record for Barstovian-Hempillian time (exempting the Crowder

Formation). In addition, there are important historic and prehistoric localities here. A mono-genus moth of unknown affiliation has been discovered in the past year which apparently lives only in the Dove Springs area.

Sand Canyon: Near new subdivisions and an area of proposed wind farms, these localities, unless protected, will be impacted in a few years by urban expansion. A wide variety of important terrestrial vertebrates are known from the locality.

San Emigdio Ranch: A recent discovery of a whale skull was made at this locality. The find has extended greatly the geographic distribution of whale fossils of Miocene age in California.

Shark Tooth Hill: Known as the "bone bed", this locality extends throughout a wide area of western Kern County. Near several oil fields, the locality has been vandalized since the 1890's mostly for it's abundant shark teeth, many of which are several inches in length. Mostly on private land, the bone bed produces one or two nearly complete skeletons almost every year. Concern for exposure of fossil hunters to "Valley Fever", a sometimes fatal illness, has resulted in tighter control of access to the Shark Tooth Hill. The California Living Museum has a team of volunteer physicians that monitor persons that work in the Round Mountain Formation.

Turritella Beds: Known for its abundant and beautiful invertebrate marine fossils, this locality is exposed for 2 miles along cliffs bordering the Kern River. Restricted access by private land owners has kept the locality from vandalism.

Tumey-Panoche Hills: A critical locality for Mosasaurs, it has been protected because of restricted access associated with the region's high fire hazard and presence in a Wilderness Study Area. A mosasaur and plesiosaur have recently been discovered and await excavation pending environmental review of the impacts of such an activity on the Wilderness Study Area.

Vaughn Gulch: This locality exhibits a classical sequence of Cambrian to Mississipian units with a wide variety of invertebrate and rare vertebrate fossils.

Wheeler Gorge: This is an important locality for Eocene and Cretaceous flora and fauna in the Transverse Ranges.

Yuha Buttes: Vast oyster beds and other invertebrate fossils form a pavement of paleobiologic material which covers several square miles. This interesting geomorphic feature is the result of differential weathering of a death assemblage of fossils which is up to 6 feet thick at the progradational contact of green-tan lake sediments and red silts of the ancestral Colorado River. A BLM approved motorcycle race course cuts through the locality and some of the fossils are destroyed by this recreational activity on a daily basis.

Conclusions

The rich fossil heritage of public and private lands in California has not been widely appreciated or managed as intensively as have similar localities in other states. Governmental agencies have existing procedures for acquiring and protecting many of these localities through cooperative agreements, Recreation and Public Purpose leases, or other land tenure adjustments. Future land use authorizations (e.g. leasing) should contain standard stipulations for the protection of paleontological resources. The Antiquities Act and FLPMA should be amended to extend protection to scientifically important invertebrate and plant fossils. Implementation of this protection should be delegated to local governmental entities through cooperative agreements that would result in regional paleontological management plans. A list of common fossils could be part of these plans, and casual collection of them by amateurs and professionals regulated with relative ease and low cost to the taxpayer.

Table 1: SELECTED FOSSIL LOCALITIES IN CALIFORNIA

NAME OF LOCALITY	COUNTY	TOW:RAN:SEC	FORMATIONS	AGE	LAND TENURE AND MANAGEMEN T INTENSITY*	IMPORTANT FOSSILS
ALVERSON (FOSSIL) CANYON	Riverside	165:9E:10,11	Imperial	UPPER MIOCENE	BLM, PRI	Mollusks other invertebrates, sharks, rays, bony fishes, sea turtle, sea cow, baleen whale
ALVORD MOUNTAINS	San Bernardino	11N:4E	"Barstow"	UPPER MIOCENE Hemphillian to Barstovian	BLM, PRI, +	Terrestrial mammals
AVAWATZ MOUNTAINS	San Bernardino	17N:6E	Avawatz/Noble Hill	UPPER MIOCENE Clarendonian	BLM, PRI, ++	Terrestrial mammals
BADLANDS	Riverside and San Bernardino	2S:2W:2-3,10-11	San Timoteo and Mount Eden	UPPER MIOCENE AND PLEISTOCENE	BLM, PRI, (R)	Horses, camel, rhinoceros
BASSET POINT - LAKE MANIX	San Bernardino	10N:4E:20	Manix	LATE PLEISTOCENE	BLM, PRI, ++	Mollusks, horse, crustaceans, fish, turtle, birds, sloth, wolf, bear, saber-tooth cat, camels, llama, bison
BENA FOREST CADY MOUNTAINS CALICO MOUNTAINS CALIENTE MOUNTAIN	Kern San Bernardino San Bernardino San Bernardino	30S:30E:8 10-9N:5E 10N:1-2E 11N:26W:19,20,21,27	Chanac Hector "Barstow" Caliente	MIDDLE MIOCENE UPPER OLIGOCENE-EARLY MIOCENE MIDDLE MIOCENE MIOCENE	PRI BLM, PRI, ++ BLM BLM	Petrified wood Earliest terrestrial mammals of Mojave Desert Insects, spiders, scorpions, larva Horse (type locality Merychippus carrizoensis), camel, rodents
CAJON PASS	Riverside	3N, 6W	Crowder Vacaros San Fransiscito	UPPER OLIGOCENE UPPER MIOCENE K/T Boundary	BLM-USFS-PRI, +	Terrestrial mammals Whales, porpoises, sharks Elasmosaur
CHINA LAKE	Inyo	24S:39-40E	White Hills	EARLY TO MIDDLE PLEISTOCENE Rancholabrean	DOD (Navy)	Ducks, geese, eagles, canids, felids, horse, bison, rodent, proboscidean, camel, deer.
COMANCHE POINT	Kern	32S:29E:15,16 2S:30E:18,19	Chanac	MIDDLE MIOCENE	PRI	Elephants, horses, camels
COSO MOUNTAINS	Inyo	19S:38E:6	Coso	EARLY PLEISTOCENE Late Blancan	BLM	Ostracods, fish, vole, rabbits, canid, peccary, camel, horse, probascidoan
COYOTE MOUNTAIN	Imperial	15S:9E:31,32 16S:9E:5,6	Imperial	UPPER MIOCENE	BLM, PRI	Mollusks other invertebrates, sharks, rays, bony fishes, turtle, sea cow, baleen whale

Table 1: SELECTED FOSSIL LOCALITIES IN CALIFORNIA

NAME OF LOCALITY	COUNTY	TOW:RAN:SEC	FORMATIONS	AGE	LAND TENURE AND MANAGEMENT INTENSITY*	IMPORTANT FOSSILS
CUYAMA PHOSPHATE BEDS	Santa Barbara	9N:26W:12,13	Branch Canyon	LOWER MIOCENE	PRI, BLM	Echinoids, mollusks, marine invertebrates, fish
DEMOCRAT DAM	Kern	27S:31E:5	Kernville Series	TRIASSIC	USFS, PRI	Mollusks, snails
DUTCH FLAT	Placer	15N:10E:3,4 16N:10E:33,34	Ione	EOCENE	BLM, PRI	Petrified wood
GOLER	Kern	28S:39E	Goler	K/T Boundary, PALEOCENE?	BLM, PRI, ++	Terrestrial mammals (oldest in Mojave Desert, turtle, crocodile, multituberculate,anisonchine condylarth, phenacodontid condylarth, mioclaenine condylarth
HEALD PEAK	Kern	27S:34E:10,11	Kernville Series	TRIASSIC	USFS-BLM-PRI, +	Pelecepods
HORN TOAD HILLLS	Kern	32S:35E:34	Horn Toad	UPPER MIOCENE/LOWER PLIOCENE	PRI, BLM	Reptiles, amphibians, shrew, mole, rats and mice, gophers, jumping mice, squirrel, rabbits, dog, cat rhino, horses, camels, ?deer, peccary, proboscideans
		12N:13W:36		Late Hemphillian		
KETTLEMAN NORTH DOME	Fresno and Kings	21S:17E	Tulare	PLIOCENE	PRI, BLM +	Oysters, barnacles, other marine invertebrates
LAKE TECOPA	San Bernardino	21N:7-6E	Tecopa	PLIO-PLEISTOCENE	BLM, PRI ++	Mammoths, camels, carnivores, horses, small mammals
LINDSAY	Tulare	19S:27E:28?	Kernville Series	TRIASSIC	PRI, BLM	Micro fossils
LUCERNE VALLEY (S PART)	San Bernardino	3-4N:1E	Old Woman Sandstone	UPPER + MIDDLE	BLM, PRI	Terrestrial vertebrates
MARBLE MOUNTAINS	San Dernardino	5N:14E:2	Latham Shale	PLIOCENE	BLM, PRI	Trilobites
MCKITTRICK BREA PITS	Kern	30S:22E:29	Tar Seep Deposit in Tulare FM	EARLY + MIDDLE CAMBRIAN PLEISTOCENE	PRI	Wolf, rat, snake, bird, insects
MARICOP BREA PITS	Kern	11N:23W:21	Tar Seep Deposit in Monterey FM	PLEISTOCENE	PRI, BLM	Wolf, rat, bird, saber-tooth cat, insects
MESCAL RANGE	San Bernardino	15½-16N:13-14E	Aztec Sandstone	JURASSIC	BLM, PRI +	Dinosuar tracks
PARADISE COVE	Kern	26S:33E:22,27	French Gulch	TRIASSIC	BLM, PRI	Fossil leaves in caleche
PARUMP	San Bernardino	21N:6,8E	Carrera	CAMBRIAN	BLM, PRI	Trilobites
PIONEER TOWN	San Bernardino	1N:5E:19-20	Pioneer Town	UPPER MIOCENE	BLM	Terrestrial vertebrates
PIUTE VALLEY HOT SPRINGS	San Bernardino	13N:19E	Piute Valley	PLEISTOCENE	BLM, PRI, State	Mammoths, camels, horses. Fossils in fault zones indicate rates of tectonism.

Table 1: SELECTED FOSSIL LOCALITIES IN CALIFORNIA

NAME OF LOCALITY	COUNTY	TOW:RAN:SEC	FORMATIONS	AGE	LAND TENURE AND MANAGEMENT INTENSITY*	IMPORTANT FOSSILS
PUNCHBOWL	Los Angeles	4N:9W:17-20	"Punchbowl"	EARLY TO MIDDLE PLIOCENE Clarendonian to Hemphillian	County, USFS	Pliohippus, weasel, dog, horses, camel, antelope
RAINBOW BASIN RANDSBURGH	San Bernardino Kern	11N:1W:16,15,24 28-29S:5-7W	Barstow Bedrock Springs	UPPER MIOCENE UPPER MIOCENE Hemphillian	BLM BLM, PRI	Camels, horses, saber-tooth cat, antelope Mammals, rodents
SALT SPRINGS HILL SAND CANYON-CACHE CREEK	San Bernardino Kern	18N:7E:17 31S:34E:35,36	Carrera Bopesta Kinnick	CAMBRIAN MIDDLE AND UPPER MIOCENE MIDDLE MIOCENE Hemingfordian	BLM BLM BLM, PRI	Trilobite exoskeletons Horse, camel, rhinoceros Plants, dog, cat, horse, camel, chaliocothere, antelope, peccary
SAN EMIGDO RANCH SHARK TOOTH HILL	Kern Kern	10N:22W:1 28S:28E:23-26 31S:35E:31-34 31S:34E:1 32S:35E:4-6	Tulare Round Mountain Silt	PLIOCENE MIDDLE MIOCENE Barstovian	PRI PRI	Whale, shark, marine invertebrate Shark, whale, seal, pecans
SUMMIT SPRINGS	San Bernardino	9-10N:13-14W	Latham Shale	CAMBRIAN	BLM, PRI	Trilobites
SOBOBA HOT SPRINGS TITUS CANYON	Riverside Inyo	1E:4S:1,11,12 13S:44-46E	Soboba Titus Canyon	LOWER MIOCENE-UPPER PLEISTOCENE EARLY OLIGOCENE Chadronian	BLM, PRI BLM	Woodland chaparral Rodents, canid, horse, brontothere, helaletid, rhino, oreodont, leptomerycids
TURRITELLA BEDS	Kern	29S:29E:1 22S:17E	Olcese	MIDDLE MIOCENE	PRI	Marine invertebrates
TUMEY-PANOCHE HILLS	Fresno	14S:11E 16S:12E	Moreno	UPPER CRETACEOUS	BLM	Mosasaurs, plesiosaurs
RED ROCK CANYON	Kern	28S:36E:33-35 29S:36E:1-3	Ricardo/Dove Springs	MIOCENE	BLM, CDPR, PRI +	Horses, etc.
VAUGHN GULCH WHEELER GORGE	Inyo Ventura	13S:36E:9 5N:23W:15,16,21,22	Vaughn Gulch Limestone Coldwater Canyon Juncal	SILURIAN EOCENE CRETACEOUS	BLM USFS	Crinoids, bryzoans, corals Marine invertebrates

* Management Intensity: R = Ongoing research, + = One dig every year, ++ = One dig every two years.

Locating Federal Fossil Collections

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On February 22, 1994, staff of the Department of the Interior (DOI) Museum Property Program mailed the Survey of Federally Associated Collections Housed in Non-Federal Institutions to 12,072 non-Federal museums and academic departments that might hold Federally associated museum collections. Responses were requested by May 1994. The final survey results will be compiled and distributed by the end of 1994 to Federal agencies that were identified by survey respondents. This abstract describes the nature of the survey project and presents preliminary results regarding vertebrate paleontology collections as reported through June 30, 1994.

The survey was proposed in 1991 by the Scientific Collections Working Group of the Interior Museum Property (IMP) Task Force. The Task Force was formed in 1991 to develop Departmentwide standards and policies for the management of Department of the Interior museum collections. In late 1991, the Task Force surveyed all DOI offices and located approximately 70 million objects representing all disciplines. Of these, 30 million Interior associated objects were reported as being held in non-Federal institutions. It was recognized that there exists an unknown quantity of Federally associated collections of which Interior bureaus have lost track.

In early 1992 the Secretary of the Interior invited the heads of other Federal agencies to join Interior in seeking information on these collections. Twenty-eight agencies met in May, 1992, as the Interagency Federal Collections Working Group. They agreed that there was a governmentwide need for data on Federally associated collections in non-Federal institutions and provided guidance for initial drafts of the survey to locate these collections. The survey evolved through multiple drafts that were developed in close coordination with the IMP Task Force, the Interagency Federal Collections Working Group, and the Office of the Departmental Consulting Archeologist. The American Association of Museums and the Association of Systematic Collections were also consulted early in the process.

It was agreed that the purposes of the survey were to gather baseline natural and cultural resource information needed by Federal managers, to identify collections for which Federal agencies may be legally accountable, and to increase access to these collections for public benefit. The single request for information on collections associated with any Federal agency was made in lieu of separate inquiries from various Federal agencies. The survey was also expected to increase dialogue among managers of Federally associated collections, lands, and programs.

In late 1992 the draft survey was tested by 9 institutions that were selected to represent diversity of discipline, governance, size, and geography. Test results were returned in early 1993. The Interagency Federal Collections Working Group reviewed the results and recommended changes for the final draft which was approved by the Department of the Interior and the Office of Management and Budget. (OMB monitors and regulates all government requests for information to reduce the reporting burden of the public.) The survey was signed by Secretary of the Interior Bruce Babbitt on January 12, 1994, and, after printing, was mailed to 11,600 non-Federal museums on a list provided by the Institute of Museum Services, and to 472 academic departments with archeology or vertebrate paleontology programs.

By June 30, 1994, approximately 500 institutions had reported Federally associated collections, and 2000 institutions had reported that they hold no Federally associated collections. In addition approximately 500 surveys had been returned by the US Postal Service as undeliverable.

This report deals only with vertebrate paleontology collections that were reported by survey respondents. Fifty institutions reported holding 247,911 vertebrate paleontology specimens plus 4,292 lots. These specimens were reported to be associated with 12 Federal agencies and one institution reported a small collection as probably Federally associated, but with no agency identified.

- Thirteen institutions reported 188,780 specimens and 4000 lots associated with the Bureau of Land Management.
- Eight institutions reported 16,597 specimens and 13 lots associated with the National Park Service.
- Ten institutions reported 10,793 specimens associated with the US Forest Service.
- Two institutions reported 10,200 specimens associated with the Bureau of Reclamation.
- One institution reported 10,000 specimens associated with the Department of Energy.
- Four institutions reported 7005 specimens and 156 lots associated with the Bureau of Indian Affairs.
- One institution reported 4000 specimens associated with the National Science Foundation.
- Seven institutions reported 516 specimens and 1 lot associated with the US Fish and Wildlife Service.
- One institution reported 10 specimens associated with the Department of Defense.
- One institution reported 1 specimen associated with the General Services Administration.
- One institution reported 41 specimens associated with the National Oceanographic and Atmospheric Administration.
- One institution reported 15 specimens associated with the US Geologic Survey.
- One institution reported 50 specimens associated with an unknown Federal agency.

Individual agencies may use these data as points of comparison with other data regarding repositories known or thought to house collections that are associated with their lands or programs. The survey results are notable because of the obviously incomplete nature of the data. No one source will identify all questions related to the location and management of Federally associated collections. A complete picture will emerge only after combining the results of thorough searches of agency records, various surveys, published journal reports, and increased dialogue between Federal agencies, professional societies, and selected repositories.

Many of the survey respondents expressed concern regarding the need for increased Federal funding for the management of Federally associated collections. Specifically, interest was expressed in funding for automation of catalog data; automation of collection locality data that could then be compared with automated Geographic Information System data on the shifting boundaries of Federal lands through time; and funding for collections facilities, equipment, and staff.

Some institutions expressed concern that increased Federal involvement in the management of Federally associated collections might restrict their use of such collections for teaching and research activities. They noted that agencies associated with the collections have expressed no interest in, and accepted no responsibility for, collections that have been maintained solely by the non-Federal institutions for decades. All institutions recognized the constraints of limited resources and the need to establish priorities in addressing the issues related to managing Federally associated collections.

Among the questions requiring increased discussion and ongoing dialogue are:

- Which standards should be used in evaluating collection documentation, preservation, and protection.

- What should be the nature of formal agreements between Federal agencies and non-Federal institutions.

- How can ownership issues be clarified.

Specific issues vary from discipline to discipline, and complete resolution and consensus will require a long term effort involving many interest groups and communities. A guiding principle in these discussions must be preservation of the public trust in which Federally associated collections are held, whether in Federal or non-Federal institutions.

Research, Conservation, and Management at an Exceptional Late Cretaceous Fossil Site

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There are few places in the world where plant fossils are preserved in growth position, and many of those are isolated or scattered occurrences of tree trunks. In 1990 an exceptional discovery was made in the badlands east of Worland, Wyoming. A layer of volcanic ash exposed in the side of Big Cedar Ridge was found to preserve a late Cretaceous landscape, including a vast "meadow" of ferns, palmettos, and small, herbaceous plants. The outcrop is nearly 5 km in north-south extent. Since 1990 the Big Cedar Ridge site has been under study by a research team including scholars from the Smithsonian, Yale University, and the University of Michigan. The Bureau of Land Management (BLM) District Office in Worland, which manages the Big Cedar Ridge area, has provided logistical support for the field parties and has been working to protect the site and develop educational opportunities for local people.

The Big Cedar Ridge site presents special opportunities and challenges for both research and management. Because the fossil plants are preserved in growth position, it is possible to reconstruct the distribution of plants on the ancient landscape, something which is rarely possible with typical plant fossil deposits. This sort of work requires quantitative sampling of the flora using techniques similar to those developed by plant ecologists studying living vegetation. This kind of ecological sampling also requires precise information on the lateral position of samples along the outcrop, usually to within a few meters. In order to do this, the research team established 100 numbered and staked sampling sites along the exposure so that all collections could be tied to specific quarry sites. Most individual quarries were less than 3 x 3 meters in horizontal dimensions.

Management of the Big Cedar Ridge site is influenced by several factors. The ash overlying the fossils is highly bentonitic and up to 4 meters thick. The first concern was to protect the site from potential commercial mining claims, so the process of withdrawing the area was initiated in 1992. A temporary withdrawal, in place until January 1996, has been obtained. This withdrawal will allow completion of an environmental analysis that will examine future management options for the area.

To protect the area from unreported fossil collecting, the BLM now requires a letter of authorization for collecting within the Big Cedar Ridge area. The authorization does not require the same qualifications that would be required for a standard permit, but is intended to ensure coordination of the efforts to explore and understand the area. Given the large area of fossiliferous exposures at Big Cedar Ridge and the high rate at which the bentonitic ash weathers, small scale collecting does not threaten the scientific value of the site. Because the scientific investigation of the site requires precise locality data, amateur collecting will enhance the scientific research best if collectors record where their fossils come from in relation to the staked sites used in the study. Controlled collecting at the Big Cedar Ridge site is being encouraged in several ways. The BLM is installing more durable markers at the sampling sites so that they can continue to be recognized. The BLM has also worked with the Washakie County Museum in Worland and researchers to install an exhibit including material on the Big Cedar Ridge site. The BLM, the Washakie County Museum, and the Smithsonian have arranged a tour of the site for local amateurs. The Smithsonian provides the BLM with copies of publications resulting from work on the Big Cedar Ridge Site and has also given the BLM District Office a copy of the photographic atlas currently being used by scientists to identify plants from the Big Cedar Ridge ash bed. This atlas is used by local collectors to identify their material, and should facilitate the recognition of exceptional material and fossils representing new or rare species.

We believe the Big Cedar Ridge site can be managed in a way that benefits scientific research and amateur collectors, as well as meeting the standards for collection, curation, and resource management required by the Smithsonian and the BLM. The site is so extensive that it would be difficult for it to be "collected out" through scientific research. The bentonitic ash in which the fossils are preserved erodes so rapidly that a moderate rate of amateur and scientific collecting will probably save specimens from destruction by weathering in the long term. Scientific research enhances the educational value of the fossil resource when the results are made available to local fossil collectors. Collecting by amateurs, in turn, can add to the scientific investigation of the site if the amateur effort is guided by knowledge gained through research. Amateurs who can recognize specimens of scientific value, and who keep detailed locality data on fossils (referring to the sites marked by the BLM), can add to the growing database on the Big Cedar Ridge site. Specimens collected by amateurs can, for the most part, be retained in private collections without loss of scientific data, but we hope that in exchange for information about their collections, amateurs will be willing to donate scientifically significant material (with location data!) to scientists working on the site.

Cooperative Management of "Our Fossil Heritage": An Example from the John Day Basin

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Most observers of federal government agencies are probably aware that the National Park Service (NPS) administers over 360 areas. A lesser number are aware that over 50 units of the national park system contain extraordinarily significant fossil localities. Although many of these areas were established for primary values that were non-paleontological (such as Yellowstone NP or Glen Canyon NRA), over a dozen were instituted **because** of these resources. These are some of the finest localities of their type on the planet.

The boundaries of these areas should encompass a reasonable portion of the important sites. Unfortunately, many don't enclose all, or even a high percentage, of the paleontological assets congress recognized when establishing the unit. Often, congressional boundaries were a compromise worked out to include politically expedient agreements. Thus, in several instances, paleontologists working on the NPS side of the fence look over at neighboring lands administered by other agencies with interest. Conversely, other land management agencies, such as the Bureau of Land Management (BLM) are aware of the vast extent of paleontological resources they administer. They would prefer to offer professional resource management, curation, and research policies compatible with their objectives, but find these activities outside normal funding channels and policy setting.

This "extended" abstract describes a mechanism for interagency management of scientifically significant fossil assemblages. We believe this approach offers land managers a cost-effective means to manage a variety of paleontological resources that would otherwise be lost to the public trust, either through natural or cultural causes.

The Situation

Hundreds of square miles in central and eastern Oregon contain a remarkable sequence of fossil assemblages. In 1975, Congress established three widely scattered areas in central Oregon as the John Day Fossil Beds National Monument (JODA). Within and between these units there are hundreds of different fossil localities, most of which require a variety of research strategies and management approaches. Such variable sequences are a testimony of the remarkable effects volcaniclastics, deposited in a topographically and biotically rich area, can have on a small region.

Fossil materials found in the JODA units range from silicified seeds and fruits associated with vegetative tissues, to the famous Bridge Creek lacustrine shales with well preserved delicate leaves, to a sequence of remarkably diverse tetrapods spanning 40 million years. The significance of these resources is not just the fact that there are well preserved fossils. There are floras and faunas in association, spanning a long time range with datable tuffs sandwiching many of the best sites. This record was established during a transition from a paratropical climatic regime to that of a cold, high desert. Potentially, it represents one of the finest windows available to view middle Eocene through late Miocene ecology.

But much more of the story is preserved in sediments exposed outside the JODA units. For completeness, it is necessary to study exposures on BLM lands in order to find sections that are "missing" within the park. It is the entirety of the stratigraphic section that is of national and international interest, not merely the portion that happens to fall into boundaries. To address research queries and also revisit many of the old "type" localities, the NPS and other researchers need to go outside JODA boundaries.

On the other side of the fence, a different situation exists. During the early 1980's, BLM specialists responsible for managing paleontological resources were ill equipped to meet federal management responsibilities. The interest was there, but due either to a lack of expertise and/or weak program guidance, management efforts were not vigorous. In the late 1980's, however, a situation occurred on BLM lands near one of the JODA units that became the **catalyst** for change in the way these two sister agencies approached their respective managerial mandates in central Oregon.

A Solution: The John Day Example

A significant specimen was collected from BLM land by an interpretive park ranger to prevent its destruction from weathering. The action of the ranger was well meaning but created a need to curate such specimens in a national repository like JODA's. At the time, there was no mechanism to do this and it drew attention to a problem, especially when dozens of other BLM sites were known to be attracting both amateur and commercial collectors. Managers from both agencies met to discuss the situation and consider alternatives. It was during these meetings that the first interagency agreement to manage paleontological resources was developed (APPENDIX ONE, IA9325-8-0001, 1988, revised 1992).

This agreement, actually a cooperative management agreement, provides both the BLM in central Oregon and JODA an administrative tool for "blurring the lines" of management and allowing a more efficient use of funds and personnel. For example, under the terms of this agreement JODA contributes its expertise in the form of a paleontologist to conduct surveys, supply taxonomic identification of specimens, determine significance of localities, and act as BLM consultant on issues involving the John Day Basin. In addition, JODA provides curatorial services for all specimens collected from BLM lands in central Oregon, as well as access to its library facilities and computerized locality system. The BLM, on the other hand, contributes timely consultation on possible adverse activities in known sensitive areas, logistical and personnel support through the purchase of material (e.g., storage cabinets, aerial photographs, etc.) and/or funding to hire seasonals to perform surveys and mapping, administering amateur volunteers for surveys and mapping, and performing achaeological surveys within JODA on an "as-needed" basis.

As our cooperative efforts have matured, there have been some exciting consequences. Through this association, BLM personnel are better able to conduct their management responsibilities toward fossil resources, and it has opened the door for future opportunities to participate in outreach efforts for the public and cooperative ventures with the scientific community. The outcome not only increases our knowledge and understanding of the resource (which is presented to the public through JODA interpretation at the various units), but contributes to more effective management.

ABSTRACTS

Quaternary Paleontology in the National Parks: Contracts on the Colorado Plateau and Salvage in the Channel Islands National Park.

Larry D. Agenbroad, Department of Geology, Northern Arizona University, P.O. Box 6030, Flagstaff, AZ 86011

Research contracts, for the past decade, have revealed an astounding record of extinct and modern fauna from National Park units on the Colorado plateau. These data promise great refinement for paleoenvironmental and paleoclimatic models. Emergency salvage on Santa Rosa Island, Channel Islands National Park, produced the most complete individual of the Channel Islands Dwarf (Pygmy) mammoth (*Mammuthus exilis*) ever recovered. The discovery sets a focus on future research.

Partners in Education - If The Subject Is Dinosaurs, You Can Teach Anybody Anything

Diane Bellis, Office of International Cooperation and Development, Research and Scientific Exchanges Division, U.S. Department of Agriculture, South Building Room 3236, Independence Avenue SW, Washington, DC. 20250.

Federal lands provide an abundance of educational opportunities. Science education in the US is, by all accounts, failing. Serious cuts are being made both to research budgets and personnel in federal agencies. Perhaps it is time to revisit how educators and researchers serve the public. Paleontologists can work with federal agencies to develop programs for visitors and for teacher education. In this talk, I will give an overview of recent developments in science and environmental education, particularly work at the National Research Council of the National Academy of Science, and describe for federal agencies how to work with academics both domestically and internationally.

Where Are the Paleontologists? Missed Research Opportunities

Diane Bellis, Office of International Cooperation and Development, Research and Scientific Exchanges Division, U.S. Department of Agriculture, South Building Room 3236, Independence Avenue SW, Washington, DC. 20250.

Paleontologists are missing opportunities for funding because of a lack of information on these opportunities and on how to package proposals. One of eight core projects in the International Geosphere-Biosphere Program, A Study of Global Change of the International Council of Scientific Unions, is PAGES (Past Global Changes). It states that "Much of the evidence for human induced changes and all of the evidence for past changes resulting from natural forces are drawn from records of the past." Fossils, and other remains of life and indicators of paleoenvironments, are the only evidence available for unraveling biogeochemical cycles. General circulation models (GCMs) can only be validated by "predicting" past climate and verification in the rock record. Certainly research budgets are shrinking, but a significant fraction of that available both domestically and internationally could be accessed by paleontologists.

Partners in Certification "Education of Volunteers"

John Bird, Vice President, Warren Clark, and Duane Taylor, Utah Friends of Paleontology, Castle Valley Chapter, College of Eastern Utah Prehistoric Museum, 451 East 400 North, Price, UT 84501

The Utah Friends of Paleontology of the Castle Valley Chapter, a state sponsored organization comprised of professional and avocational paleontologists, have developed an intensive certification program to train volunteers in paleontological methods, techniques, and procedures to increase public awareness of our fossil heritage.

The program is divided into three levels: novice (level I); apprentice (level II); and site supervisor (level III). Over 300 hours of classroom, laboratory and fieldwork are required for the three levels of certification. All areas of training are taught and supervised by professional geologists, paleontologists, and museum staff. The curriculum addresses ethics, legal issues, introductory geology, basic scientific methodology, laboratory procedures, excavation techniques, and other pertinent subjects.

Utah Friends of Paleontology's partnership, developed primarily with the College of Eastern Utah Museum and the Cleveland-Lloyd Dinosaur Quarry, will be illustrated by specific examples of cooperation. At the Cleveland-Lloyd Quarry, members have devoted a considerable number of hours to various projects such as quarry preparation, analytic surveys, visitor center assistance, and the construction of disabled person facilities. Avocationalists of the chapter have volunteered thousands of hours in removal and preparation of fossil bones at five dinosaur fossil sites permitted through the College of Eastern Utah. During the recent two year period, they were instrumental in the discovery, removal, and preparation of four new dinosaur species.

Utilizing CD-ROM Technology to Store and Retrieve Paleontologic Data

Elisabeth M. Brouwers, Geologist, U.S. Geological Survey, Denver Federal Center, Box 25046, MS 919, Denver, CO 80225-0046.

The CD-ROM (Compact Disk - Read Only Mode) is fast becoming the vehicle of data storage for the sciences. A CD is durable, easy to handle, enormous in its capacity (over 600 megabytes), and able to handle a variety of data types. The US Geological Survey is taking an active role in this technology, having generated nearly 20 CD-ROMs in the past 2 years under the DDS (digital data series) format. A CD-ROM requires a computer, CD-reader, and a super VGA color monitor.

The CD to be displayed is the first DDS with paleontological data. It is presently in draft form with an anticipated late spring publication date. The CD includes four separate files, each being the equivalent of a large publication. The files consist of a text describing taxonomy, biostratigraphy, and paleoecology, a number of line drawings and figures, color photographs of outcrops and study areas, and black and white scanning electron photomicrographs. Each file includes 100-400 photomicrographs, which is the equivalent of 5-20 fossil plates in a paper publication. One photograph requires several hundred bytes of storage, so that a single CD has the capacity to store several thousand images. "Thumbnail," or small size images, enable the reader to view several images at the same time; particular images can be displayed individually or as pairs for comparison. Photo images can be enhanced by changing brightness, contrast, and color, and an image can be selectively magnified. The beauty of this type of data storage is its low production and publication cost, huge storage capability, and ease of use. Enormous data sets representing, for example, the entire results of a project or the inventory of a collection, can be published as a single entity. Any image displayed on the monitor can be printed.

Building a Team to Successfully Protect Paleo Resources

Pat Buccello, Special Agent, National Park Service, Rocky Mountain Region, C/O Zion National Park, P.O. Box 474, Springdale, UT 84767

As theft of paleo resources continues, the issue of protection has become critical. Hard lessons can be learned from the worldwide decimation of archeological artifacts which has led to the loss of scientific and cultural information from many important sites.

The scientists, interpreters, and protectors of paleo resources cannot wait for official guidelines and directives on working together and building a paleo protection team. The framework for such a team has been established for several years from archeological protection. It is now time to apply that framework to paleo issues and begin a proactive protection program.

Issues to be discussed include:

- Educating each other, with each discipline bringing their resources and needs to the table.
- Educating the public, through sharing scientific finds & losses, interpreting the message in schools, and publicizing the criminal aspects.
- Establishing a plan for investigating thefts and networking among agencies.
- Educating your local US Attorneys.

Partnerships in Discovery

Don Burge, Director, Pam Miller, and John Bird, College of Eastern Utah Prehistoric Museum, 451 E 400 N, Price, UT 84501

The poster presentation will demonstrate the beneficial relationship between professional paleontologists, volunteers, and amateur groups. Specific examples from the College of Eastern Utah Prehistoric Museum's paleontology project will illustrate how partnerships can be used in protecting our fossil heritage. The presentation will attract professional and amateur audiences as the museum describes the development of a world class lab and storage facility with limited staff and funds. Educational programs initiated through these partnerships will be highlighted.

Strategies for Effective Volunteer Management

Sarah Christian, Denver Museum of Natural History, 2001 Colorado Blvd., Denver, CO 80205-5798.

This session will touch on the basic strategies for effective management of volunteer programs. It will be relevant to session participants who already have an existing program, as well as to those just getting started. The presentation will touch on topics such as recruitment, selection, placement, training, motivation, evaluation, and recognition. A bibliography and handouts will be provided.

Why use volunteers?
- Takes time, support, communication
- Provides community involvement
- Diversity of thought and energy
- Public relations ambassadors

Recruitment
- Look at your organization
- Define your program
- Write job descriptions
- Recruitment styles/methods

Selection/placement
- Who does it?
- Application
- How to make a winning match
- Interview
- Orientation

Training
- Introduction to institution manual
- Orientation/need to feel productive
- On-site training

Motivation
- Achievement
- Recognition
- Challenging work
- Increased Responsibility
- Growth/leadership development
- Involved team approach
- Delegation

Evaluation
- Formal/informal
- Recognition
- Chance to retrain
- Creates commitment/dedication

Selling the Past: The Trade in Fossil Resources.

Daniel J. Chure, Park Paleontologist, National Park Service, Dinosaur National Monument, Box 128, Jensen, UT 84035.

The international commercial trade in fossils yields profits in the tens of millions of dollars per year. Virtually all types of fossil material are sold, from protozoan fossils to trilobites, from pine cones to complete dinosaur skeletons. Individual specimens sell for as much as $900,000. This talk will focus on:

- The range of materials sold and the prices they bring.
- The factors driving the market (investment and speculation, religious use by new age devotees, curiosity, the impact of the film "Jurassic Park" on the price of insects in amber, educational uses, souvenirs, etc.).
- The hawking of fossils through the mass media, such as the QVC Home Shopping Network.
- The recent development of selling casts in the commercial catalogs.
- The impact of high prices and commercial dealer activities on scientific research, resource management, and educational efforts. Examples will be shown of materials similar to those found in fossil parks which are routinely sold in commercial catalogues.

Picket Wire Canyonlands: Management Opportunities

Debra E. Dandridge, Archeologist, U. S. Forest Service, Comanche National Grassland, La Junta, CO 81050

The dinosaur tracksite in Picketwire Canyonlands is one of the "newest" additions to the Federal land base in southeastern Colorado. Over 3,000 inquiries to the work center in La Junta in a little more than two years have demonstrated a curiosity and interest in the area by the general public and subject specialists. This presentation will demonstrate methods that the Comanche National Grassland is using to provide access to the general public, educate them about some of the significant resources, and, at the same time, conserve those resources with limited and shrinking budgets. The methods and techniques presented are interim strategies until Picketwire Canyonlands becomes fully integrated into the Forest planning progress.

This presentation will touch on nearly all of the topic categories with emphasis on interpretation/education and resource management. In actuality, interpretation/education, research/inventory, law enforcement/resource management, and parnerships are also effected.

Life Styles of the Rich and Famous Florissant Fossils

William A. Dexter, National Park Service, Florissant Fossil Beds National Monument, P.O. Box 185, Florissant, CO 80816.

There remains controversy regarding the assumed environmental conditions for the Florissant formation during the upper Eocene Epoch (Chadronian Age). The correct answers to these controversies may lie in our understanding of the life styles of Florissant's famous fossils.

Hutton's fundamental paleontological principle, "Uniformitarianism," is our primary tool for understanding. To interpret these past conditions based on the present applies not only to physical geological processes but to all of the biological world. It affects the structures of organisms, their functioning processes, and controls the histories of ecosystems. Fossils provide evidence for specific life styles, i.e. tolerance ranges, energies needed for survival, reproductive conditions, durations of life cycles, atmospheric and water conditions (temperatures, pH, etc.), length of seasons, daylight (sun or shade), solar constant, elevation and other climatic factors.

To reconstruct interrelationships of these prehistoric environments and ecosystems will require in-depth research into the rich and famous Florissant fossils, including 1175 species of insects, 51 species of spiders, other miscellaneous invertebrates, 113 species of plants, and a few mammals, birds and fish. We need to compare the life styles of these fossil genera to the known lifestyles of their modern counterparts.

This paper will also identify several recent Florissant fossil discoveries, comparing their life styles to their modern relatives (i.e. tsetse flies and predaceous diving and long horned beetles).

Fossil Locality Data, Recording and Management

Emmett Evanoff, Research Associate and Instructor, and Peter Robinson, University of Colorado Museum, Campus Box 315, Boulder, CO 80309-0315.

There are currently a wide variety of systems to record fossil locality data in the various government agencies and within agencies. Some of these systems meet current professional requirements for data management, but many are incomplete and have been confused with acquisition records and specimen registers. This course is designed for land managers of paleontologically significant areas to develop locality databases that will be complete and useful in land management decisions.

This short course will examine the gathering, recording, and management of fossil locality data. Information to be discussed includes:

- Setting up a fossil locality database.
- Dealing with pre-existing locality information.
- Data requirements for new localities.
- Developing locality and paleontologic resource maps.
- Computer management of the database.

The relation between locality data and other paleontologic databases, such as acquisition numbers and specimen registers will be clarified. The course will include exercises on locating and recording fossil localities using legal (cadastral), Universal Transverse Mercator (UTM), and longitude and latitude grid systems. Computer database management systems will also be demonstrated.

Paleontological Databases, Potential, Access, and Concerns

Thomas W. Henry, Geologist, U.S. Geological Survey, Denver Federal Center, Box 25046, MS 919, Denver, CO 80225-0046.

Panelists

Laurie Bryant, Paleontologist, Bureau of Land Management, Casper District Office, 1701 East E Street, Casper, WY 82601

Ted Fremd, Park Paleontologist, National Park Service, John Day Fossil Beds National Monument, 420 West Main St., John Day, OR 97845

Jere H. Lipps, Director, Museum of Paleontology, University of California/Berkeley, Berkeley, CA 94720

Computerized databases now provide unique opportunities for scientists and land managers to easily amass vast amounts of information about paleontological resources (fossils). Electronic data communication and exchange technology are undergoing revolutionary changes and growth throughout the world, permitting access to, and transfer of geographic, stratigraphic, and taxonomic information from universities, museums, federal and state geological surveys, land management agencies, and other institutions. Such databases compiled for public lands provide a valuable resource for land management agencies to augment effective monitoring of paleontological activities and to assist in the formation of partnerships. Access to these paleontological databases, unless managed wisely, can create serious problems, particularly for land management agencies.

Collections on the Information Superhighway

Jere Lipps, Director, and D. Lindberg, Museum of Paleontology, University of California, Berkeley, CA 94720.

Electronic data communications and exchange technology are undergoing phenomenal growth. Data and information from paleontological institutions around the world can be made readily available through the internet. Data exchange protocols such as FTP, GOPHER, and MOSAIC clients provide fast and reliable data transfer. These technologies provide for the construction of large paleontological databases based on the irreplaceable and priceless holdings of institutions worldwide and provide unmatched systematic resources for research and teaching. The University of California Museum of Paleontology has been a leader in computerization since the mid 1960's. During this time the Museum's computer records system has progressed from an 80 column punch card format run on a mainframe computer to a fully relational database system using inhouse computing facilities with data (text, images, and sound) remotely accessible via anonymous FIP, GOPHER, and MOSAIC clients on the internet.

Interagency Investigation of Theft of Paleontological and Mineral Resources near Arches National Park, Utah

Karen McKinley-Jones, Park Ranger, National Park Service, Arches National Park, P.O. Box 907, Moab, UT 84532

Arches National Park rangers were involved in a nine month, multi-agency investigation of the theft of paleontological and mineral resources from state owned lands just west of the park. Based on information received last spring, rangers contacted four individuals; a longtime Moab rock shop owner and fossil hunter, a female companion, and two rockhounds from Rock Springs, Wyoming, who were excavating dinosaur bones and chert in the Dalton Wells area. After obtaining consent, a search of the Wyoming residents' vehicle revealed dinosaur bone that had been collected at this site. Subsequent investigations by Arches rangers, Bureau of Land Management rangers, and the Grand County Sheriff resulted in state charges being filed against three of the four individuals. Unfortunately, theft of paleontological resources charges were quickly dismissed by the Grand County Justice Court judge because he was not made aware of the precedent setting nature of the citations issued (this was the first known citation involving the state's relatively new Paleontological Protection Act). The state proceeded with charges against the Moab resident (a Canyonlands National Park concessioner) in District Court, contending that he had collected mineral resources from state land without a permit. A suppression hearing in December was held, with trial date set for this past spring. However, several continuances have occurred, and the case is still awaiting adjudication. This is the first time such a case involving the protection of mineral resources has been taken to District Court in Utah.

Protecting Paleo Resources: A Case of Educating Ourselves and Working with Others at Arches National Park, Utah

Karen McKinley-Jones, Park Ranger, National Park Service, Arches National Park, P.O. Box 907, Moab, UT 84532

National Park Service (NPS) initiative monies are funding inventories of the Morrison formation and areas of megatracksites in and surrounding Arches National Park. Nearly 30 localities have been found that were unknown to park managers, with more sites expected to be found. Part of this project will include surveys of fossil rich State of Utah lands adjacent to Arches.

A side benefit to this project is a paleontological site monitoring and protection program that is being developed by a law enforcement commissioned Park Ranger, using information and expertise gained from working with researchers. This program is being developed to complement an existing cultural site monitoring and protection program.

Recently, the State of Utah administratively transferred lands immediately bordering the park from State Trust Lands status to Sovereign Lands status. State Trust lands, by law, are to be developed for the greatest economic benefit. Sovereign lands are managed for aesthetic, wildlife or other resource values, and for multiple use. This action will afford a higher level of protection for natural and cultural resources adjacent to the Park. NPS managers were invited to comment during this process.

The Bureau of Land Management (BLM) provided a remote sensor on the state land site which keyed an alarm coded into BLM radios. They then called us if their ranger couldn't respond. This was done through informal and formal agreements of the various agencies in order to protect a valuable resource. A Memorandum of Understanding was also signed between local NPS and BLM offices providing for law enforcement services between the agencies.

Educational Outreach: Casting and Molding and John Hanley Fossil Kits

Robert W. O'Donnell, Museum Specialist, U.S. Geological Survey (retired), 2793 S. St. Vrain St., Denver, CO 80236

Hands-on activities are powerful tools for generating interest in paleontological material. Such activities can be successfully employed with all age groups and all levels of knowledge. Availability of materials for hands-on activities is limited. We need to provide more activities and materials to create a greater understanding and respect for fossils and earth science.

People get a charge out of handling fossils. While there are many that are definitely hands-off, there are many that are hands-on, too. The John Hanley Memorial Fossil Teaching Kits were put together to give children (and adults) the chance to examine good specimens. Wherever possible, the specimens are the real thing. Otherwise, they are very good casts. These kits are loaned, free of charge, to anyone who requests them. There has been **no** problem with stealing. The kits are available through the US Geological Survey and the Colorado School of Mines Geology Museum.

A second activity that excites young and old alike is learning to make molds and casts of fossils. We make casts of a small Therapod track from the Lower Jurassic Navajo fm. in the Moab, Utah, area. We have successfully cast up to a hundred of these tracks at once, with first and second graders, without destroying the room where the casting was done. This activity develops awareness and appreciation of our paleontological resources and often gets students curious enough to pursue further study of fossils and earth science.

For more information on Fossil Kits:
Susann Powers, USGS Library GEO Center, Colorado School of Mines, (303)236-1015 (303)273-3815

For more information on casting workshops:
Bob O'Donnell, Colorado School of Mines, 2793 South St. Vrain, Denver, CO 80236
(303)273-3321 or 936-4146

Using GIS and GPS as Tools for Protecting and Managing Paleontological Resources at Florissant Fossil Beds National Monument, Colorado

Michael Reynolds, Chief of Resource Management, National Park Service, Cape Cod National Seashore, South Wellfleet, MA 02663-0205

An extensive inventory and monitoring system is being established to locate and monitor paleo sites within the Florissant Fossil Beds National Monument using Geographic Information Systems (GIS) and Global Positioning Systems (GPS). The field sites are located and stored as GPS points or polygons and are then downloaded into GIS software for integration with other resource or threat layers developing in the GIS system. The paleo sites can be modelled with digital elevation maps, geologic layers, soils, and park developments or plans to support research purposes, resource protection, monitoring; and for locating other previously unknown sites by comparing locations of known sites with areas of similar geologic or other resource parameters. The GPS field technologies allow for visiting and recording sites without the need for obvious field marking. Emerging technological changes in GPS will allow for better "navigation" in the field back to known sites for future monitoring. Types of hardware and software used and the positive and negative aspect of these tools in this project will be discussed.

Characteristics of Thieves and Non-thieves of Petrified Wood at Petrified Forest National Park, Arizona

Joseph W. Roggenbuck, Professor, and Dennis W. Stratton, Graduate Research Assistant, Department of Forestry, Virginia Polytechnic Institute, Blacksburg, VA 24061

Three research approaches were used to identify the demographic, knowledge, attitudinal, and behavior patterns of park visitors who take and don't take petrified wood. The three research approaches were:

- Unobtrusive observations of the nature and extent of theft at two popular and high wood concentrations sites at Petrified Forest National Park.
- Double-blind interviews of thieves and a sample of nonthieves as they left the park.
- An eleven page mailback questionnaire completed by observed thieves and nonthieves, and by a representative sample of park visitors.

Observed thieves differed from observed nonthieves or the general visitor population in that thieves were more likely to be over 62 years of age; be less educated; visit the park in larger groups; spend more time at "open-access" wood sites and less time at the wood site enclosed by a fence; be impulsive collectors; have park attitudes somewhat less supportive of protecting petrified wood; act (or not act) out of fear of being caught or fined; less supportive of providing more information about appropriate park behavior or of searching vehicles when they leave the park.

Public Lands and Geological Higher Education

Lee Shropshire, Professor of Geology, University of Northern Colorado, Greeley, CO 80639

Emmett Evanoff, Research Associate and Instructor, University of Colorado Museum, Campus Box 315, Boulder, CO 80309-0315.

Public lands constitute essential geological and paleontological resources for higher education. Colleges and universities use federal, state, and local lands for field trips, geology field camps, research projects, and field courses. Fossils are integral parts of geological investigations, and proper field descriptions and collecting techniques are essential parts of curricula for field courses. Federal, state, and local agencies also are essential for research and educational activities on public lands, for they conduct tours, provide informative lectures, arrange fee waivers for educational groups, and provide permits for research collecting of rock and fossil specimens.

Communication and cooperation between government and universities is critical to the success of all educational endeavors which utilize public lands. Research projects in national parks are closely monitored by federal personnel. Paleontological research involving collecting vertebrate fossils on Bureau of Land Management lands is subject to permit. A permitting process is being initiated by the US Forest Service. Such projects can be mutually beneficial for researchers and government entities in that these projects are often valuable sources of information on the geological and/or paleontological attributes of the public lands. For most instructors an important goal is creating in their students an awareness of the fragility of much of our natural environment and a sense of responsibility to care for it. As human populations increase, there is an ever increasing urgency to educate young citizens about respecting and protecting our geological and paleontological heritage.

Taphonomy of an Orellan (Early Oligocene) Fossil Site In the Scenic Member Of The Brule Formation, South Dakota

Kimberlee Stevens, Graduate Assistant, South Dakota School of Mines, 501 E. St. Joseph St, Rapid City, SD 57701.

This poster will address the taphonomy of a unique fossil site in Badlands National Park. Preliminary findings of the work and a discussion of the spatial bone distribution, the osteological and taxonomic representation, the sedimentary profile, and possible models of accumulation will be presented. This fossil site is a large accumulation of individual and articulated elements (*Archaeotherium*, *Subhyracodon*, and *Mesohippus*) crossing stratigraphic boundaries, making it unusual to the White River Group.

The South Dakota School of Mines and Technology and Badlands National Park have a cooperative agreement for the management of this site. Funding and technical expertise for this site have come from both the Park and the School of Mines. For the past two summers, workers in the field have collected fossils, matrix, and data from this site. The fossils are being prepared, curated, and studied at the School of Mines' Museum of Geology.

Research Goals in Vertebrate Paleontology: Strategies for Resource Mitigation

Richard K. Stucky, Curator of Paleontolgy, Denver Museum of Natural History, 2001 Colorado Blvd., Denver, CO 80205.

Vertebrate paleontological resource management is best accomplished within the framework of the overall goals of the science:

- To describe the diversity of vertebrate life through time.
- To understand the history of vertebrate life.
- To use this information for testing and developing new theories of evolution and ecology.

New Global Positioning Systems (GPS) allow for precise geographic locations of specimens. Photography and field measurement allows for precise stratigraphic locations of specimens. All kinds of mitigation work should require precise stratigraphic and geographic location. Other data should be collected when it is associated with a specific research objective. A system of determining scientific values for paleontological sites will be developed in this presentation.

Aspects of U.S. Geological Survey Paleoclimatic Research in the Western United States

Robert S. Thompson, Geologist, U.S. Geological Survey, Denver Federal Center, Box 25046, MS 919, Denver, CO 80225

Over the last several years US Geological Survey studies of sediments on public lands in the western United States have revealed aspects of the profound environmental and climatic changes that have occurred since the middle Pliocene. The Survey is analyzing fossil pollen, ostracodes, and diatoms to determine the nature, amplitude, and frequency of vegetational and hydrologic changes. Modern calibration data sets from the region provide quantitative estimates of past climatic changes, and the entire array of vegetational, hydrologic, and paleoclimatic data are being used to evaluate numerical model simulations of past climates.

Three million years ago (Ma), the Sierra Nevada, the Transverse Ranges, and other major western mountain chains were significantly lower than today. Consequently, more moisture reached the interior Western United States than now. Large lake systems dotted the western landscape and coniferous forests were widespread, while steppe and desert vegetation associations were less dominant than today. Quasi-cyclic climatic variations occurred, but they were of lower magnitude than those of the late Pleistocene in this region. At approximately 2.5 Ma the first large scale late Cenozoic Northern Hemispheric glaciation caused wide spread aridity in the West, which apparently persisted until c. 2 Ma. Then, relatively moist climates prevailed across the region until ~800,000 years ago (800 ka), when (although data are sparse) it appears that aridity increased. The large, moisture blocking mountain ranges may have attained near modern stature by that time. The large amplitude ~100 kyr climate oscillations characteristic of the late Pleistocene began prior to 250 ka, with relatively long (80 to 90 kyr) moist periods alternating with dry periods of shorter duration (10 to 20 kyr).

Physics of Dinosaurs

Jo Wixom, Science Department, Wester[n] State College, Gunnison, CO 81231

This interactive workshop provides models for school/agency partnerships that are being used in both public and private schools by this award winning educator. These models may reform the way scientists and science educators do business. Effective partnerships with local, state, and national agencies have produced remarkable educational experiences for both elementary and secondary students and teachers, while promoting research, public awareness, and program funding. The presenter shares strategies for school involvement, suggests interagency program development ideas, and proposes sources of funding. She also involves participants in activities from her dinosaur science curriculum using paleontology to teach basic science principles.

Paleontological Research Initiative And Interpretive Educational Products

Joseph Zarki, Chief of Interpretation, National Park Service, Joshua Tree National Park, 74485 National Monument Dr., Twentynine Palms, CA 92277

David Whitman, Chief of Interpretation, National Park Service, Dinosaur National Monument, P.O. Box 210, Dinosaur, CO 81610

A portion of research funds from the NPS Morrison Research Initiative in the Rocky Mountain Region has been dedicated toward an interpretive and educational product. This presentation will outline preliminary planning efforts and the various interpretive themes and media considered thus far. Ideas and comments will be welcomed.

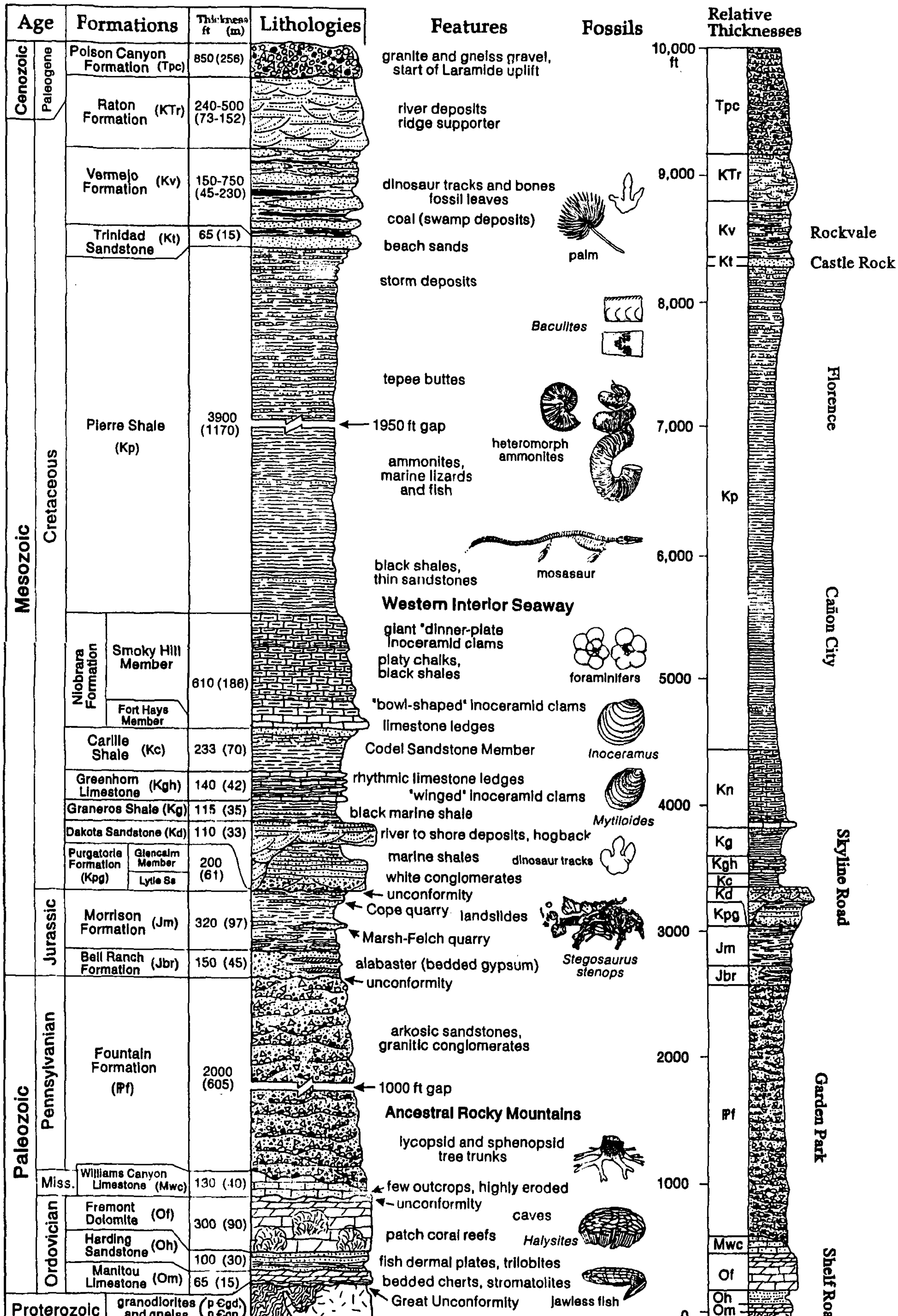
APPENDIX

FIELD TRIP

GARDEN PARK FOSSIL AREA
&
FLORISSANT FOSSIL BEDS NATIONAL MONUMENT

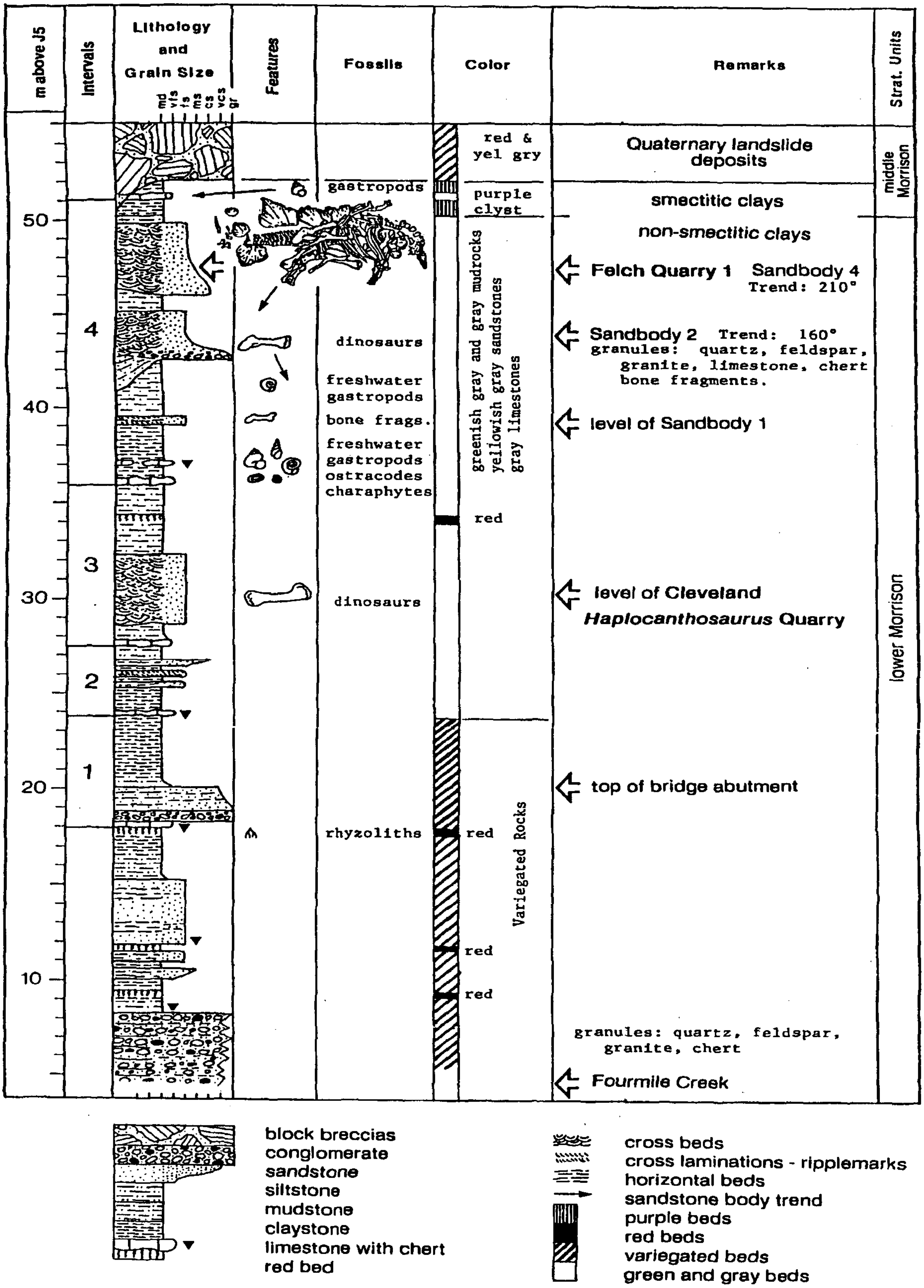
Field Trip participants at the Garden Park Fossil Area (above) and by the Big Stump at Florissant Fossil Beds National Monument (below).
Photos by Dan Grenard

Rocks of the Cañon City Basin

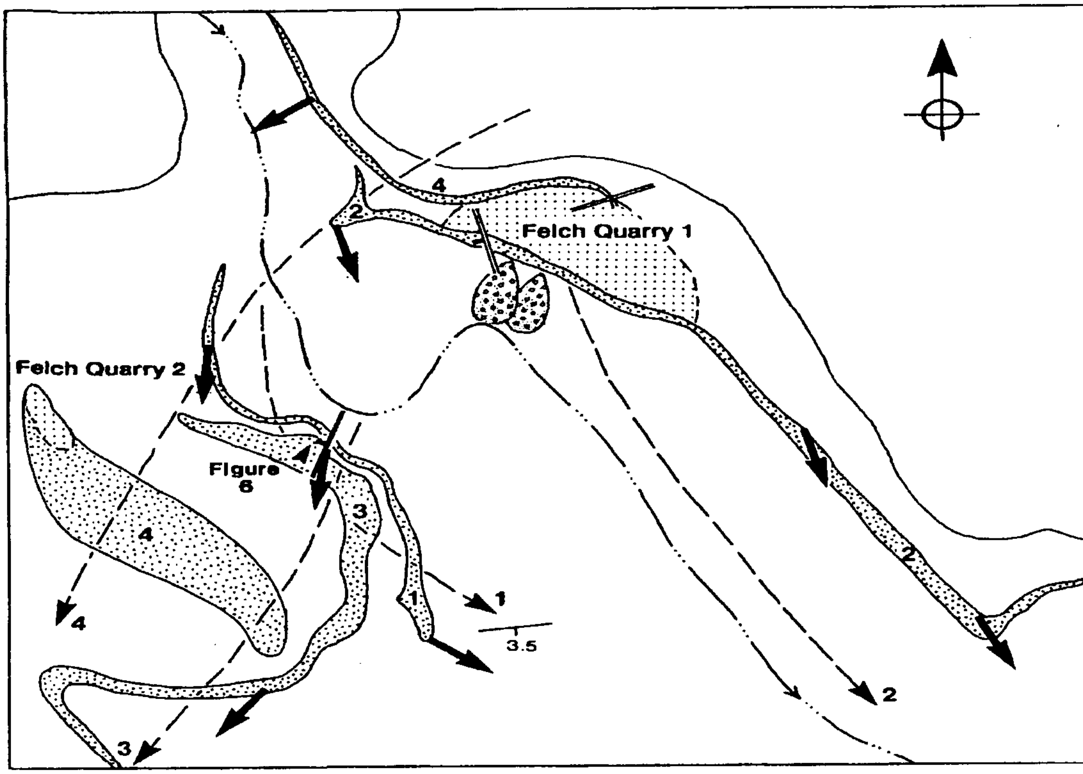


Compiled by Emmett Evanoff, 1996

Garden Park Fossil Area



Garden Park Fossil Area



0 m 50

sandstone body

orientation of lateral accretion stratification

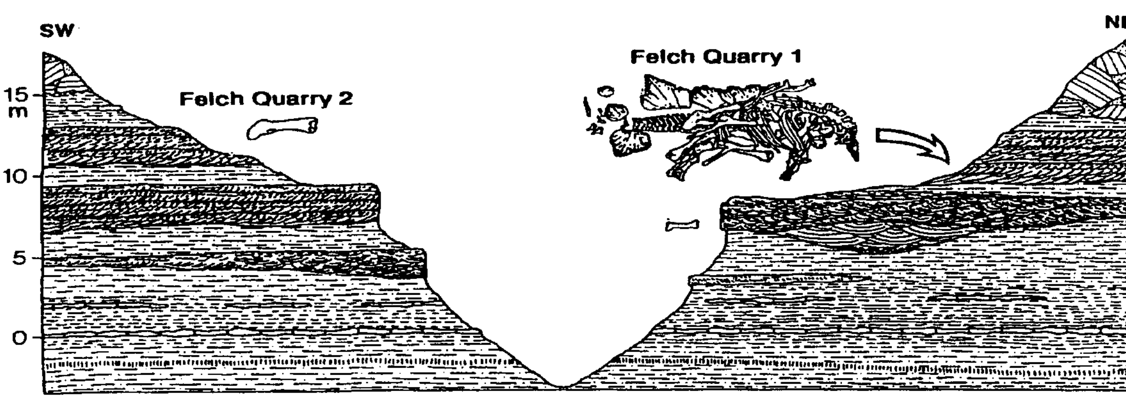
paleocurrent directions from crossbeds

strike and dip of lower limestone bed

2 sandstone body trend

spoils pile

Quaternary landslide deposits



landslide breccia

siltstone

claystone

limestone

red bed in siltstone

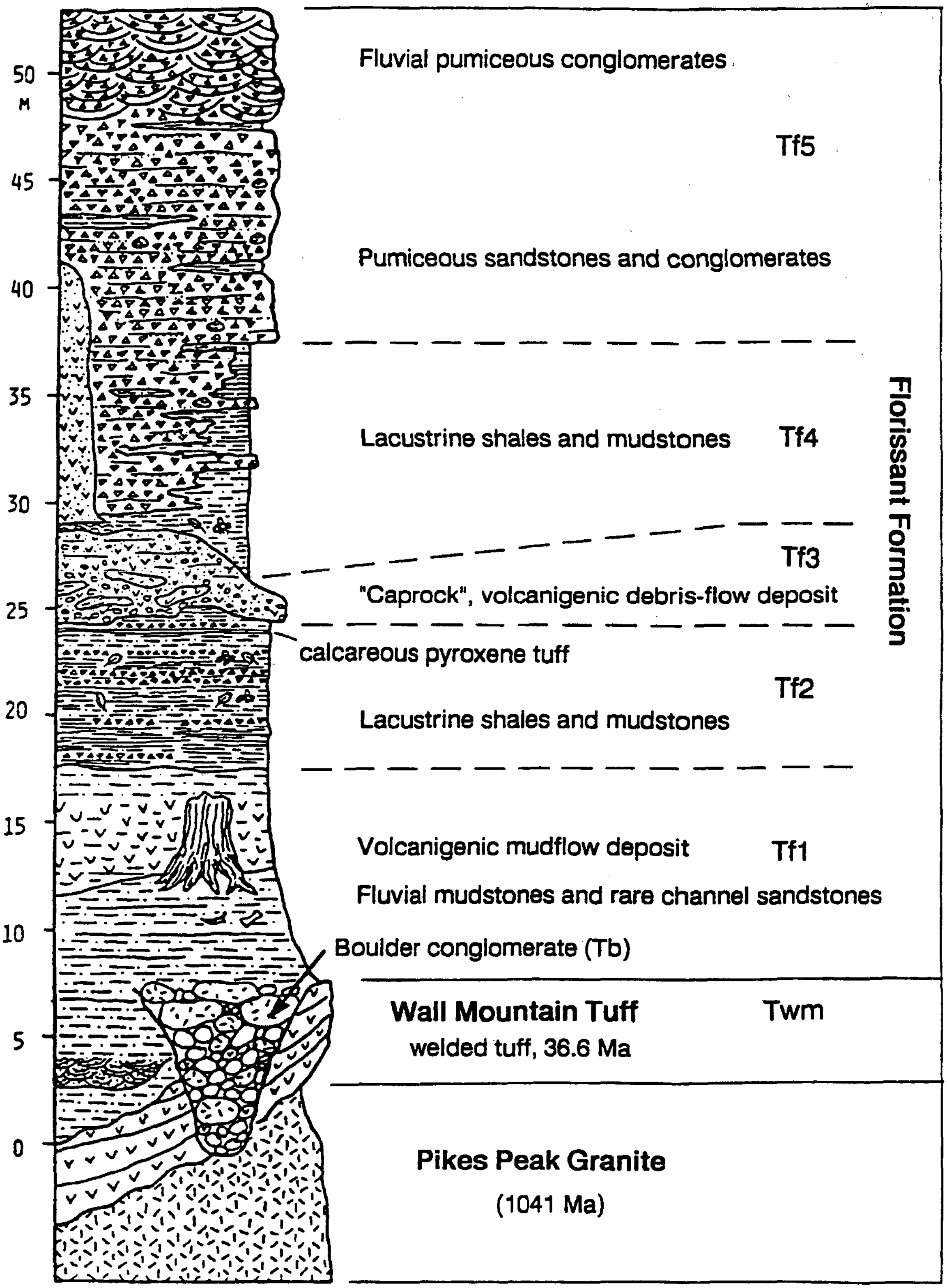
sandstone channel deposits

flow toward the viewer (to SE)

flow toward the left (to SW)

thin sandstone (overbank deposit)

Generalized stratigraphic units within Florissant Fossil Beds National Monument.



FLORISSANT INVERTBRATE FOSSILS (Rev 2/97)

A summary of the major groups of invertebrates from the Florissant Fossil Beds National Monument.

PHYLUM ARTHROPODA

CLASS INSECTA

Florissant is the one of the richest localities in the world for fossil insects. In the 1890's Dr. S. H. Scudder identified over 900 species. The following list was summarized from Dr. F. Martin Brown's studies of Florissant insect fossils. Included are 18 Insect orders, 123 families and approximately 1000 species. This list will likeley be revised as more study is done. Many of the fossil insects have not yet been identified.

Order **THYSANURA**
(Tassel Tail)
silverfish

Family	**& No. Species**
Lepismatidae	1

Order **EPHEMEROPTERA**
(Short Lived Wing)
mayflies

Family	**& No. Species**
Ephemeridae	5
Siphlonuridae	1

Order **ODONATA**
(Toothed)
dragonflies

Family	**& No. Species**
Aeshnidae	20
Calopterygidae	16
Coenagrionidae	12
Libellulidae	1
Lestidae	3
Agrionidae	12

Order **EMBIOPTERA**
(Long Lived Wing)
web spinners

Family	**& No. Species**
Anisembiidae	2

Order **PHASMATODEA**
(Apparition)
(formally ORTHOPTERA)
walkingsticks

Family	**& No. Species**
Phasmatidae	1

Order **ORTHOPTERA**
(Straight Wing)
grasshoppers

Family	**& No. Species**
Acrididae	6
Tettigoniidae	5

Order **DERMAPTERA**
(Skin Wing)
earwigs

Family	**& No. Species**
Forficulidae	2

Order **DICTYOPTERA**
(Net Wing)
(formally ORTHOPTERA)
roaches

Family	**& No. Species**
Blattidae	2

Order **ISOPTERA**
(Equal Wing)
termites

Family	**& No. Species**
Termitidae	6

Order **HEMIPTERA**
(Half Wing)
bugs

Family	**& No. Species**
Tingidae	3
Notonectidae	3
Reduviidae	1
Gerridae	1
Lygaeidae	2
Belostomatidae	2

Order **HOMOPTERA**
(Same Wing)
cicadas

Family	**& No. Species**
Psyllidae	2
Aphididae	22
Fulgoridae	29
Cicadidae	3
Cercopidae	27
Coccidae	1
Cicadellidae	21
Cixiidae	3
Dictyopharidae	1

Order **NEUROPTERA**
(Nerve Wing)
lacewings

Family	**& No. Species**
Corydalidae	1
Chrysopidae	2
Hemerobiidae	1
Sialidae	5

Order **COLEOPTERA**
(Sheath Wing)
beetles

Family	**& No. Species**
Bruchidae	3
Ptinidae	4
Dermestidae	1
Chrysomelidae	3
Elateridae	3
Staphylinidae	17
Throscidae	1
Cerambycidae	8
Spondylidae	1
Carabidae	11
Paussidae	1
Cucujidae	1
Trogossitidae	
Ostomidae	2
Scarabaeidae	3
Trogidae	1
Colydiidae	2
Scolytidae	2
Tenebrionidae	5
Cantharidae	1
Bostrichidae	3
Dryopidae	
Parnidae	1
Lampyridae	3
Salpingidae	
Pythidae	1
Rhipiphoridae	1
Melandryidae	1
Curculionidae	
Rhychitidae	1
Erotylidae	3

Order **HYMENOPTERA**
(Membrane Wing)
ants, wasps & bees

Family & No. Species	
Braconidae	20
Alysiinae	1
Ichneumonidae	100+
Stephanidae	1
Tenthredinidae	63
Pamphilidae	1
Lydidae	1
Pergidae	1
Blasticomidae	1
Torymidae	6
Agaonidae	1
Eurytomidae	2
Ormyidae	1
Pteromalidae	1
Cleonyminae	1
Chalcididae	5
Ibaliidae	1
Figitidae	1
Cynipidae	1
Evaniidae	4
Aulacidae	1
Diapriidae	3
Belytia	2
Apidae	3
Bombinae	2
Anthophoridae	1
Megachilidae	12
Melittidae	1
Scelionidae	1
Serphidae	
Proctotrupidae	1
Bethylidae	2
Chrysididae	1
Scoliidae	3
Tiphiidae	
Cosilidae	3
Formicidae	9
Pompilidae	8
Vespidae	5
Eumenidae	4
Sphecidae	3
Crabronidae	2
Nyssonidae	2
Pemphredonidae	1
Philanthidae	1
Anthophoridae	
Ceratininae	1
Andrenidae	9
Panurginae	1
Halictidae	2

Order **TRICHOPTERA**
(Hair Wing)
caddisflies

Family & No. Species	
Rhyacophilidae	22

Order **LEPIDOPTERA**
(Scale Wing)
moths & butterflies

Family & No. Species	
Pieridae	2
Nymphalidae	8
Libytheidae	2
Caterpiller	
Phylledestes vorax	

Order **MECOPTERA**
(Long Wing)
Scorpion Flies

Family & No. Species	
Panorpidae	2

Order **DIPTERA**
(Two Wing)
Flies

Family & No. Species	
Tipulidae	Abundant
Culicidae	Abundant
Chironomidae	Abundant
Bibionidae	Abundant
Mycetophilidae	25
Nemestrinidae	7
Bombyliidae	21
Empididae	9
Phoridae	3
Platypezidae	2
Syrphidae	Several
Otitidae	
Ortalidae	5
Sepsidae	2
Sciomyzidae	1
Lauxaniidae	1
Piophilidae	1
Agromyzidae	2
Heleomyzidae	1
Trichoceridae	1
Stratiomyidae	3
Mydidae	
Mydasidae	Several
Glossinidae	

CLASS ARACHNIDA

Spiders are represented with 5 families and 32 separate species.

Family & No. Species	
Salticidae	7
Laterigradae	5
Tubitelaridae	12
Retitelaridae	6
Orbitelaridae	20

PHYLUM MOLLUSCA

Information from Emmett Evanoff

CLASS GASTROPODA

snails

Order **Lymnophila**
Family Lymnaeidae
Stagnicola sieverti (Cockerell)
Lymnaea ? scudderi Cockerell
Lymnaea ? florissantica Cockerell

Family Planorbidae
Gyraulus florissantensis (Cockerell)
Promenetus sp.

Order **Geophila**
Family Thysanophoridae
Polygyrella ? laminarium (Cockerell)
Family Vitrinidae
Vitrea ? fagalis Cockerell

CLASS BIVALVIA

clams

Order **Veneroida**
Family Sphaeriidae
Saphaerium florissantense Cockerell
Musculium sp.

PHYLUM ANNELIDA

Segmented worm

FLORISSANT MEGAFLORAL FOSSILS (Rev. 1/97)

This list of fossil foliage, fruits and seeds from the Florissant Formation is modified from H.D. MacGinitie, 1953, *Fossil Plants of the Florissant Beds, Colorado*, with additions and revisions based upon more recent studies, particularly those of S.R. Manchester. Some identifications are questionable and may be revised in the future. About 140 fossil plant species (including some unidentified that are not listed here) are known from foliage or fruits. Additional taxa are known from the fossil pollen record.

Division Bryophyta

Family Grimmiaceae

Plagiopodopsis scudderi Britton and Hollick

Plagiopodopsis cockerelliae (Britton and Hollick) Steere

Division Sphenophyta

Family Equisetaceae

Equisetum florissantense Cockerell

Division Pteridophyta

Family Aspidiaceae

Dryopteris guyottii (Lesquereux) MacGinitie

Division Gnetophyta

Family Gnetaceae

Ephedra miocenica Wodehouse

Division Coniferophyta

Family Taxaceae

Torreya geometrorum (Cockerell) MacGinitie

Family Cupressaceae
[including former Taxodiaceae]

Chamaecyparis linguaefolia (Lesquereux) MacGinitie

Sequoia affinis Lesquereux

Family Pinaceae

Abies rigida Knowlton

Picea magna MacGinitie

Pinus florissantii Lesquereux (soft pine; ovulate cone)

Pinus macginitieii Axelrod (2-3-needled hard pine with articulated seeds)

Pinus wheeleri Cockerell (5-needled soft pine)

Pinus sp. (5-needled hard pine)

Pinus sp. (hard pine, cone formerly assigned to *P. wheeleri*)

Division Magnoliophyta; Class Magnoliidae

Family Lauraceae

Lindera coloradica MacGinitie

Persea florissantia MacGinitie

Sassafras hesperia Berry

Family Aristolochiaceae

Aristolochia mortua Cockerell

Family Berberidaceae

Mahonia marginata (Lesquereux) Arnold

Mahonia obliqua MacGinitie

Mahonia subdenticulata (Lesquereux) MacGinitie

Family Platanaceae

Platanus florissantii MacGinitie

Family Eucommiaceae

Eucommia sp.

Family Ulmaceae

Cedrelospermum lineatum (Lesquereux) Manchester

Celtis mccoshii Lesquereux

Ulmus tenuinervis Lesquereux

Family Cannabidaceae

Humulus florissantella (Cockerell) MacGinitie

Family Moraceae

Morus symmetrica Cockerell

Family **Juglandaceae**

Carya florissantensis Manchester (fruits)

Carya libbeyi (Lesquereux) MacGinitie (leaves)

Juglans (?) *sepultus* Cockerell

Family Fagaceae

Castanea dolichophylla Cockerell

Fagopsis longifolia (Lesquereux) Hollick

Quercus dumosoides MacGinitie

Quercus knowltoniana Cockerell

Quercus lyratiformis Cockerell

Quercus mohavensis Axelrod

Quercus orbata MacGinitie

Quercus peritula Cockerell

Quercus predayana MacGinitie

Quercus scottii (Lesquereux) MacGinitie

Quercus scudderi Knowlton

Family Betulaceae

Asterocarpinus perplexans (Cockerell) Manchester and Crane (fruits)

Paracarpinus fraterna (Lesquereux) Manchester and Crane (leaves)

Family Tiliaceae

Tilia populifolia Lesquereux

Family Sterculiaceae

Florissantia speirii (Lesquereux) Manchester

Family Salicaceae

Populus crassa (Lesquereux) Cockerell

Salix coloradica MacGinitie

Salix libbeyi Lesquereux

Salix ramaleyi Cockerell

Salix taxifolioides MacGinitie

Family Styracaceae

Halesia reticulata MacGinitie

Family Hydrangeaceae

Hydrangea fraxinifolia (Lesquereux) Brown

Philadelphus minutus MacGinitie

Family Grossulariaceae

Ribes errans MacGinitie

Family Rosaceae

Amelanchier scudderi Cockerell

Cercocarpus myricaefolius (Lesquereux) MacGinitie (or similar extinct genus)

Crataegus copeana (Lesquereux) MacGinitie
Crataegus hendersonii (Cockerell) MacGinitie
Crataegus nupta (Cockerell) MacGinitie
Holodiscus sp.
Malus florissantensis (Cockerell) MacGinitie
Malus pseudocredneria (Cockerell) MacGinitie
Prunus gracilis (Lesquereux)MacGinitie
Rosa hilliae Lesquereux
Rubus coloradense (MacGinitie) Wolfe and Tanai
Vauquelinia coloradensis (Knowlton) MacGinitie
Vauquelinia liniara MacGinitie

Family Leguminosae

Caesalpinites acuminatus (Lesquereux)MacGinitie
Caesalpinites coloradicus MacGinitie
Cercis parvifolia Lesquereux
Conzattia coriacea MacGinitie
Leguminosites lespedezoides MacGinitie
Astragalus wilmattae Cockerell
Phaseolites dedal MacGinitie
Prosopis linearifolia (Lesquereux) MacGinitie
Robinia lesquereuxii (Ettingshausen) MacGinitie
Vicia sp. Knowlton

Family Thymelaeaceae

Daphne septentrionalis (Lesquereux)MacGinitie

Family Myrtaceae

"*Eugenia*" *arenaceaeformis* (Cockerell) MacGinitie

Family Onagraceae

Gen. et sp. indet. (flower)

Family Celastraceae

Celastrus typica (Lesquereux) MacGinitie

Family Euphorbiaceae

Euphorbia minuta (Knowlton) MacGinitie

Family Rhamnaceae

Colubrina spireaefolia (Lesquereux) MacGinitie
Rhamnites pseudo-stenophyllus (Lesquereux) MacGinitie
Ziziphus florissantii (Lesquereux) MacGinitie

Family Vitaceae

Parthenocissus osbornii (Lesquereux) MacGinitie

Family Staphyleaceae

Staphylea acuminata Lesquereux

Family Sapindaceae

[including former Aceraceae]

Acer florissantii Kirchner
Acer macginitiei Wolfe and Tanai
Athyana haydenii (Lesquereux) MacGinitie
Cardiospermum terminalis (Lesquereux) MacGinitie
Dipteronia insignis (Lesquereux) Brown
Dodonaea umbrina MacGinitie
Koelreuteria allenii (Lesquereux) Edwards
Sapindus coloradensis Cockerell
Thouinia straciata MacGinitie

Family Burseraceae

Bursera serrulata (Lesquereux) MacGinitie

Family Anacardiaceae

Cotinus fraterna (Lesquereux) Cockerell
Rhus lesquereuxii Knowlton and Cockerell
Rhus obscura (Lesquereux) MacGinitie
Rhus stellariaefolia (Lesquereux) MacGinitie
Schmaltzia vexans (Lesquereux) Cockerell

Family Simaroubaceae

Ailanthus americana Cockerell

Family Meliaceae

Cedrela lancifolia (Lesquereux) Brown
Trichilia florissantii (Lesquereux) MacGinitie

Family Rutaceae

Ptelea cassioides (Lesquereux) MacGinitie

Family Araliaceae

Oreopanax dissecta (Lesquereux) MacGinitie

Family Apocynaceae

Apocynospermum sp.

Family Convolvulaceae

Convolvulites orichitus MacGinitie
Porana tenuis Lesquereux

Family Oleaceae

Osmanthus praemissa (Lesquereux) Cockerell

Family Caprifoliaceae

Diplodipelta reniptera (Becker)Manchester and Donoghue

Family Adoxaceae

Sambucus newtonii Cockerell

Division Magnoliophyta;
Class Liliopsida

Family Potamogetonaceae

Potamogeton sp.

Family Palmae (Arecaceae)

Palmites sp.

Family Cyperaceae

Cyperacites lacustris MacGinitie

Family Gramineae (grass)

Stipa florissantii (Knowlton) MacGinitie

Family Typhaceae (cattail)

Typha lesquereuxii Cockerell

Family Smilacaceae and/or **Dioscoreaceae**

Smilax and/or *Dioscorea* sp.

FLORISSANT VERTEBRATE FOSSILS (Rev. 2/97)

CLASS OSTEICHTHYES (bony fishes)
ORDER AMIIFORMES
Family **Amiidae** (bowfins)
Amia dictyocephala Cope
Amia scutata Cope
ORDER CYPRINIFORMES
Family **Catostomidae** (suckers)
Amyzon commune Cope
Amyzon fusiforme Cope
Amyzon pandatum Cope
Amyzon sp. indet. Cope
ORDER SILURIFORMES
Family **Ictaluridae** (catfishes)
Ictalurus pectinatus (Cope)
ORDER PERCOPSIFORMES
Family **Aphredoderidae** (pirate perches)
Trichophanes copei Osborn, Scott & Spier
Trichophanes foliarum Cope

CLASS AVES (birds)
ORDER CUCULIFORMES (cuckoos)
Family **Cuculidae**
new genus and species
ORDER CORACIIFORMES (African rollers and their relatives)
Family **Coraciidae**
New combination needed for "*Palaeospiza*" *bella* Allen (formerly described as a perching bird within Passeriformes)
Incertae sedis (affinities unknown)
"*Fontinalis*" *pristina* Lesquereux (a feather originally described as a moss)
"*Charadrius*" *sheppardianus* Cope (originally described as a plover; later placed into *incertae sedis* by Olson)

CLASS MAMMALIA (mammals)
ORDER MARSUPIALIA
Family **Didelphidae**
Peratherium sp. Gazin (similar to modern pygmy opossums)
ORDER PERISSODACTYLA
Family **Equidae**
Mesohippus sp. (small three-toed horse)
Family **Brontotheriidae**
gen. indet. (brontothere)
Family **Rhinocerotidae**
gen. indet. (Rhino)
ORDER ARTIODACTYLA
Family **Merycoidodontidae** (Oreodontidae)
Merycoidodon sp. (oreodont)
ORDER PROBOSCIDEA
Family **Elephantidae**
Mammuthus sp. Mammoth
The teeth & lower jaw of a mammoth were found in Pleistocene gravels (45,000+ BP), **not** in the Eocene Florissant Formation

FIELD TRIP

DINOSAUR RIDGE

Participants inspecting dinosaur tracks on the Dinosaur Ridge field trip.
Photos by Scott Foss

ROAD LOG TO DINOSAUR RIDGE

This road log covers a 6-mile loop around Dinosaur Ridge, located between Morrison and Lakewood, Jefferson County, Colorado. Beginning at the intersection of Colorado Highway 470 (C-470) and Morrison Road, it follows a route north on Rooney Road, west on Alameda Parkway, south on County Road 93 to Morrison, and then east on Morrison Road back to C-470. The most detailed part of the log covers the 1.2 miles of Alameda Parkway as it crosses the Dakota hogback (Dinosaur Ridge), past the exposures of dinosaur tracks and dinosaur bones from the Cretaceous and Jurassic periods.

mileage		
cum.	*incr.*	
-	-	Begin at C-470, Morrison Road exit. Go west on Morrison Road, toward Morrison.
0.0	0.0	Turn right (north, toward Bandimere Speedway) on Rooney Road, the first road intersection immediately west of C-470.
0.1	0.1	The square sandstone structure visible ahead to the left is an old lime kiln. From about 1878 until the 1930s, Cretaceous limestone was quarried near here. Limestone was "burned" in kilns like this to produce lime for whitewash, etc. This limestone (Fort Hayes Member of the Niobrara Formation) was part of the marine sediments deposited in the Cretaceous seaway which covered the central U.S., including much of Colorado.
0.7	0.6	Underpass beneath C-470.
1.2	0.5	Near-vertical beds of the Niobrara Formation are visible on the left across C-470. In most places on the Dakota hogback, strata dip about 30-40° to the east. The much steeper dip of the beds here is due to proximity to the Golden Fault, which runs NNW-SSE near the course of C-470. The Golden Fault has no surface exposures and is considered to be inactive; there is no evidence for movement on it for at least the past 0.5 million years.
1.3	0.1	Rooney Gulch is the north-south drainage on the east side of Rooney Road. This creek provides habitat for plants and animals, and a number of archaeological sites have been found near the gulch.
1.8	0.5	Road crosses Rooney Gulch.
2.4	0.6	Intersection with Alameda Parkway; turn left (west).
2.5	0.1	Overpass across C-470.
2.7	0.2	Entrance to the Dinosaur Ridge Visitor Center, formerly the Wagner Ranch. This stone house (c.1950) and barn (c.1983) were purchased in June, 1994 by Jefferson County Open Space for use as a visitors' center to Dinosaur Ridge, to be operated and maintained by the Friends of Dinosaur Ridge. A "limited-facility", part-time office and visitors' center is now (10/94) open; facilities, exhibits, and hours of operation will be added and expanded in the coming months and years. The Friends of Dinosaur Ridge has made it possible for over 15,000 visitors to tour Dinosaur Ridge during each of the past two years!
2.8	0.1	Intersection with Rooney Road (north segment). To the south of the intersection is the

historic Rooney Ranch, one of the earliest permanent settlements in the Denver foothills area. This 200 acre ranch (earlier encompassing as much as 4500 acres) has been continuously occupied by the Rooney family for about 135 years. The main house was built between 1860-1865, of local sandstone from the Dakota hogback.

reset mileage

0.0 0.0 On the south side of Alameda Parkway, at the southeast corner of this intersection, is a dirt parking area which is a convenient rendezvous point for parking and pooling cars to drive over Dinosaur Ridge, or to begin a walking tour. There is also a Port-a-Potty provided by the Friends of Dinosaur Ridge, and the first of a series of interpretive signs erected by the Friends in 1992. Follow Alameda Parkway as it heads west up the Dakota hogback, past the "Dinosaur Ridge National Natural Landmark" sign.

The area was designated a National Natural Landmark in 1973, and an application as a National Historic Landmark is pending. In March, 1993, Dinosaur Ridge was included in the State Register of Historic Properties; and in January, 1994, after application by the USGS and the Friends of Dinosaur Ridge, the U.S. Board on Geographic Names officially recognized "Dinosaur Ridge" as a named topographic feature which will appear on all future USGS topographic maps. For map purposes, "Dinosaur Ridge" has been officially defined as the entire 4.7-mile section of the Dakota hogback lying north of Morrison Road (at Bear Creek) and south of W. Colfax Avenue (at Lena Gulch).

0.1 0.1 Wooden sign--"Benton Shale". This black, soft and easily eroded, fissile (splits easily into thin layers) shale is made of fine-grained, organic-rich mud deposited on the floor of the Cretaceous sea after it rose and covered the shoreline on which the Dakota Sandstone had earlier been deposited. This series of geologic signs (which continues eastward on Alameda Parkway) was erected by the Colorado Scientific Society. (On current geologic maps, this shale is also called the "Graneros Shale".)

A little to the left of the sign is a large, orange-brown concretion in the Benton Shale. A concretion--any nodule that is harder and more erosion-resistant than its surrounding rock--is produced by mineral growth which solidly cements together the grains of a sedimentary rock. Often, concretions form around some central nucleus, which may be a pebble or a fossil. The color of this concretion shows that it is rich in iron; it is composed of the minerals *siderite* and *limonite*.

0.15 0.05 Stop #15 (sign on left) - overlooking the Rooney Ranch, homesteaded in the 1860's.

0.2 0.05 Stop #14 - these gray-black, fissile strata are still the Benton Shale. Marine animals which lived in this sea included fish, marine reptiles (crocodiles, mosasaurs), ammonites, and clams. *Fossils* in the Benton Shale along this roadside are not too common, but one can find fish scales, fish teeth, and mollusk shells, and an occasional ammonite.

0.25 0.05 As you continue uphill from here, the soft, gray, fissile, thin-bedded, fine-grained Benton Shale grades into the underlying Dakota Sandstone, which is lighter colored (gray-white), coarser-grained, harder, and thicker-bedded. The Dakota Sandstone is a shoreline deposit, formed on beaches, tidal flats, estuaries, and river channels. The Benton Shale formed where finer-grained muds settled out in deeper water offshore. The position of the shoreline was gradually shifting westward while the sandstone and shale were each being deposited in their respective environments.

0.3 0.05 Pull-off with room for parking on the right. A crude switchback path leads to one row of dinosaur tracks *(Iguanodon?)* in the middle of a smooth sandstone bedding surface located about 50 feet above the road. Unlike the other tracks visible along Alameda, these footprints are raised slightly above the level of the sandstone around them, are slightly darker in color, and have pointed claw-like toes. There were four large tracks, one of which has recently broken loose and slid down to the bottom of the slope due to natural erosion; plus what appear to be one or two smaller (juvenile?) tracks.

0.35 0.05 Stop #13 - here, a Cretaceous river channel or tidal channel appears to have eroded down into the earlier-deposited beds of the Dakota Sandstone, and then filled with finer-grained gray silt. One row of imperfectly preserved, iron-stained *Iguanodon* tracks can be seen about 10 feet above road level if one climbs up over the first group of boulders. Many of the sandstone blocks here contain thin, vertical burrow tubes of sand-dwelling invertebrates; also, look for the larger, cone-shaped depressions--an enigmatic type of trace fossil (what do you think formed these?).

To the left of this area is the "Mangrove Swamp", an orange (iron-stained) sandstone bed containing many fossil wood impressions--sticks and branches. This may represent vegetation torn up by a storm (a hurricane?) from a nearby coastal swamp forest, and washed into the shallow water to sink, be buried by more sediment, and rot away, leaving only the imprints.

Just ahead up the road is a bed with good ripple marks.

0.40 0.05 Stop #12 - The main, fenced trackway site contains tracks of the herbivorous *Iguanodon* (a relative of the duckbill dinosaurs) and at least two kinds of meat-eating (theropod) dinosaurs: a small *Ornithomimus*-like animal (a Coelurosaur?), and (represented by just a few tracks) a somewhat larger theropod. The positions and orientations of the most recognizable tracks are shown on Martin Lockley's map of this site, reproduced in the *A Field Guide to Dinosaur Ridge*. This is an active, ongoing research site; excavations to expose new trackways were conducted in Nov.-Dec., 1992, and careful removal of the remains of a thin shale bed which directly covers the track-bearing sandstone layer is continuing. When you see them, the tracks may have been carefully colored with charcoal to make them more recognizable from a distance.

0.45 0.05 Stop #11 - Trace fossils; the Dakota sandstone here is full of the sand-filled burrows of invertebrate organisms that lived in the sands of the beach and tidal flats.

0.55 0.10 Milepost 2, on the left (east) side of the road.

0.6 0.05 Stop #10 - Ripple marks in the Dakota Sandstone.

Uphill from this stop is some limited room for vehicle parking.

0.65 0.05 Stop #9 (sign on left) - *A Field Guide to Dinosaur Ridge* discusses ecology of the area, located on the boundary between the High Plains and the Rocky Mountains. Among other things, the hogback is a major spring and fall raptor flyway; several thousand migrating hawks, of at least 17 species, have been counted flying north along the ridge each April.

0.7 0.05 Wooden stairs on the right lead to the Dakota Ridge Trail, a Jefferson County Open Space hiking trail which runs north along the crest of the Dakota Hogback to connect with the parking area for the I-70 Road Cut ("Point of Geologic Interest"). Follow the stairs to take the trail north; to go south, cross Alameda and walk up hill along the left shoulder outside the concrete barriers, to the curve in the road, where the trail leaves the road and follows the ridge crest south, dropping down the west side to join the highway. There is limited parking space here on the right, past the stairway.

0.8 0.10 Stop #8 - Walk along the outside (left) shoulder of the road, behind the concrete barrier. This is a view stop, to contemplate the view east from the hogback: the Golden Fault (not visible, but paralleling the course of Rooney Road and C-470); the sequence of Cretaceous marine sediments which overlie the Dakota Sandstone; the younger Cretaceous terrestrial (deposited on land, in river channels or lakes) sedimentary rocks which contain the scars of clay and coal mines visible on the far side of C-470; the Cretaceous-Tertiary boundary (marking the extinction of the dinosaurs), contained within the Denver Formation on the lower slopes of Green Mountain; and the Denver Basin, a large structural basin (a downwarp or "sag" in the layered rock sequence) which extends across Denver on to eastern Colorado and Nebraska, and from which much oil and gas are produced from the Dakota Sandstone. A lot to see!

Stop #7 - Slightly further ahead at the bend in the road, is an area where small impressions of fossil plant fragments can be seen in the Dakota Sandstone.

Stop #6 - The "puzzle" is a large ball-shaped concretion in the Dakota Sandstone. This concretion is composed of sandstone solidly cemented together mainly by growth of the iron-containing carbonate mineral, *ankerite*.

0.85 0.05 Stop #5 - Coming out of the curve, several small-displacement faults are visible in the thin-bedded sandstones of the lower part of the Dakota Sandstone on the right side of the road.

Stop #4 - A view to the west: Mount Morrison (Precambrian gneiss and granite), Red Rocks Park (red sandstone and conglomerate of the Fountain Formation, from the 300-million-year-old Pennsylvanian Period), and other overlying rock formations from the Permian, Triassic, and Jurassic periods. A place to see and contemplate the uplift of the Rocky Mountains, which began about 70 million years ago, forming the present landscape and lifting up these fossil-bearing rocks to expose them to our view!

0.9 0.05 The red-stained sandstones on the right are debated as belonging to either the lower part of the Dakota Sandstone (Cretaceous Period) or the upper part of the Morrison Formation (Jurassic Period); the contact between the two formations is in this general vicinity.

0.95 0.05 Stop #3 - The deep, sometimes uniformly spaced depressions in certain sand beds of the Morrison Formation here are believed to be dinosaur tracks, possibly of *Apatosaurus*. (We should note that some geologists have argued that these are not really tracks at all, but are just "load casts"--lobe-shaped irregularities in the bottom of a sandstone layer, produced randomly by settling and uneven compaction of soft, water-saturated sands and muds deposited in a river channel. What do you think?)

1.0 0.05 Sandstone boulders lining the left side of the road contain some excellent dinosaur bones. These came from the sandstone bed in the Morrison Formation exposed in the road cut on the right a short distance ahead. Other boulders along the road here are from the Tertiary-age lava flows (about 62 million years old--just after the dinosaurs became extinct) that form North and South Table Mountains near Golden.

Stop #2 - on the right is the "Morrison Formation" sign in the series erected by the Colorado Scientific Society

1.05 0.05 Stop #1 - dinosaur bones exposed in the roadcut are at the approximate site of one of the original 1877 dinosaur quarries in the Morrison Formation, located by Arthur Lakes and excavated by Lakes, Benjamin Mudge, and other excavators working for Prof. Othniel Charles Marsh of Yale University. The bones now exposed are in a channel sandstone--a sandstone bed deposited in an ancient river channel, interbedded with the much softer greenish and reddish shales which make up much of the Morrison Formation. (In the channel sandstones, look for conglomerate (gravel) beds composed of small pebbles. The shales accumulated on flood plains and in shallow lakes bordering the Jurassic rivers, and a few thin, hard limestone beds also formed in the lakes.) The Morrison Formation, of Late Jurassic age, is about 145 million years old. The bones discovered here in 1877 were the first dinosaur bones that were more than fragments to be found in the western U.S.; *Apatosaurus* (= Brontosaurus), *Stegosaurus*, *Allosaurus*, and *Diplodocus* were all discovered and named from the several quarry sites located between here and the town of Morrison. The first *Stegosaurus* in the world was discovered right here; the Colorado State Fossil is truly a "Colorado Native"! Bones visible in the roadcut and in the loose boulders along the roadside include leg bones, vertebrae, ribs, and an apparent shoulder blade (scapula), most likely of *Stegosaurus*. The bones are colored brown from iron which has been deposited in the bones after their burial, probably plus some residual organic matter. The bones are only partly "petrified", or replaced by new minerals; about half of the bones as we see them are still composed of calcium phosphate (the mineral *apatite*), of which bones and teeth are composed--the same mineral that made up the bones when they were part of a living dinosaur. After burial, the minerals calcite, ankerite, and quartz were been deposited in the bones--particularly within the hollow cells and channels which carried blood and fluids in the interior of the bones. These bones are moderately radioactive, because uranium (along with iron) is one of the elements that has been precipitated in the bones from groundwater which has percolated through this porous sandstone bed throughout the course of time since the bones were buried.

1.1 0.05 The small tree on the right is near the lower contact of the Morrison Formation; below it is the Ralston Creek Formation, slightly older but still from the Jurassic Period. The Ralston Creek Formation (which some geologists consider to be no different than the lower part of the Morrison Formation) is not noted for fossils here.

1.2 0.10 Intersection with the highway connecting I-70 to the town of Morrison, at the north entrance to Red Rocks Park. [From Alameda Parkway north to I-70, this is designated State Highway 26; the road continuing south to Morrison is designated Jefferson County Road 93.]

Turn left (south) toward Morrison.

1.85 0.65 On the right, another entrance to Red Rocks Park.

Just beyond, on the left, the Dakota Ridge Trail reaches the highway after descending the west side of the hogback.

2.9 1.05 On the left, an old wooden loading platform marks the site of a former uranium prospect in the Morrison Formation. A small mine adit, in the hillside above the platform, has been sealed by the Mined Land Reclamation Board. Just to the right of the mine adit is a large scar in the hillside where sandstone is believed to have been quarried for local building stone use. It is unlikely that any significant amount of uranium was ever found here, and the wooden platform was probably built for transportation of the building stone rather than for uranium ore.

2.95 0.05 Visible on the hillside above to your left is the bare, light greenish-colored scar where sandstone was quarried from the Morrison Formation. The site of one of the 1877 dinosaur bone quarries ("quarry #10") is located several hundred feet further uphill and further south of this scar, to the left of a small deciduous tree. Above, forming the jagged skyline of the hogback ridge, is the hard, yellow-white Dakota Sandstone.

3.1 0.15 Intersection with Stone Street (one way) in Morrison; turn right.

3.15 0.05 Traffic light; intersection with Morrison Road (State Highway 8); turn left.

An 0.65-mile side trip from here takes you to the Morrison Natural History Museum, constructed by the town of Morrison in 1988 in a refurbished 1945-era log cabin. To reach the museum, turn right instead of left at the Morrison Road traffic light. After 0.2 mile, turn left at the last traffic light at the west end of town, and continue to follow Highway 8 another 0.45 mile south, crossing Bear Creek. The museum is the log building with a gravel parking lot on the right side of the highway. The Morrison Natural History Museum is open 1-4 p.m., Wed. through Sun. (other hours by appointment), and there is no admission charge (donations are accepted). It contains exhibits about the geology, paleontology, history, plants and wildlife, and ecology of the Morrison area. Paleontologic exhibits include a large collection of world-wide fossils, plaster replicas of local dinosaur tracks, and several large dinosaur bones from the Morrison area. These include several of the original *Stegosaurus* bones collected in 1877 and which are now, on loan from the Yale-Peabody Museum, being cleaned and prepared for future scientific study and exhibit--Morrison's "Return of the Native" project. School groups may arrange tours of the museum, which include a simulated fossil hunt and other activities, for a small fee.

3.3 0.15 Continuing along the main route: parking spaces along Morrison Road on the right (next to Bear Creek) are the closest place to park if you wish to walk to see dinosaur tracks which are exposed on the cliffs ahead, on the north side of Morrison Road. A path along the north side of the road, safely separated from traffic by a barrier fence, leads to the tracks.

3.4 0.10 Approximate location of the tracks, exposed on the underside of an overhanging ledge of Dakota Sandstone, about 15 feet above ground level. To reach the site, park where noted above, cross Morrison Road (carefully!), and walk east along the left (north) side of the road; stay to the left of the barriers which isolate the walkway from traffic on the road. Seen from below, these appear to be natural sand-filled casts of three-toed dinosaur tracks, formed when a later layer of sand washed in and filled the tracks left by one or more strolling *Iguanodon*. (We should note that some geologists are not convinced that these are really dinosaur track impressions; do you think they could be load casts (see Stop #3), or casts of tree roots that grew in this mud layer?)

3.6 0.2 Intersection on left with the south segment of Rooney Road, the starting place of our field trip. Just ahead are the entrance ramps to C-470.

---P.J. Modreski, U.S. Geological Survey, Oct. 1994

Sources of additional information:

Friends of Dinosaur Ridge (Wagner Ranch visitor center):
16831 W. Alameda Parkway, Golden, CO 80401
Telephone 303 967-DINO (-3466) (recorded message)
Guided tours of Dinosaur Ridge can be arranged by the Friends for schools or other groups for a small charge.

Morrison Natural History Museum: (open Wed.-Sun. 1-4 pm)
Box 564, Morrison, CO 80465
Telephone 303 697-1873 (recorded message)

U.S. Geological Survey "GEO Center" free reference center for teachers (7:30 am-4 pm weekdays)
at USGS Library, Building 20, Denver Federal Center
(east of Kipling Ave., between 6th Avenue and Alameda, in Lakewood)
Telephone 303 236-1015 (GEO Center c/o Susann Powers)

Books:

A Field Guide to Dinosaur Ridge, by Martin Lockley; 1990, Friends of Dinosaur Ridge and University of Colorado at Denver Dinosaur Trackers Research Group, 29 p.

Fossil Footprints of the Dinosaur Ridge Area, by Martin Lockley and Adrian Hunt; 1994, Friends of Dinosaur Ridge and University of Colorado at Denver Dinosaur Trackers Research Group, 53 p. *[Second publication in the Dinosaur Ridge series]*

Archaeology of the Dinosaur Ridge Area, by Kevin D. Black; 1994, Friends of Dinosaur Ridge and the Colorado Historical Society, with the Colorado Archaeological Society and the Morrison Natural History Museum, 37 p. *[Third publication in the Dinosaur Ridge series]*

Colorado's Dinosaurs, by John T. and Jannice L. Jenkins; 1993, Colorado Geological Survey Special Publication 35, 74 p.

Other publications - Available from U.S.G.S. Map Sales Office, Building 810, Federal Center. USGS maps and books may be purchased by mail (Box 25286, Federal Center, Denver CO 80225) or in person at the sales counter (open 8 a.m.-4 p.m. weekdays, telephone 237-7477). Many free brochures are also available here. ***Note--teachers can purchase all maps at 1/2 price if ordered (in person or by mail) on school letterhead!***

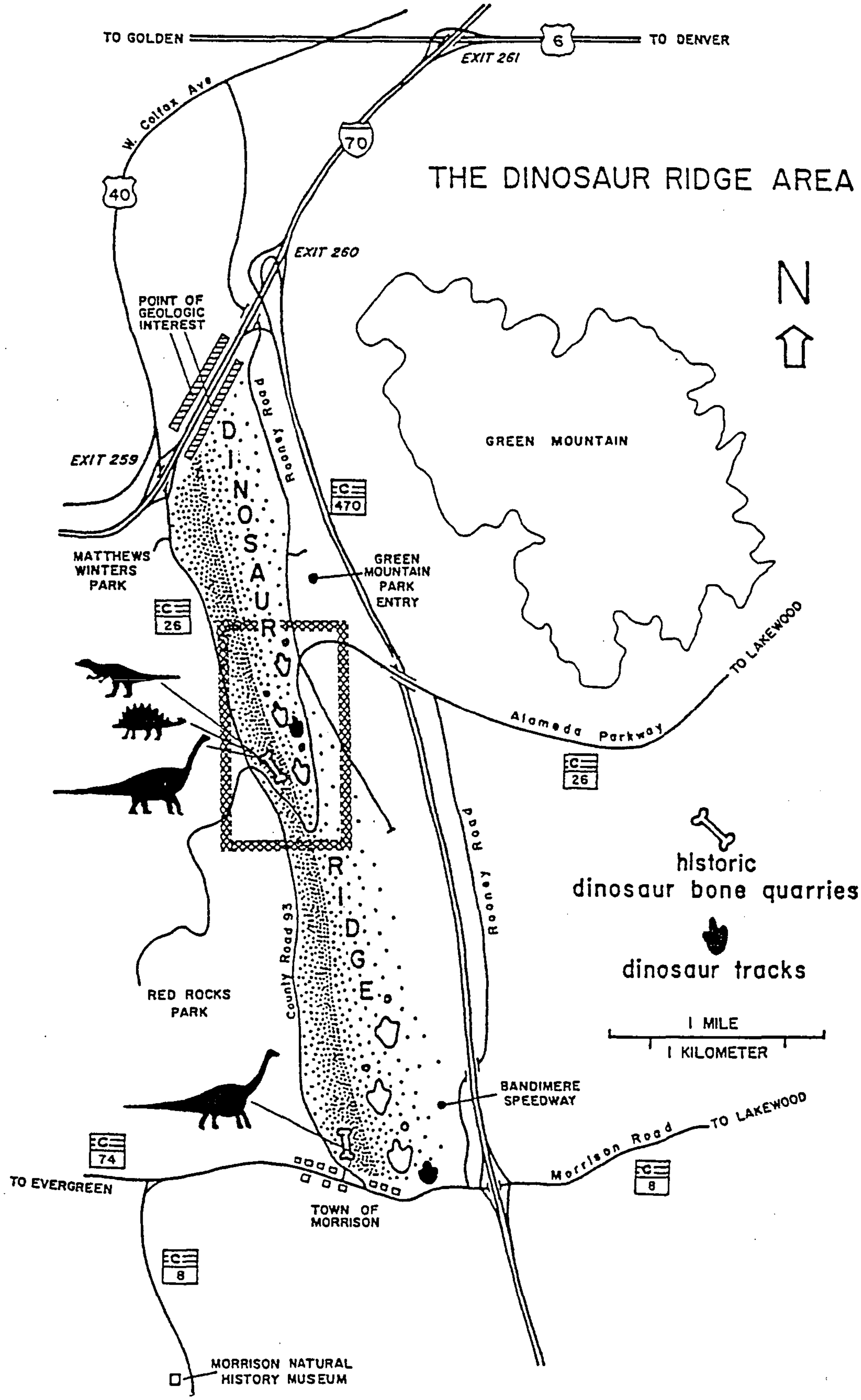
Geologic map of the Morrison quadrangle, Jefferson County, Colorado, by Glenn R. Scott; 1976, U.S. Geological Survey Map I-790-A, $3.60.

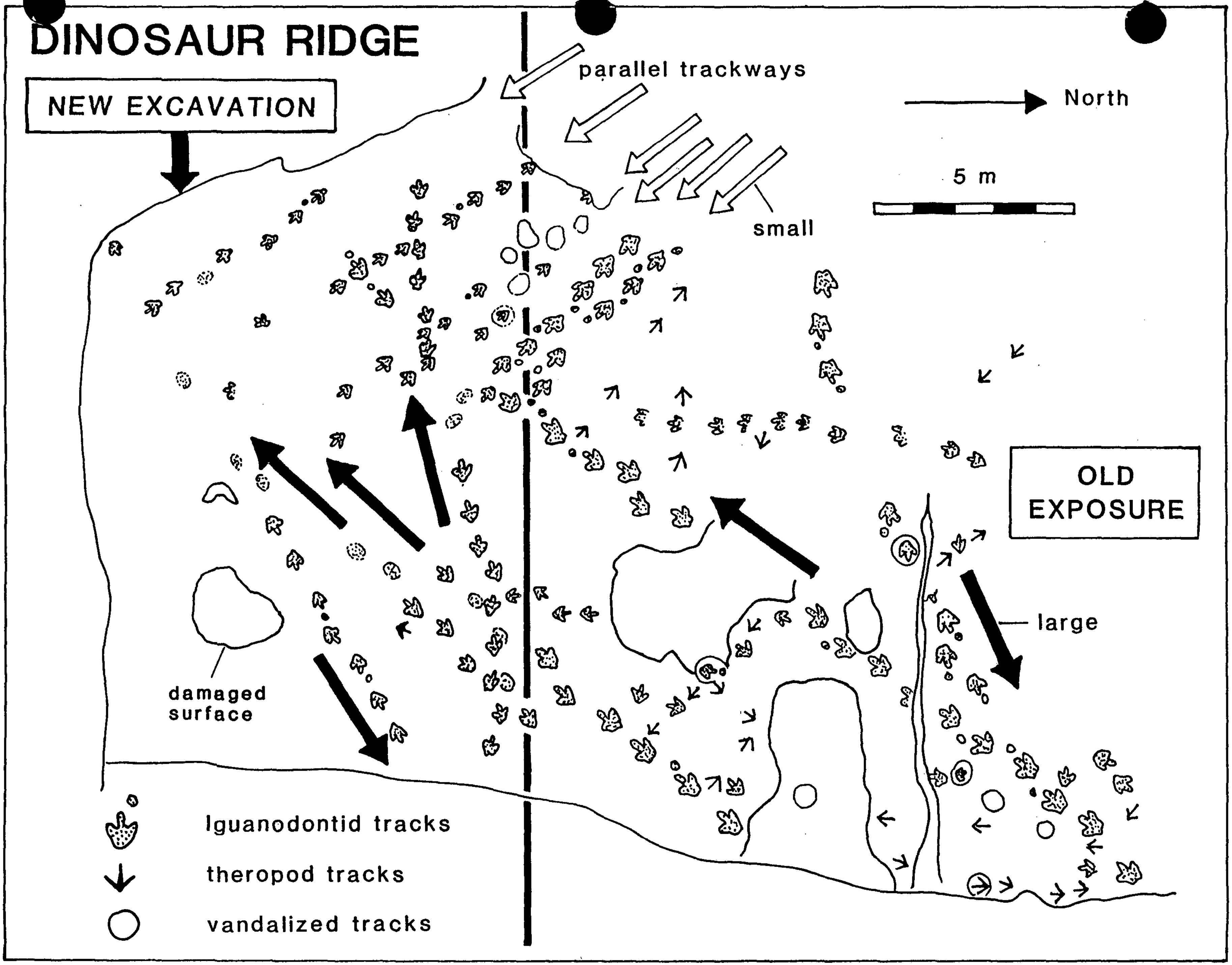
Map showing some points of geologic interest in the Morrison quadrangle, Jefferson County, Colorado, by Glenn R. Scott; 1972, USGS Map I-790-E, $3.10.

Mountains and Plains: Denver's Geologic Setting, by D.E. Trimble, G.R. Scott, and W.R. Hansen; 23-page brochure (no charge).

Fossils, Rocks, and Time, by Lucy E. Edwards and John Pojeta, Jr.; 25-page brochure (no charge).

Our Changing Continent, by John S. Schlee; 23-page brochure (no charge).


THE DINOSAUR RIDGE AREA
TO GOLDEN
TO DENVER
6
EXIT 261
W. Colfax Ave
40
70
EXIT 260
POINT OF GEOLOGIC INTEREST
EXIT 259
Rooney Road
DINOSAUR RIDGE
C 470
GREEN MOUNTAIN
N
MATTHEWS WINTERS PARK
GREEN MOUNTAIN PARK ENTRY
C 26
TO LAKEWOOD
Alameda Parkway
C 26
Rooney Road
historic dinosaur bone quarries
dinosaur tracks
County Road 93
RED ROCKS PARK
1 MILE
1 KILOMETER
BANDIMERE SPEEDWAY
C 74
TO EVERGREEN
Morrison Road
TO LAKEWOOD
C 8
TOWN OF MORRISON
C 8
MORRISON NATURAL HISTORY MUSEUM


DINOSAUR RIDGE
NEW EXCAVATION
parallel trackways
North
5 m
small
OLD EXPOSURE
large
damaged surface
Iguanodontid tracks
theropod tracks
vandalized tracks

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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