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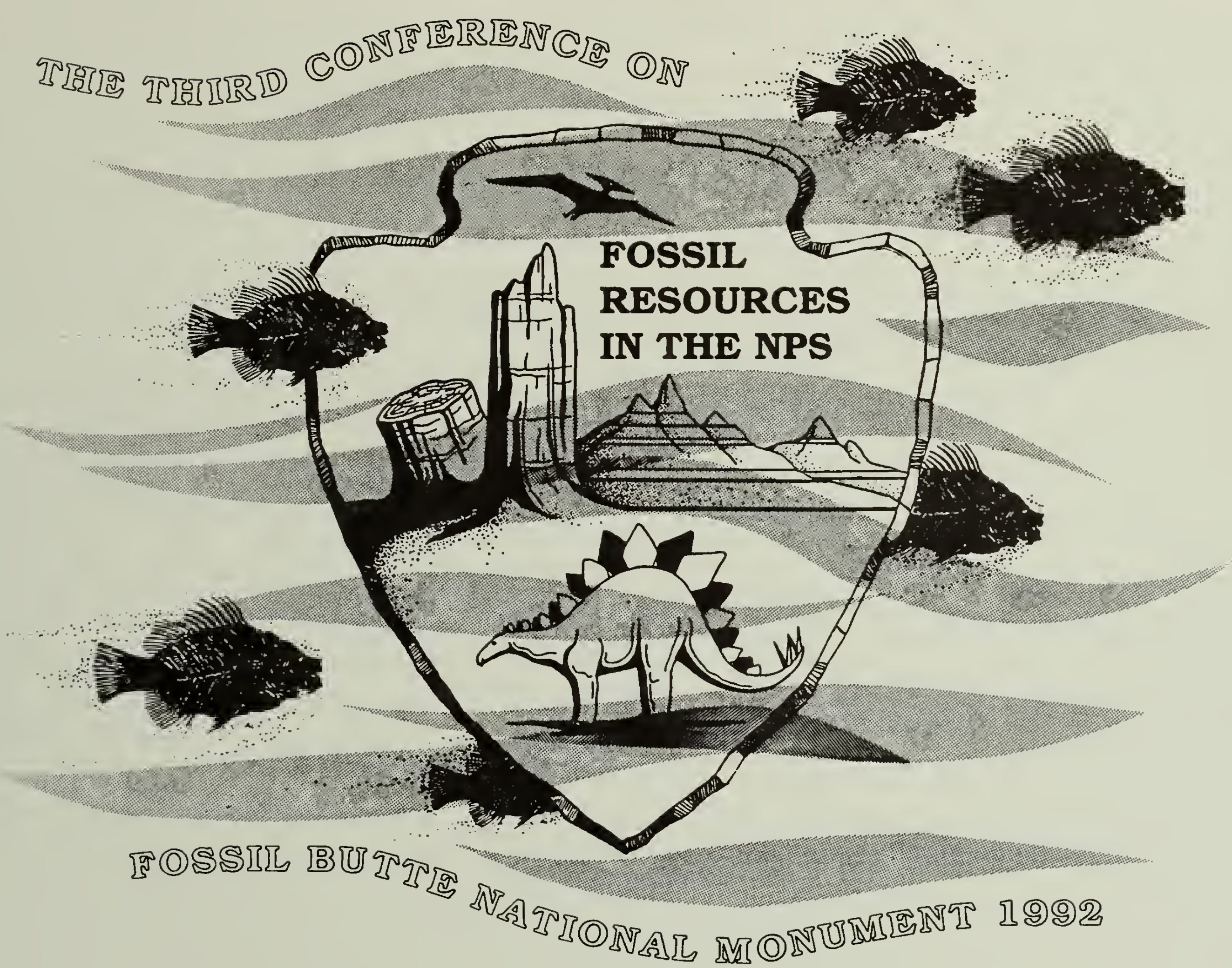
Proceedings of the Third Conference on Fossil Resources in the National Park Service

Rachel Benton and Ann Elder, Editors

Natural Resources Report NPS/NRFOBU/NRR-94/14



United States Department of the Interior • National Park Service
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Proceedings of the Third Conference on Fossil Resources in the National Park Service

14-17 September 1992
Fossil Butte National Monument, Wyoming

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Natural Resources Report NPS/NRFOBU/NRR-94/14

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Contents

Abstracts

(organized alphabetically by author)

Papers

(organized alphabetically by author)

Preface

The Third Conference on Fossil Resources in the National Park Service was hosted by Fossil Butte National Monument, Wyoming, 14-17 September 1992. Eighty-seven participants representing the National Park Service (NPS), the Bureau of Land Management (BLM), western state parks, Canadian provincial parks, selected universities, and amateur societies traveled to Kemmerer, Wyoming, for 3½ days of meetings. The conference was made possible through a grant from the Director's Servicewide Cooperating Association Fund and a generous donation from the Dinosaur Nature Association.

Dinosaur National Monument hosted a fossil conference in 1986 and Petrified Forest National Park hosted a fossil conference in 1988. Florissant Fossil Beds National Monument plans to host the 1994 meetings. The goal is to create a tradition of biannual meetings.

Paleontological issues took on national proportions during 1992. Several meetings were held across the United States to discuss protecting fossil resources on federal lands. Senator Max Baucus (Montana) introduced Senate Bill 3107, the Vertebrate Paleontological Resources Protection Act, designed to protect vertebrate fossil resources on federal lands. Two confiscations of vertebrate fossils occurred on BLM land and Cheyenne River Indian Reservation land, making headlines in major newspapers and magazines throughout the United States. The 1992 conference hosted at Fossil Butte served not only as a brainstorming session for ideas on fossil resource management, but also as a summary of the many controversial events that occurred in 1992.

Developing and organizing the third conference was a community effort. We would like to thank the staffs of Fossil Butte and Dinosaur national monuments as well as the numerous volunteers, professionals, and local community people who contributed greatly to the success of the meetings. We would also like to thank the participants themselves, for the success of any gathering such as this is directly related to the diversity of the participants and the energy they expend. The conference was indeed successful.

The following publication is a compilation of ideas from the professionals who attended the meetings. We hope that the publication will be a valuable resource for land management agencies and academic institutions. The document is also a "status report" on paleontological resource management for federal lands in 1992.

Rachel Benton
Fossil Butte National Monument

Ann Elder
Dinosaur National Monument

Figure 1. Conference participants gather around the Fossil Butte National Monument entrance sign. Eighty-seven people attended the conference.

Figure 2. A complete set of videotapes was made of the conference. Individuals interested in borrowing the tapes should contact the superintendent at Fossil Butte National Monument.

Figure 3. Conference field trip participants gather around as Tom Lindgren of Green River Labs explains quarry operations.

Figure 4. Conference field trip participants view the fossil bird locality where several articulated bird bones and skulls have been found (please see enclosed Field Trip Guide on page 87).

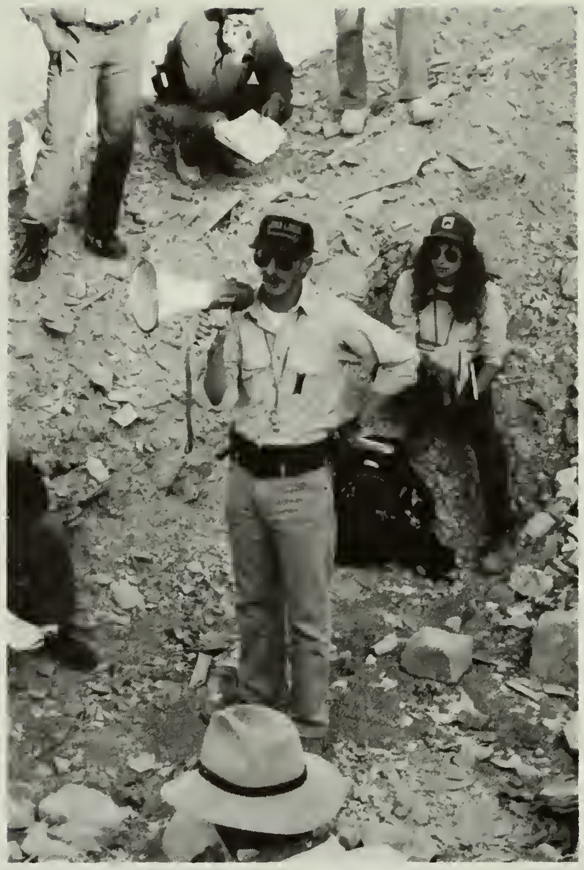

Figure 5. Dr. Paul Buchheim of Loma Linda University explains the stratigraphy of the middle unit of the Fossil Butte Member.

Memorandum to Director

N3019

January 19, 1993

Memorandum

To: Director, National Park Service, WASO

Through: Regional Director, RMR-D

From: Superintendent, Fossil Butte National Monument

Subject: The Status of Paleontology in the National Parks and Recommendations Resulting from the Third Conference on Fossil Resources in the National Park Service

In honor of its 20th anniversary, Fossil Butte National Monument recently hosted the Third Conference on Fossil Resources in the National Park Service. The conference was extremely productive and created important ties between professional paleontologists, National Park Service, BLM, and Canadian Provincial Parks personnel. The conference participants believed it was important to summarize the status of paleontology in the National Parks and make recommendations for the future. The following comments were drafted on September 17, 1992, the last day of the conference and refined over the last three weeks. We hope that these comments will be of value in the development of future programs.

NPS Paleontological Positions:

Several positive changes have occurred since the First Conference on Fossil Resources in the National Park Service in 1986. At that time, only four paleontological positions existed in the National Park Service (NPS). Today, there are eight permanent positions, one seasonal position, and two parks have requested new positions for FY94. On the Washington level, the Division of Wildlife and Vegetation is advertising a Geologist/Paleontologist position (series 1315, GS-13) which will include the responsibility of coordinating fossil programs service-wide. We are delighted to see the additional personnel added to the ranks of the NPS.

With each new employee further paleontological research can be pursued and coordinated on park lands. Technical information can be presented more clearly to the general public and fossils which are prone to theft and erosion are more likely to be protected. However, several parks with significant paleontological resources remain at risk and have little hope of getting technical personnel on board. Without specialists, paleontological resource management often receives less attention than visitor management.

One of the recommendations from the Vail Conference was to increase the number of scientific specialists throughout the NPS. We concur with this recommendation and hope that the number of paleontological positions will continue to grow not only at the park level, but at the Regional and Washington levels as well.

We would also like to see an expansion in the diversity of NPS paleontologists. All of the positions mentioned, except for one, are held by vertebrate paleontologists. Paleontological resources in the NPS include not only vertebrates but invertebrates, trace fossils and fossil plants. The NPS would be better served if it included paleobotanists, invertebrate paleontologists and other pertinent professionals.

NPS Training

The past three fossil conferences have provided important training and built awareness among NPS employees. The conferences have been designed to address issues most critical to fossil resources. However, the conferences depend heavily on the willingness of a park to host them and on a viable funding source. Conference funding also limits participant numbers, thus many NPS employees with direct responsibility for fossil resources are unable to take advantage of the training opportunity. Out of a total of 64 NPS units, which contain significant paleontological resources, 13 park units, 2 regional offices and the Washington Office were represented at the Third Conference on Fossil Resources. At present, only one NPS service-wide course discusses paleontological issues--Curatorial Methods, offered by the WASO Curatorial Services Divisions, addresses fossils as museum specimens.

We suggest that other NPS training programs, such as Federal Law Enforcement Training, ARPA Training and the Resource Management Trainee Program address fossil issues. These courses target NPS personnel who are often responsible for the protection, management, and interpretation of fossil resources in parks where a paleontologist is not on staff. For effective protection of paleontological resources, law enforcement rangers need to know how to recognize fossils in the field and paleontological sites which have been vandalized. Resource management specialists need to have knowledge of the type of paleontological research pursued in their area so they can write permits, review research proposals and properly monitor the resource. With the proper training these individuals will become familiar with paleontological resources and will feel comfortable addressing these important issues.

Perhaps one of the responsibilities for the new paleontological position in the Washington Office would be to work with FLETC, the Mather Training Center and the Resource Management Trainee Program to develop ways of including paleontological training sessions within the curriculum of these instructional programs. NPS paleontologists, university faculty, natural history museums, the Society of Vertebrate Paleontology and the Society for the Preservation of Natural History Collections are ready to assist in the instruction of these courses.

NPS Guidelines: NPS-77, NPS-53, and Resource Management Plans

The recent addition of a chapter on paleontology in NPS 77 provides important guidelines for responsible paleontological resource management. Likewise, recent revisions in NPS 53 make the permitting of fossil collection more effective. We support the changes to both of these documents and recognize their usefulness in managing fossil resources. As these documents are revised in the future, we suggest that those sections dealing with fossils are reviewed to keep them current and efficient.

We are concerned, however, that the recent revisions in NPS 53, which allow park managers to grant collecting permits for vertebrate fossils, could cause some inconsistency in the permitting system. We propose an addendum to both NPS 77 and NPS 53 requesting those individuals who do not have a strong background in paleontology to consult with a park paleontologist or the Chief Regional Scientist before granting a research permit. Courses dealing with paleontological issues at FLETC and the Resource Management Trainee Program could also be useful in these situations.

Dr. Robert Schiller, Assistant Regional Chief Scientist, Rocky Mountain Region, has suggested the possibility of establishing a core group of NPS paleontologists from across regional boundaries (Paleontological Advisory Committee) to evaluate significant paleontological issues within the NPS along with potential research requests.

At present, NPS 53 is based only on the authority of the Organic Act. The Antiquities Act of 1906 does not specifically mention paleontological resources and it has been determined in court that this Act does not include paleontological resources in its scope. **Senate Bill 3107**, The Vertebrate Paleontological Resources Protection Act, introduced by Senator Max Baucus (D-MT), would provide the NPS authority to write research permits involving the collection of vertebrate fossils. Vertebrate paleontologists employed by the NPS recommend the passage of the Baucus

Bill so that NPS 53 will be based on a stronger foundation. This bill would standardize the permit system throughout the federal government.

Because specimens collected within the park boundaries remain NPS property but can be housed in other institutions, there is concern among permittees that materials can be recalled at any time. Ann Hitchcock, Chief Curator, WASO, lead a discussion on this issue and is considering some of the points made. Several park managers have found the Resource Management Plan to be an invaluable tool for writing grant proposals and developing cooperative agreements. Unfortunately, the present coding system does not offer enough options to adequately cover paleontological activities. We suggest that the coding system be reviewed by NPS paleontologists to determine what codes would be most effective. The increase in codes would allow WASO to more easily identify paleontological projects for funding.

Cooperative Agreements with other Federal Agencies

Because paleontological resources do not stop at park boundaries, it is important for the NPS to build cooperative agreements with other federal agencies. Several talks at the Conference dealt with this issue and there were many requests to discuss this topic in further detail. Both the United States Forest Service (USFS) and the Bureau of Land Management (BLM) are in the midst of developing paleontological resource management policies. We in the NPS can provide assistance to these agencies as they develop new policy. The overriding theme at the Third Conference on Fossil Resources in the NPS was how can all of the federal land management agencies work more closely as a unit to protect fossil resources.

Presently there exists a Memorandum of Understanding between the United States Geological Survey (USGS), the NPS, the USFS, and the BLM with the USGS acting as an advisor on paleontological issues to the other three agencies. However, the NPS employs more vertebrate paleontologists than the USGS. We are concerned that such a limited staff at the survey may not be able to address the issues which are presently being evaluated. We are also concerned that certain individuals employed by the USGS have stated publicly that they do not support the protection of vertebrate fossils on public lands and they consider fossils to be a renewable resource. The existing Memorandum of Understanding with the USGS could have a serious effect on paleontological resources and the development of future policy. We feel the agreement with the USGS should be reconsidered.

Cooperative agreements should be extended to universities with extensive paleontological collections and scientists who are interested in doing research on NPS lands. Northern Arizona University is already involved in such an agreement, and its faculty does extensive research on park lands in the Rocky Mountain Region. They also house NPS collections in university repositories.

Future Goals and the Task Force on Paleontology in the National Parks

We propose a gathering of paleontologists to act as an advisory committee on future policy dealing with paleontological issues. Many of the suggestions included in this letter could easily be implemented with direction and careful planning.

To further increase awareness, we would like to formalize a newsletter along similar lines as "Park Paleontology"--a news publication which has received positive response from several park units. Relevant news articles by NPS paleontologists, researchers, and interested employees could assist park service personnel in dealing with paleontological resource management and interpretive issues. An alternative would be to propose "Park Science" establish a paleontology column to reinforce management's concern for this resource.

Overall, fossil resources in the National Park Service are better protected and managed than they were six years ago at the time of the First Conference on Fossil Resources. This is due primarily to the increase in NPS paleontological positions and a greater awareness of fossils service-wide. However, more attention is still needed. Paleontology is often unrecognized in resource management and protection thus causing the NPS to fall short of its goal to preserve and protect. This oversight must be corrected if the integrity and value of fossil resources are to be preserved.

David McGinnis

Conference Agenda

Monday, 14 September 1992 NPS-related Issues

* 8:00 - Superintendent's welcome

<u>Session I</u>: Resource Management 8:10 a.m.-12:15 p.m.

* 8:10 - NPS-77: Its practical applications to paleontological resources *Ted Fremd*

* 8:40 - Recognizing fossils in the field and responsible paleontological collection *Laurie Bryant*

* 9:10 - Prospecting and salvaging fossils: A case study at John Day Fossil Beds National Monument *Ted Fremd*

* 9:40 - Using technology to manage fossil resources

9:40 - Remote sensing: A case study in New Mexico *Dave Gillette*
10:00 - GIS: How to get started *Bob Cushman*
10:15 - GIS: A case study at Dinosaur *Ann Elder*

* 10:25 - Break

* 10:40 - Paleontological preparation from find to finish *Ann Elder*

* 11:15 - Conserving paleontological collections *Gerald Fitzgerald*

* 12:15 - Lunch

<u>Session II</u>: Interpretation 1:15 p.m.-5:00 p.m.

* 1:15 - Bridging the gap between visitors and scientists *Kim Sikoryak*

- Creative paleontological interpretation
- Approaching issues on commercial collection
- Hands-on interpretation (consumptive use of fossils)

* 2:00 - Ways to approach geological time and geological dating *Linda West*

* 2:30 - The creation science argument *Kim Sikoryak*

* 3:00 - Break

* 3:15 - The challenge of exhibiting and interpreting fossils in situ--work in progress at:

3:15 - Fossil Butte *Rachel Benton*
3:25 - Mesa Verde *Jack Smith*
3:45 - Agate Fossil Beds *Reid Miller*
4:05 - Dinosaur National Monument *Dan Chure*
4:25 - Dinosaur Provincial Park *Fred Hammer*
4:45 - Closing remarks and discussion *Andy Beck*

* 4:55 - Introductory session on interpretive trading cards *Dave McGinnis*

* 6:30 - Open house and cookout at Fossil Butte

Tuesday, 15 September 1992 NPS-related Issues cont.

Session III: Fossil Resources Protection 8:00 a.m.-12:00 noon

* 8:00 - Summary of NPS involvement in the confiscation at Hill City *Rachel Benton*

* 8:05 - The growing fossil market *Dan Chure*

* 8:30 - Theft of paleontological specimens *Vince Santucci*

* 8:50 - Recognizing vandalism sites: How to determine when you're being ripped off *Laurie Bryant*

* 9:35 - NPS-53 and standardizing the NPS permit system *Vince Santucci*

* 10:00 - Break

* 10:15 - Building a database in fossil investigations: Update on past and present fossil cases *Dave Stimpson and Fred Hurlock*

* 11:00 - Establishing a paleontology program within a national park *Dan Chure*

* 11:30 - Position management: Getting who you need *Walt Dabney*

* 12:00 - Lunch

Session IV: Research on National Park System Lands 1:00 p.m.-2:40 p.m.

* 1:00 - Introduction *Dan Chure*

* 1:05 - Importance of paleontological research on national park system lands

* 1:25 - An outside researcher's perspective *Paul Buchheim*

* 1:55 - NPS perspective *Dan Chure*

* 2:40 - Break

Session V: Paleontological Research Beyond NPS Boundaries 2:55 p.m.-5:00 p.m.

* 2:55 - Building cooperative agreements with the Bureau of Land Management *Ted Fremd*

* 3:25 - Society of Vertebrate Paleontology position on paleontological collection on federal lands *Bob Hunt*

* 4:00 - Summary of accomplishments from the 1992 Northern Plains Governors' Conference, or "Shootout at the Holiday Inn" *Jim Martin*

* 5:00 - Dinner

* 6:30 - Presentation of paleontology through interpretive trading cards: Group workshop *Dave McGinnis*
Conservation assessment workshop *Gerald Fitzgerald*
Poster session at Fossil Country Frontier Museum

Wednesday, 16 September 1992

Field Trip: Fossil Butte National Monument and surrounding area led by *Paul Buchheim and Lance Grande*

8:00 a.m.-5:00 p.m.

* Environments of deposition and the dynamics of Eocene Fossil Lake
* Paleoecology and the interrelationship of various faunas
* Commercial quarries
* Fossil bird site

* 7:00 - Banquet at Luigi's: Keynote speech, "Pleistocene Paleontology on the Plateau"

Thursday, 17 September 1992

Session V: Cont.

* 8:00 - Brainstorming session: Recommendations to the NPS director resulting from the Third Conference on Fossil Resources *Rachel Benton*

* 8:30 - Recent developments in legislation dealing with paleontological resources on federal lands: Summary and discussion of the conclusions made from the North American Paleontological Convention conference panel *Vince Santucci*

* 9:00 - The role of fossils in multiple-use planning *Mike O'Neill*

* 10:00 - The 1991 *Allosaurus* find in Greybull, Wyoming, and other paleontological work in the Big Horn Basin *Mike Bies*

* 10:30 - Break

* 10:45 - The state permit system in Wyoming: Does it work? *Brent Breithaupt*

* 11:15 - Utah Antiquities Act of 1992 *Dave Gillette*

* 11:45 - Break

* 12:00 - Research issues at Fossil Basin and their relationship to Fossil Butte National Monument *Lance Grande*

* 12:30 - Paleontological program development at Anza Borrego Desert State Park *Paul Remeika*

* 1:30 - Adjourned

Have a Safe Trip Home

Abstracts

The 1991 Allosaurus Find in Greybull, Wyoming, and Other Paleontological Work in the Bighorn Basin

Mike Bies

Bureau of Land Management Office
P.O. Box 119
Worland, WY 82401

The Worland Office of the Bureau of Land Management serves as a clearinghouse for information regarding paleontological fieldwork. Much of this information includes recent research results and land records. Quad-centered orthophotographs or topographic maps facilitate finding particular localities or roads in the Big Horn Basin. Permitted paleontologists check in with the Bureau of Land Management before starting their fieldwork, and, as a result, the BLM staff generally knows who is working where.

Big Al, an articulated *Allosaurus* discovered by Siber and Siber of Switzerland in 1991 and recovered by the Museum of the Rockies for the Bureau of Land Management, generated tremendous public interest in paleontology. The Bureau of Land Management is currently reviewing and revising its management plans to take into account the fossils near the Big Al quarry. Lands in the vicinity are protected under a temporary closure until long-term plans are in place.

A Smithsonian Institution discovery of a paleobotany site has resulted in a review of present management plans. Plan modifications are expected to take into account the fossil deposit which includes the flowers, reproductive organs, leaves, stems, and roots of the plants and the associated duff and soil layers. Approximately 60 new species were identified in the first season of research at the Meeteetse Formation site. Temporary measures will provide protection while the long-term plans are developed.

The Bureau of Land Management has an active program to make information about resources, including paleontology, available to the public. One of the efforts is the cosponsorship of a paleontology seminar with the Washakie County Museum. This seminar provides an opportunity for interaction between the researchers and local enthusiasts. The Bureau of Land Management is also developing displays with local museums and providing tours of paleontological excavations.

The State Permit System in Wyoming: Does It Work?

Brent H. Breithaupt

Geological Museum
University of Wyoming
Laramie, WY 82071

Wyoming has a rich tradition in the science of vertebrate paleontology. Since 1856, fossil vertebrates have been documented from the state. To protect these nonrenewable scientific resources on state public lands, permits are required by law before any kind of fossil is disturbed or collected (i.e., nonexclusive scientific fossil removal and exclusive commercial fossil removal permits). Additionally, no paleontological specimens found on state-owned lands may be removed from the state of Wyoming without the consent of the Wyoming Board of Land Commissioners. All such specimens forever remain the property of the state unless deemed common by the board. Problems of enforcement, rumors of noncompliance, and the quality and quantity of rare specimens that appear in private collections cast doubt on the effectiveness of the system. Wyoming's permit system for the preservation of paleontological resources on state public lands is not a model system; however, it is a system that has been developed to accommodate a diversity of concerns.

Recognizing Fossils in the Field and Responsible Paleontological Collecting

Laurie J. Bryant

Bureau of Land Management
Wyoming State Office
Cheyenne, WY 82001

Fossil recognition is based on pattern matching. Known "patterns" of appearance (texture, shape, color, size) are matched with what is seen in the field. Learning the patterns involves seeing and handling fossils; the more experience a collector has, the easier fossils are to recognize. Successful collectors learn to shut out distracting visual stimuli and focus on the object of their search.

Once found, fossils on the surface may be collected by simply picking them up, assigning them a unique field number, and placing them in a container. Large, fragile, and deeply buried specimens usually need to be excavated carefully, immobilized in a jacket of plaster-soaked burlap, and turned over as they are removed from the ground. The process is different for every specimen and rock type, and can only be learned through long (perhaps sad) experience.

Much of the value of fossils is in the locality and the geologic data collected with them. Scientific collecting includes mapping the location and making complete notes on the sediment, and placing, associating, and stratigraphically positioning the specimen(s). The collector should always carry maps, notebook, pens, compass, and labeling materials along with tools.

Fossils belong in public institutions where they are accessible to scientists and the public. The final phase of collecting is depositing specimens, with associated notes and maps, in an institution where they can be cleaned, identified, and preserved.

Recognizing Vandalism Sites: How to Determine When You're Being Ripped Off

Laurie J. Bryant

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Wyoming State Office
Cheyenne, WY 82001

Fossils are in great demand as objects of beauty and wonder. Amateur and commercial collectors (and some professional paleontologists) are ignorant or unmindful of permit requirements and other laws. However, they often leave recognizable evidence of their activities.

Surface collecting usually is undetectable. Excavations are easier to spot; characteristic prism-shaped holes, bits of plaster or plaster-soaked burlap, plastic tarps, and other debris are often left behind. Discarded tools such as whisk brooms, ice picks, and small paint brushes may be found nearby or buried in backfill.

Some collectors target the small specimens best found by screening the sediment. These collectors often leave large excavations with characteristic shapes. Amateurs, too, may create large (and often disorderly) quarries. Both such sites can be recognized by fresh surfaces and mounds of debris at the base of the quarry site.

Trucks and other heavy equipment for a major quarry need level roads for good access. However, new or improved roads may also lead to vandalism sites or to places frequently visited by many amateur or casual collectors.

Commercial catalogs can provide evidence of illegal collecting. Know what fossils may be found in your area. Be familiar with local rock formations and their ages. Develop a library of commercial catalogs and search them for specimens that may have been collected from parks and monuments. Pass your concerns on to the Society of Vertebrate Paleontology, law enforcement agencies, or both. Media coverage and educational efforts help alert illegal collectors to your awareness of the problem and your intention to stop it.

An Outside Researcher's Perspective

H. Paul Buchheim

Professor of Geology
Department of Natural Sciences
Loma Linda University
Loma Linda, CA 92350

National parks and monuments have been established to preserve and protect natural and historical wonders. Fossil Butte is no exception as it is one of the most famous fossil localities in the world. Once established, most parks spend most of their budgets on administering and maintaining park facilities, roads, trails, exhibits, and other aspects that enhance the park for the public. These are the immediate needs of parks. However, only limited resources are allocated toward scientific research in parks.

Parks contain some of the most important natural resources, which demand study and explanation. These demands have in part been met by establishing grant programs such as the University of Wyoming-NPS Research Center, which funds research in national parks and monuments within the Rocky Mountain Region. Funding from this source has enhanced my research significantly over six years and through two separate grants.

Logistical and moral support from park administrators and scientists has also made my research more productive. The staff at Fossil Butte National Monument has gone out of its way to assist in important ways, including making phone, computer, fax, and copying facilities available. The new visitor center and maintenance building have provided other essentials, such as showers and water. Parks that make extra efforts in some of these simple but essential areas will do much to encourage research.

The addition of a research-oriented park scientist can greatly enhance research in parks. Ted Fremd, who served in this capacity at Fossil Butte National Monument a few years ago, did much to facilitate and encourage my research. After a gap of a few years, Rachel Benton, also a vertebrate paleontologist, was added to the staff. Like Ted Fremd, she has encouraged my research and has spent a significant amount of time assisting in fieldwork.

Paleontological research in national parks can be served best by establishing park scientist positions and hiring academic rather than administrative personnel in those positions. These employees know and understand best the needs of researchers and can direct and promote research in the parks.

The Challenge of Exhibiting and Interpreting Fossils In Situ: Work in Progress at Dinosaur National Monument

Daniel J. Chure

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Dinosaur National Monument
Jensen, UT 84035

Dinosaur National Monument is famous for its display of dinosaur bones within the Quarry Visitor Center. Over the last four decades, more than 1,500 dinosaur bones have been exposed and left where they were buried 145 million years ago. Exhibits tell the story of the quarry's dinosaurs and their environment. The preparation lab has windows that allow visitors to view activities when lab work is in progress.

In 1992, excavations at the Dinosaur quarry were terminated and paleontological activities shifted full time to other sites. More than 400 paleontological sites have been documented in Dinosaur, some of which are extremely significant and have been the focus of excavations for the last 5 years. These activities have provided a more complete understanding of the Morrison ecosystem and have made the Morrison exposures within Dinosaur an important benchmark for those studying the formation.

An in situ fossil exhibit at Dinosaur was appropriate for interpretive activities and for the scientific development of the quarry for which the monument was established. However, such in situ development may not be appropriate at all fossil parks. In situ exhibits can develop their own momentum and draw funds and personnel away from more important resource management, science, and interpretive needs. Each park should carefully evaluate in situ development proposals to ensure that they are serving important science and interpretive needs. Sites should not be developed simply because visitors desire to see fossils in the rock.

Some Observations on the Commercial Trade in Vertebrate Fossils

Daniel J. Chure

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Dinosaur National Monument
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A large and lucrative international trade in vertebrate fossils exists, with sales in the tens of millions of dollars per year. Both body fossils (bones, skulls, and skeletons) and trace fossils (eggs, eggshell fragments, footprints, and coprolites) are sold. Individual specimens (such as the skull of *Triceratops*) have been offered for as much as $300,000, and even specimens with considerable plaster reconstruction have sold for six figures. Uses of these resources range from collector's items, to dinosaur bone handle knives, to use in New Age *earth healing* ceremonies, *spirit bags,* and *magic wands.* In addition, a growing trend can be seen in using fossils as an investment opportunity, with fossils having grown 15 times in price between 1970 and 1990.

A perusal of catalogs from commercial dealers shows that material similar to that found in several national park system units (Agate, Badlands, Bering Land Bridge, Dinosaur, Florissant, Fossil Butte, and Petrified Forest) is widely sold. Increased demand, high dollar value, the remote nature of many national park system units, and inadequate NPS law enforcement and paleontological staff combine to make park paleontological resources particularly vulnerable to illegal collection.

Establishing a Paleontology Program in the National Park Service

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Jensen, UT 84035

NPS-77 (*Natural Resources Management Guideline*) provides technical direction in establishing a paleontological resource management program within national park system units. However, an equally important component is managing a program so that it can compete successfully for funding and staffing and become a robust science activity.

The paleontologist must develop a vision for the program based upon the enabling legislation of the unit and his or her knowledge of relevant paleontological issues. Planning is critical in implementing the vision, and the paleontologist must be involved in developing appropriate planning documents (General Management Plan, Statement for Management, Interpretive Prospectus, etc.). Especially important is the Resource management Plan, which will identify issues and problems, and develop proposals and budgets for correcting deficiencies. Paleontologists must be creative in obtaining funds from within and outside the National Park Service. Outside researchers, graduate students, and volunteers can be used to achieve goals that cannot be reached with existing resources. Assisting in training interpretive and law enforcement staff, bringing park staff to view excavations, preparing press releases on recent discoveries, and keeping staff aware of new developments and issues in paleontology will integrate the paleontology program into the overall park function and make it a team effort rather than an isolated science function.

Park managers need to support paleontological staff by encouraging their attendance at professional meetings and their involvement in research activities and publication in scholarly journals.

Paleontological Research on Federal Lands: A National Park Service Perspective

Daniel J. Chure

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Dinosaur National Monument
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While the benefits of paleontological research can be enormous, such benefits rarely, if ever, come without a cost. Overseeing outside researchers takes away personnel, time, and money from other activities. Park paleontologists may find themselves supervising colleagues, friends, and world-recognized authorities. In some cases, close supervision may be needed to assure that park needs are met. When more than one researcher or institution is working simultaneously within the park, park staff may need to juggle conflicting research needs and personalities.

Parks can provide some simple amenities to attract researchers. Campground spaces, trailer sites and hookups, showers, access to lab facilities, specimen preparation, field equipment, and access to research libraries are all examples of such amenities. Such facilities can be counted as in-kind contributions by researchers seeking outside funding.

Outside researchers have made substantial contributions to the paleontology program at Dinosaur. These researchers have inventoried fossil localities, assisted in excavations, provided groups of volunteers to assist park staff, conducted needed geological studies to provide a stratigraphical and paleoecological framework for the park's paleontological resources, studied the fossilization process at the Dinosaur quarry, and described new genera and species of fossil vertebrates. Research at Dinosaur has enhanced the park's image with professional earth scientists and helped the park to achieve its mission. Because of this work, Dinosaur will continue to be a major site for paleontological studies well into the future.

The Importance of Paleontological Research for the National Park Service

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NPS Management Policies identifies two purposes for research in the National Park Service: (1) to support staff in carrying out the NPS mission by providing an accurate scientific basis for planning, development, and management decisions, and (2) to encourage investigators to use parks as natural laboratories when such use is consistent with NPS policies. Research may be generated by park needs, as identified in planning documents, or by outside researchers who find park resources critical to solving a scientific problem.

Paleontological research is much more than digging up and identifying a fossil. Among the many types of paleontological research are (1) field excavations, (2) inventories, (3) geological studies in which fossils play an important role, and (4) studies on existing museum collections. All such research may provide information critical to park management and may be conducted by park staff, outside researchers, contractors, or a combination of these.

The objective of a comprehensive paleontological research program in a park established for fossil resources should be to reconstruct the ecosystems preserved in the rocks. To achieve such an objective, many different types of studies will be needed. However, as a park becomes known for having an active paleontological program, more researchers who are willing to participate in that program will be interested in the park. Both the park and the science will benefit, fulfilling the two purposes for NPS research given in *NPS Management Policies*.

Paleontological Resource Management at Florissant Fossil Beds National Monument, Florissant, Colorado

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Over the past three years, a variety of paleontological studies have been initiated or completed at Florissant Fossil Beds National Monument. Among these studies was the research of Dr. Emmett Evanoff of the University of Colorado Museum and the graduate research of Kate Gregory of the University of Arizona. Dr. Evanoff and his students concentrated on mapping the geological units of the Florissant Formation, describing the stratigraphical sequences and identifying fossil vertebrate localities. Evanoff's research yielded more detailed stratigraphical descriptions of the Florissant Formation and new finds of a *Mesohippus* jaw with teeth and a Titanothere bone. Gregory studied the fossil plants that occur in the late Eocene lake deposits in the monument. In her study, Gregory used a new statistical analysis of leaf characteristics to interpret the ancient climate of Lake Florissant. The results of Gregory's research indicate that the climate was more temperate during the life of Lake Florissant than was previously thought. Her conclusions were published in the July 1992 issue of *Geology* and should provide a springboard for discussion in the near future. Evanoff's and Gregory's findings support the reinterpretation of the age for the Florissant flora and fauna as late Eocene (Chadronian), rather than Oligocene.

Recent work by the park staff concentrated on mapping the paleontological resources within the monument, identifying the areas that are most vulnerable to vandalism and illegitimate collecting, and setting up a monitoring program for preserving the resources. The project used a global positioning system to plot sites of paleontological and resource management significance.

Professionalizing the National Park Ranger

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The National Park Service is entrusted to manage the nation's and indeed some of the world's premier natural and cultural treasures. The national park ranger is recognized as the symbol of the good steward of these treasures and is generally highly respected by the visiting public.

We assume, undoubtedly, that the ranger is a well-educated, highly motivated, and extensively trained individual who is personally committed to protecting, managing, and interpreting this nation's premier national park system. In many cases, this scenario is true. However, the assumption that the ranger is well-educated is actually a matter of chance, for in the current classification series for park ranger, education beyond high school is not required.

While much of the ranger force does have formal education past high school and has degrees that are related to the resources, a growing number of rangers are coming into the National Park Service with no education past high school. This trend and the fact that no higher education requirements exist has been a concern with some people inside the National Park Service and a growing number outside the agency.

Park rangers perform many different types of work. Much of this work, particularly that which is predominantly technical skill oriented, does not necessitate college training. While such additional education is generally an advantage, the skills are learned on the job through formal training and experience. Some ranger positions, in addition to the technically oriented positions, have educational qualifications for successful job performance. Currently, however, most ranger jobs are classified into the GS-025 series, a nonprofessional series with no post-high school educational requirements.

The situation is changing. The Resource Management Trainee Program has moved many of the ranger positions in resource management into the general biological series. We should now seriously evaluate other positions in resource management, protection, and interpretation and establish professional requirements where appropriate.

Using GIS Technology to Manage Fossil Resources: A Case Study at Dinosaur National Monument

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Though many techniques of collecting fossils have changed only slightly over the past 100 years, recent advances in computer software now make mapping paleontological sites much more accurate and graphic. Global positioning systems are being used to map fossil locations to 1 m accuracy. Geographic information systems (GIS) are being used to graphically display site information, integrate fossil themes with other components such as geology, slope, and vegetation, and map individual fossil locations from a specific site.

Dinosaur National Monument has begun the process of recording all fossil locations using global positioning systems. The monument has also begun to digitize the location of each bone from Douglass Quarry, using the present-day cliff face and historical quarry maps. Once complete, this project will benefit the general public as well as scientists. Besides allowing a more thorough assessment of the taphonomy, paleontology, and river dynamics of the site, possible applications include interactive exhibits where visitors to Dinosaur can look at the quarry face and retrieve data on specific bones, and traveling exhibits where the quarry face is graphically reproduced, allowing museums to show how skeletons in their collections were originally deposited.

Paleontological Preparation from Find to Finish

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Fossil preparation is the process of conserving the remains and evidence of past life. Fossil preparation starts while the specimen is still in the ground, from the moment that excavation begins, and ends in the lab when the fossil's condition allows the maximum amount of scientific information to be gathered.

Only trained professionals should attempt to collect and prepare fossils from national park system lands. Because many vertebrate fossils are known from only a few individuals, unnecessary damage to even one specimen can rob science of a substantial amount of data. Certain materials and techniques can present health and safety problems that only trained professionals can recognize. Safety problems include hazardous fumes, airborne particulates and radiation.

The process of collecting and preparing fossils varies from site to site and from fossil to fossil. Therefore, professional preparators must have experience with many different specialized techniques and tools. Though the specific process varies, a professional preparator generally follows the steps outlined below in preparing a vertebrate fossil.

1. Stabilize the fossil while it is still in the ground.
2. Field-prepare the specimen.
3. Remove the fossil from the surrounding rock.
4. Transport the specimen to a fossil preparation lab.
5. Finish preparing the specimen.

Associated field data such as stratigraphic information, locality description, sedimentary features, and taphonomic observations also needs to be recorded when a specimen is collected. A poorly preserved fossil that is correctly prepared can offer a wealth of scientific information. But a well-preserved fossil, poorly prepared, can be virtually useless.

Conserving Paleontological Collections

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Conservation is a new and developing field in the natural sciences and will affect the way that paleontologists must care for collections. No longer concerned only with treatments and materials, conservation now places the emphasis on prevention. This holistic approach to collections care is critical in the natural sciences, where we have large numbers of specimens, and will prove most cost-effective in the long run.

One way to assess collections care is to examine the agents of deterioration, following the concept developed at the Canadian Conservation Institute. Specimen deterioration can be attributed to one of the following agents: fire, criminals, flood, pests, pollutants, physical forces, relative humidity, temperature, light, and custodial neglect. This approach forces collection specialists to analyze all aspects of the museum environment and assess the impact that each has on the specimens.

Preventing deterioration can be accomplished at three levels: the building or room, the cabinet, or the individual specimen. Specialists can attack the problem in one of three ways: removing the problem, establishing a barrier, or treating the problem. Following the logic of this approach, the risks to specimens in storage, on display, or even going on loan can be assessed and the appropriate measures put in place to ensure their safety.

Paleontological Resources Management, NPS-77, and its Practical Applications

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The National Park Service developed recommendations for the first time in 1991 (NPS-77) to provide an effective and methodical approach to preserving important fossil assemblages on national park system lands. Intended for a wide variety of sites, these general guidelines may prove especially helpful for managers charged with a preservation mandate, but confronted with little experience in preserving paleobiotas.

The primary objectives consist of identifying, evaluating, and protecting significant deposits. Key issues include developing a park research plan and using resource management planning to define suitable projects with professional paleontologists. Additional components include preparing baseline information provided by literature searches, examining major repository collections, and contracting other work should the park not have a resource specialist on staff. Some documentation samples are discussed, including simple collect/leave flowcharts, locality forms, and additional methods of tracking specimens once they have been collected.

Cyclic Prospecting and Salvaging Fossils

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Many classic localities of Tertiary mammals in North America occur in badlands exposures of strata with matrices that have characteristic weathering patterns. Allowing scientifically significant specimens to erode from these beds with no attempt to recover the associated data is inconsistent with informed management policies. Each unit of a formation must be considered independently, and based on preservational properties, a schedule may be developed to periodically canvass the rocks for significant materials that have been partially exposed. At some areas, overlays are prepared on high-resolution color stereo aerial photographs that outline the boundaries of areas scrutinized during prospecting events. As each specimen is retrieved, data is entered into an ANCS-compatible database with detailed coordinates.

This procedure has recovered many specimens that would have been lost due to weathering, vandalism, or primitive record keeping. Investigators can determine where a specimen was collected to within 1 m, or query the database to recover information on all specimens collected from within a small geographical or stratigraphical interval. A minor but notable benefit is being able to reunite faunal samples, microvertebrate assemblages, and even individual organisms that were separated by different collection episodes.

Cooperative Agreements and Administration of Vertebrate Fossil Localities

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The legislative boundaries of many national park system paleontological sites do not encircle all, or even the majority, of the nationally important fossil localities within the area. When the managers of the surrounding lands are amenable, research and responsible conservation can be furthered by pooling bureau assets. In Oregon, a cooperative agreement provides analysis and curation for localities on land administered by the Bureau of Land Management that are at least as significant as many of those within the John Day Fossil Beds National Monument. The National Park Service has greatly benefited from enhanced resource knowledge and research, the Bureau of Land Management has been able to provide effective management at a minimal cost, and the public directly profits from merged agency resources.

Spin-offs of the agreement include completing a paleontology workshop for affected BLM employees in Oregon and studying a site on BLM lands with the Oregon Museum of Science and Industry's field education center. The museum is receiving technical support for an educational and research project from the National Park Service. The Bureau of Land Management is purchasing the required aerial photographs and is providing research access to important specimens. Students are provided with an opportunity to learn not just principles of paleontology, but responsible curatorial methods as well.

Using Remote Sensing Technology to Manage Fossil Resources: A Case Study in New Mexico

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Beginning in 1986, scientists from Los Alamos National Laboratory, Sandia National Laboratory, and Oak Ridge National Laboratory have conducted ground-based experiments at the excavation site of the sauropod dinosaur, *Seismosaurus halli*, in a coarse fluvial sandstone in the Brushy Basin Member of the Morrison Formation (Upper Jurassic), Sandoval County, New Mexico.

The goal has been to locate bones of the skeleton in the subsurface, 2-3 m beneath the irregular caprock, before excavation. Ground-penetrating radar is the most versatile technique, and the only one available commercially. Proton-free precession magnetometry, originally developed for locating buried sunken ships in the Caribbean and Gulf of Mexico by towing behind a ship, has been turned on end to measure magnetic anomalies on a 1-m grid at the site. Various techniques measure the emission of gamma rays from the radioactive bones by scintillation counting and also by grid mapping. Acoustic diffraction tomography requires down-hole sensing and an artificial acoustic source (hammer on steel, or downward-directed shotgun blast); this technique is the only one that produces an image. As the excavation proceeds, these techniques are being evaluated for accuracy and their potential for wider application.

Ground-penetrating radar and acoustic diffraction tomography produced positive indications of subsurface bone that were confirmed by excavation. However, both also produced positive indications where no bone was found (false positives). Therefore both techniques must be used in conjunction with other field evidence and are useful in excavations where bone is already known to be present. These techniques have also been valuable in determining skeletal orientation and predicting skeletal curvature from rigor mortis. Scintillation counting and magnetometry are less versatile and their effectiveness remains to be evaluated.

All four techniques are still being tested at the *Seismosaurus halli* locality, and the radar will soon be tried at bog sites in the Wasatch Mountains for Mammoth bones.

Utah Antiquities Act of 1992

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Utah state laws providing for fossil resource protection and management, including cave sites where archeological remains may be recovered, apply variously to federal property, state-owned lands, and private lands. The Utah Antiquities Act of 1992 clarifies the responsibilities of several state agencies: division of state history (and the office of the state paleontologist), division of state lands, and the Utah Museum of Natural History.

Fossil resources on federal and state lands that may be associated with archeological remains are protected by both federal laws (Section 106 of the Historic Preservation Act, the Archeological Resources Protection Act, and the National Environmental Protection Act) and state laws in Utah that require consultation with the state historic preservation officer before disturbance.

Fossil resources in Utah not potentially associated with archeological remains are protected by state laws for sites on state-owned lands and by federal laws on federal lands. The state laws identify critical paleontological resources as all vertebrate fossils and fossil sites, plus exceptional fossils and fossil sites, which by definition include type localities, sites with unusual preservation, sites that preserve rarely occurring taxa, or sites that are otherwise important to the discipline of paleontology. Critical paleontological resources may neither be sold, nor the sites leased for commercial purposes. Applications for excavation permits on state-owned lands may be required to include a filing fee, a bond, or a right-of-entry fee. A curation agreement approved by the Utah Museum of Natural History is required for all surface collecting and excavation permits. No permit is required for prospecting or surveying.

Connecting Cretaceously: Interpretation at Dinosaur Provincial Park

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Dinosaur Provincial Park covers 25.6 sq. mi. (66.3 sq. km) in southern Alberta and is a UNESCO world heritage site that contains globally significant paleontological resources from the Late Cretaceous period. The park also protects endangered riparian habitat and wildlife, as well as the largest area of badlands in Canada.

Established in 1955, the park first began offering informal interpretive programs in the late 1960s led by ranger staff. Trained interpreters began delivering events in 1976, and the program has evolved to being one of the largest in the Provincial Parks Service.

The interpretive program attempts to bring the visitor to the resource through a wide range of creative approaches. A natural preserve (with access by conducted tour only) covers nearly one-half of the park. Park staff lead interpretive hikes and bus tours into the preserve, taking visitors to in situ displays and active collecting sites. From the field to the lab, visitor opportunities also include hands-on tours of the preparation lab of the Royal Tyrrell Museum's field station. Evening events that include interpretive theater provide an entertaining and informative format to round out the program.

Of particular interest to this conference are the four structures in the park that protect in situ fossils. Two of these are cinder-crete block buildings, one is a low-lying pyramid-shaped pod, and another is a regular garage door mounted on a horizontal track. A review of the construction procedures of these displays and their effectiveness will be presented as well as cost specifications for a proposed new in situ structure.

Vertebrate Fossil Resources on Federal Lands: Position Statement of the Society of Vertebrate Paleontology

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The Society of Vertebrate Paleontology is a professional scientific organization with over 1,500 members in North America and throughout the world dedicated to advancing the science of vertebrate paleontology. Amateur paleontologists are included among the membership. The society has taken the position that (1) vertebrate fossils are a nonrenewable resource; (2) permits to collect vertebrate fossils on federal lands should be required of all individuals; (3) fossils acquired through these permits should be available for study in accredited museums and universities as part of the public heritage; and (4) collecting fossil vertebrates on federal lands for commercial use should be prohibited to conserve these fossil resources for the people of the United States.

We strongly endorse the present policy of the National Park Service prohibiting commercial collecting on lands under its administrative jurisdiction. The Federal Land Policy and Management Act of 1976 (P.L. 94-579) supports responsibly managing fossil resources and prohibiting commercial collecting on federal lands. The act (section 102[a].8) states that "[t]he public lands shall be managed in a manner that will protect the quality of scientific [and] historical . . . values." Furthermore, fossil vertebrates are protected under the National Environmental Policy Act of 1969 as "[n]atural aspects of our national heritage" and should be "preserved" (section 101[a].4).

Results and Recommendations of the 1991 Paleontological Resource Survey of the Oglala National Grassland

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In 1991, the University of Nebraska State Museum (U.S. Forest Service Challenge Cost-Share Agreement No. 02-07-91-013) surveyed vertebrate fossil resources and assessed the impact of illegal vertebrate fossil collecting on the Oglala National Grassland near Toadstool Park, Sioux County, Nebraska. The fossiliferous bedrock in the area is the Paleogene-aged White River Group, which yields vertebrate fossils that are frequently collected and marketed.

That summer we inventoried 15.5 sq. mi. (9,920 acres) of the Oglala National Grassland. Of the bedrock surveyed, 21% showed physical evidence of illegal collecting (shallow pits, abandoned tools, spilled plaster, etc.). Illegal activity was concentrated in the Chadron Formation (88%), which is most accessible to vehicles. We identified 39 areas of special sensitivity (complete skeletons, skulls, groups of rare specimens, and microfossil sites). Of these sites, 28% showed evidence of illegal fossil collecting. We observed daily illegal fossil collecting in Toadstool Park and three occasions where individuals in vehicles fled the vicinity upon seeing our survey team.

The survey cost $0.71/acre and included geologically mapping fossil-bearing rock units, thoroughly documenting and salvaging jeopardized fossil specimens, identifying and documenting areas of special sensitivity, thoroughly documenting evidence of illegal fossil collecting, and compiling a report containing detailed maps and descriptions of the paleontological resources of the areas surveyed.

The report (submitted 30 March 1992) contained several recommendations, including (1) performing additional surveys to define areas of special sensitivity, allowing more efficient use of law enforcement time, money, and personnel; (2) an increased law enforcement presence on the Oglala National Grasslands; and (3) stiffer penalties to serve as a deterrent to illegal activities. Fossils collected during this survey are housed in the University of Nebraska State Museum (Division of Vertebrate Paleontology) and were collected under U.S. Forest Service Special Use Permit (User No. 2033).

The Northern Plains Governors' Conference: Fossils for the Future, or "Shootout at the Holiday Inn"

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On 24-26 August 1992, a governors' conference convened in Rapid City, South Dakota. The U.S. Forest Service conceived the conference as the agency began to recognize management duties concerning fossil resources. Almost two years ago, the conference planner proposed to educate the public, politicians, and governmental officials about the problems of managing this limited resource. Five topics were targeted as important issues: public awareness and education, economic development, private landowners' rights, public land management, and conservation and preservation.

We welcomed the host governor, the Honorable George S. Mickelson of South Dakota, and Keith Ferrell, editor of OMNI Magazine, who gave a keynote address. Various experts made presentations involving the five topics for the rest of the day. During the afternoon, in keeping with the overall theme of fossils for the future, Ozzie Tollefson presented "The Great Dinosaurs," an educational program for school-aged children. Although the children's visit was cancelled, the presentation was enthusiastically received and was one of the high points of the conference. The program was followed by a panel discussion on current paleontological topics and included a professional paleontologist, two amateur paleontologists, a commercial collector, a museum representative, a tribal representative, and a private landowner.

On the second day, discussion groups were planned for each of the five topics. However, a hostage-taking situation that morning caused the hotel to cancel the remainder of the conference. Although the conference was interrupted, its proceedings were published (Northern Plains Governors' Conference, 1992) including written submissions from panel discussion participants.

The Challenge of Exhibiting and Interpreting Fossils In Situ: A Case Study at Agate Fossil Beds National Monument

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At Agate Fossil Beds National Monument, several factors combine to make in situ fossil exhibit development and maintenance especially challenging. In order of importance these problems are (1) the absence of a staff interpretive specialist or paleontologist, (2) a nonresident site manager, (3) the conduct of early excavations, (4) the nature of the host rock, and (5) the configuration of the bone beds.

Correcting the first two of these problems requires an enlightened commitment (timetable) at the regional and Washington office levels; the third is nonreversible and so must be mitigated by carefully planning and obligating special project funds. Exhibit design and production efforts that effectively address the fourth and fifth elements at the subject site require technical expertise normally available at the regional office or Denver Service Center levels.

Coming to terms with these challenges represents a lesson in managing paleontological resources, particularly in regard to the perspective of visitors who arrive at this national monument with rational expectations. Conversely, failing to address either organizational or physical limitations when developing this classic Miocene site is to ignore the intent of its enabling legislation.

The Role of Fossils in Multiple-Use Land Management

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The Bureau of Land Management today administers much of what remains of the nation's once vast land holdings--the public domain--which once stretched from the Appalachian Mountains to the Pacific. Some 270 million acres, as well as 570 million acres of mineral estate, most of which are in Alaska and the western continental U.S., are managed by the Bureau of Land Management. In managing these lands, the Bureau of Land Management is guided by the principles of multiple use and sustained yield and a recognized need to protect and enhance the natural and human environment. Intense competition exists for public lands among user groups with conflicting needs and philosophical positions on how to manage them. The Bureau of Land Management uses professional resource management principles and standards in making resource allocation decisions. Conflicting laws and user group demands, however, significantly influence the decision making process, forcing the Bureau of Land Management into the midst of controversy and making politics a fact of everyday life.

Paleontological resources are among the many values managed by the Bureau of Land Management under its multiple use mission. Like any other resource value, these resources must be given full consideration in the Bureau's planning process. Thus, they enter into the full range of conflicts where the Bureau of Land Management must take into account the long-term needs of future generations for renewable and nonrenewable resources. The challenge to the Bureau of Land Management is allocating public land resources in a manner that protects and preserves those resource values that are an important part of our national heritage.

Paleontological Program Development at Anza Borrego Desert State Park, California

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Anza Borrego is the second-largest state park in the United States. Within its 600,000-plus acres, two paleobasins are filled with one of the most complete Neogene fossiliferous stratigraphical sequences, and a standard reference section, reflecting basin-margin environments of deposition in the Salton Trough-Gulf of California structural depression.

The park's rich and diverse paleontological resources include 200 species of marine invertebrates and 130 species of vertebrates (Hemphillian-Rancholabrean Land Mammal Age), including a dozen holotypical specimens. Together, the collected assemblage represents the largest repository of Pliocene and Pleistocene-aged invertebrate and vertebrate fossils in North America.

Recently, Anza Borrego suspended field collection activities to reevaluate and upgrade its paleontology program. The district superintendent recruited a staff park ranger with expertise in geology and paleontology to serve as park paleontologist and to administer the entire program. In 1991, a six-member paleontology advisory board was appointed and convened to assist the park paleontologist in establishing professional standards, stimulate research from academics, and identify deficiencies and goals. Finally, the Paleontology Resource Management Plan and the comprehensive Paleontology Collection Management Policy established formal procedures and policies for managing, permitting, performing field reconnaissance and site evaluation, and curating all the nonrenewable resources.

Today's efforts involve reacquiring the Imperial Valley College Museum collection; planning and developing a Colorado desert research center; and implementing a formal certification program in paleontology with a curriculum designed to train park volunteers and research assistants to continue collection, field, and research efforts in paleontology.

Theft of Paleontological Resources

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An ever-expanding market for fossils places increased pressure on federal land managers to adequately protect these resources. National park system areas like Badlands and Petrified Forest national parks suffer extensive loss of paleontological resources through illegal collecting activities. The theft of fossils from federal lands is difficult to control given the large expanses of fossiliferous exposures and the limited staffs available to patrol remote areas.

Illegal fossil collecting can be classified into three categories: inadvertent casual collecting, intentional casual collecting, and illegal commercial collecting.

Inadvertent casual collecting is performed by an individual who does not realize that removing a fossil specimen is prohibited. Typically, this type of collecting is limited to a single event. This activity is often encountered with visitors who are not aware of the NPS preservational philosophy.

Intentional casual collecting is the conscious theft of a fossil resource by a visitor. The individual ignores the park regulations to obtain a souvenir. This activity can be rationalized by views such as "this one specimen will not be missed" or that "the specimen will be better protected in my care." Generally, this type of collecting is limited to a single event.

Illegal commercial collecting involves systematically removing fossil specimens for sale on the fossil market. The economic gains outweigh any possible threats of being discovered and prosecuted. This activity can be long-term and have a major impact on the park's paleontological resource.

Park paleontologists and resource managers should be aware of the potentially different types of illegal fossil resource threats and take vigorous steps to reduce them through effective paleontological resource management planning.

NPS-53 and Standardizing the National Park Service Permit System

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The NPS guidance in paleontological resource permitting comes directly from NPS-53 and NPS-77. The importance of the permitting system extends well beyond regulating fossil collecting in a park. The permit serves as an educational tool for resource managers overseeing multiple-resource areas. Threatened or endangered species of extant animals and plants, sensitive breeding areas, and other significant resources may all occur in areas that overlap paleontological exposures. The permit should be designed to inform the researcher of other resource concerns, park regulations, and acceptable practices. Permits also serve as a historical record of research activities within a park.

Although NPS guidelines serve as a baseline, specific permitting procedures can vary between national park units. Parks with a staff paleontologist may approve paleontological collecting permits on the park level, while other parks may opt to obtain regional approval. NPS-77 suggests that in situations when fossil specimens are in imminent danger of damage or loss through erosion, theft, vandalism, or all of these, that the superintendent can authorize collection. The National Park Service employs paleontologists in three regions (Pacific Northwest, Rocky Mountain, and Western) who can serve as contacts for paleontological issues.

An important aspect of a paleontological collecting permit is that it addresses the curatorial responsibilities of the researcher. All fossil specimens collected within a national park remain the property of the National Park Service and must be cataloged into the NPS National Catalog. Many NPS fossil collections can be stored in approved outside repositories, but can still be recalled at any time by the park.

Preserving Paleontological Resources on Federal Lands: North American Paleontological Conference Panel Discussion and Senate Bill 3107

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The North American Paleontological Conference (NAPC), which met during June 1992 in Chicago, provided an opportunity for a broad spectrum of paleontologists to discuss managing fossil resources on federal lands. The panel discussion, entitled, "Paleontology on Public Lands," provided a forum where professional and amateur paleontologists, commercial fossil dealers, and federal land managers could voice their concerns.

Many of the opinions expressed during the NAPC roundtable discussion were in direct opposition to the conclusions expressed in the 1987 National Academy of Sciences Report. The NAS report of 1987 stated that fossils are a renewable resource and that fossils on public land should not be subject to permit requirements or other regulation. Obviously, this report does not represent the opinion of most paleontologists or land managers and further discussions are necessary.

On 30 July 1992, Senator Max Baucus (Montana) introduced Senate Bill 3107, the Vertebrate Paleontological Resources Protection Act. This bill is intended to fill a legislative void that currently exists for paleontological resources. The escalating commercial market for fossils, along with the theft of paleontological resources from federal lands including national parks, clearly indicate that greater protective legislation is needed.

Interpreting Paleontological Resources: Personal Services

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Fossils and paleontology are a paradoxical challenge to interpreters. Fossils are familiar and attractive, yet paleontology is viewed as esoteric and inscrutable. This dichotomy can be made to serve interpretation. A key element of the interpretive interaction is initial contact. In small groups, where most meaningful interpretation takes place, the interpreter has an opportunity to assess the visitor and plan the level of sophistication of the interpretive interaction.

Fossils lend themselves to the full range of personal interpretive services. Roving contacts, spontaneous short talks, informal interchange at the visitor center, and demonstration of the actual work of paleontology (especially in the controlled setting of the laboratory) provide the best opportunities for effective communication. Interpretive topics that are common to all paleontological resources include (1) fossils are familiar, (2) fossils are exotic, (3) fossils are controversial, (4) fossils are inscrutable, (5) paleontologists are inscrutable, (6) fossil resources are subtle and fragile, and (7) fossils depend on associated data for value.

Visitors want to see fossils close up--and in a meaningful context. Interpreters can accommodate this desire in exhibits, in the field, and in the laboratory. This activity must be monitored closely, however, especially when fossils are in hand. Visitors will quickly judge the importance of fossil materials by watching how the staff treats them. Careful handling is the most powerful way that staff can shape the attitudes they would like visitors to exhibit towards these resources.

An Interpreter's Guide to Creationists

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No one need believe in evolution, because evolution is not a belief system. Evolution is a scientific theory, a "best working explanation" of what we observe in the natural world. We in the National Park Service interpret paleontological resources based solely on current evolutionary theory because we are enjoined by the First Amendment to the Constitution against propounding a religious view--any religious view. This basic tenet is sometimes challenged with the contention that *scientific creationism* is an alternative scientific theory or, conversely, that evolution is itself not a scientific theory but a religious belief. Both of these contentions have been judged without legal merit in federal courts.

Interpreters and scientists often fail to communicate with creationists because some or all of the parties involved do not recognize the disparate nature of their philosophies. The paleontologist proceeds from a rational, mechanistic, empirical position and may find little common ground with the creationist for whom the acceptance of infallible doctrine is a founding premise. The best tactic for the interpreter is to recognize the philosophical divergence up front, celebrate the democratic heritage that protects and separates both points of view, and discuss relative positions in as open and forthright a way as possible. The prime objective must be exchanging observation and opinion in an atmosphere that permits both parties to maintain self-respect. The most successful interpreters are patient, well-informed, and realistic in their expectations to effect change. Interpreters intent on "winning" by debate are likely to become frustrated, angry, and ineffective.

Sheltering Archeological and Paleontological Sites

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Problems in preserving archeological and paleontological sites and also providing for visitor access to them begin as soon as sites are excavated. Materials formerly protected by being buried in the earth become subject to many sources of deterioration, both natural and human-caused, once they are exposed. A number of methods for dealing with these problems have been tried since at least 1903 when a primitive shelter of wood and corrugated iron was built over an adobe ruin at Casa Grande, Arizona. Ordinarily, shelters are designed and built after excavation, and their construction often adds one more potential source of damage to the exposed materials.

The idea of constructing permanent protective shelters before excavation is one which has rarely been considered, and few examples exist which can demonstrate their feasibility or practicality. However, some shelters have been built while excavations were still in their early stages, and these have shown the practicality of the concept both for protecting the site and for providing access to the public. Examples of this midway approach include the structures at the Mammoth Site at Hot Springs, South Dakota, and at the quarry in Dinosaur National Monument in Utah. Another is the shelter/museum at the famous Chinese archeological site of Xian. In each of these, however, the problems of protecting the partially exposed materials during construction have been the same as in completely excavated sites. Most of the hazards to sites from shelter construction can be eliminated by building the shelters before the ground is disturbed.

A continuing problem is how to design structures that can cover the areas encompassed by many archeological and paleontological sites. An adequate structure for these large sites requires considerable engineering and is bound to be costly. Examples presently exist, however, of structures designed for quite different purposes which would be capable of enclosing large archeological and paleontological sites. The Boeing Museum of Flight in Seattle, Washington, is one, and the hangars built at several Strategic Air Command bases to shelter oversize aircraft, are another. Both offer basic designs which could be adapted to archeological and paleontological needs. The engineering problems, then, are capable of solution. The cost of such structures, however, continues to be a serious obstacle.

Ways to Approach Geological Time and Geological Dating

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The sheer vastness of geological time may be as difficult for professionals as for laypersons to comprehend. Familiar analogies can be helpful, such as an hourglass (or is it still familiar to anyone in this day of digital watches?) to illustrate the principle of radiometric dating for gauging absolute ages or a stack of paperwork piling up on one's desk as an example of determining relative ages (if an occasional memo, etc., has a date on it, then one can also interpolate some absolute ages). Various writers, artists, and speakers have compressed geological time into more familiar spans such as a day or a calendar year (e.g., Carl Sagan in *Cosmos*), or portrayed geological time visually on scales ranging from yardsticks to tall buildings (e.g., Walter Cronkite in the recent series *Dinosaur!*). Such expressions can help give an understanding of the relative positions and lengths of geological eras and periods, and perhaps most significantly can point out the comparatively recent development of "advanced" life, especially our own species.

Papers

The 1991 Allosaurus Find in Greybull, Wyoming, and Other Paleontological Work in the Big Horn Basin

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The Bureau of Land Management Worland District functions as a clearinghouse for information about paleontological fieldwork. The Bureau of Land Management has information regarding previous work in specific areas. The bureau also has on file aerial photographs and maps of the lands that it administers. Much of the existing resource inventory information, such as fence lines, soils, vegetation, and roads are recorded on quad-centered orthophotographs. This information is not available from other sources in many cases. Although the data are not for sale, they are commonly shared with land users.

At present, the BLM archeologist acts as an information resource for researchers. Individuals conducting fieldwork in the area can obtain information on what facilities are available, who else is in the area, and what has been done recently. Until professional paleontologists are hired at the district and resource area levels of the organization, the archeologists will probably be the point of contact for permits and other administrative information. The Wyoming BLM state office paleontologist will provide the professional assessments required by these individuals.

The discovery of *Big Al,* the *Allosaurus* recovered from the *Big Al* quarry on public lands adjacent to the Howe Quarry, created a great deal of interest in the paleontology of the Big Horn Basin. Since that discovery the Bureau of Land Management has withdrawn approximately 5,000 acres of federal lands in the area from the mineral laws and is currently reviewing existing management plans and preparing revisions as needed to take into account the paleontological resources found in the area. However, mineral leases in the area will continue with special conditions to protect paleontological resources. The area may be segregated from mining operations under the 1872 Mining Act or paleontological mitigation may be required. These resources are predominantly large vertebrates from the Morrison and Cloverly formations. The nearly complete articulated *Allosaurus*, several sauropods, and a pterosaur are among the specimens collected by the Museum of the Rockies. The area will probably qualify as an area of critical environmental concern, and special management prescriptions will be developed to allow continued paleontological research activities without the threat of the paleontological resources being destroyed by development or by using other resources.

The Big Cedar Ridge Quarry was discovered in 1991 by Scott Wing of the Smithsonian Institution. This paleobotany area is believed to be the oldest known locality where plant, soil, and topographic associations have been determined. The deposit contains plant material, including flowers, reproductive organs, leaves, stems, and roots with associated soil of a Meeteetse-age forest and open glade mosaic. Approximately 100 sites at the Big Cedar Ridge locality were documented in 1992, resulting in at least 100 previously unknown species being identified. A large number of described species were found that were not previously known in the Meeteetse Formation. The Bureau of Land Management is currently reviewing existing management plans for the area to take into account these plant fossils. We expect that a withdrawal will be obtained to segregate the lands from the 1872 Mining Act. We do not expect that mineral leasing or recreational use of the area will have to be stopped. However, special conditions on mineral leases providing adequate protection and interpretation for recreation users in the area is anticipated. This area is also expected to qualify as an area of critical environmental concern. Special management prescriptions will be developed to allow continued paleontological research and to avoid destroying these deposits with other resource development activities.

Our public information efforts include cosponsoring a paleontology seminar with the Washakie County Museum and Cultural Center. Our staff works closely with the museum to arrange for speakers currently working in or near the Big Horn Basin. Topics for papers range from Pleistocene human occupation of the area to the geological stratigraphy of the Big Horn Basin. The meetings provide a free exchange of information between professionals and local people who may be aware of fossil localities that are not known to the professionals. We are also working with the Washakie County Museum and the Greybull Museum to provide long-term displays and information for the public.

We are becoming more active in managing paleontological resources on public lands and look forward to working with the professional and amateur communities. Coordination and communication are major goals and should help us to more efficiently manage the resource.

The State Permit System in Wyoming: Does it Work?

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Introduction

Wyoming is a unique geological area. Because of the limited vegetation and the abundance of Mesozoic and Cenozoic era outcrops containing vertebrate fossils, Wyoming has been known since the early 1800s for important information about the past life that once occupied this area of North America. Every year, scientists from around the world travel to Wyoming to study significant paleontological material. The Society of Vertebrate Paleontology considers all vertebrate fossils nonrenewable resources whose scientific values must be maintained. Because of their scientific importance and rarity, fossilized vertebrate animals are protected by law on public lands in Wyoming.

Fossils are the basis for our understanding of past life and environments. The protection of this knowledge is paramount, and information loss should be guarded against, taking precedence over short-term or monetary goals. Detailed locality and stratigraphic data are critical and specimens must be properly collected and curated. Scientists should be involved with removing vertebrate fossils from public lands. Once collected, this material should reside in a suitable, responsible paleontological repository.

History

Although the first vertebrate fossils were discovered in the area that we currently know as Wyoming in the early 1800s, the wealth of Wyoming's fossil record did not became known until the middle of the 19th century. The early explorers took back east with them many of the unusual rocks and fossils that they found in the Rocky Mountain West. New prehistoric animals were discovered by studying these fossils. Eventually, scientists from around the country came to Wyoming to take advantage of its unique paleontological resources. Commercial fossil interests were also established in the late 1800s in Wyoming, particularly for the unique and well-preserved Green River Formation fishes found in the western part of the state.

Because of the tremendous interest that developed in the state's vertebrate fossils, Wyoming protects these unique scientific resources in its constitution. Legislation requires that a permit must be obtained from the Wyoming State Board of Land Commissioners before any paleontological deposit on state public lands is disturbed. This board is authorized to promulgate and enforce regulations that are needed to protect the paleontological deposits of the state from injury. In addition, no one can remove from Wyoming any parts of a paleontological deposit without the consent of the board of land commissioners. Most of the material found on state public lands forever remains the property of Wyoming. Only those items that have been deemed common enough to be sold or that are scientifically exchanged are exempt from this last statement. Violations of these statutes is a misdemeanor. Wyoming's system was developed to allow both scientists and commercial operators to collect fossils on state public lands. The intent of following these provisions to serve the best interests of the people of Wyoming and preserve Wyoming's paleontological resources.

History of Collecting in the Green River Formation

To understand Wyoming's current permit system, a short history of collecting in the Green River Formation is necessary. In the early 1850s, while Wyoming was being surveyed for the transcontinental railroad, a partial skeleton of a fossil fish was discovered. Although the records are unclear, this specimen appears to be that of an Eocene epoch gar fish from the lacustrine deposits (i.e., Lake Gosiute) of the Green River Formation (Breithaupt 1992). In 1856, the first documented, collected, and described vertebrate fossil from Wyoming was discovered during Dr. Ferdinand Vandiveer Hayden's Survey of the Territories. Dr. John Evans (geologist for Hayden's survey) uncovered the remains of a small, herring-like fish in the buff-white, fine-grained rocks that crop out along the Green River near the present-day town of Green River, Wyoming. Hayden took the specimen to Dr. Joseph Leidy in Philadelphia for identification. Leidy named the specimen *Clupea* (Leidy 1856). In 1907, professor D.S. Jordan redescribed this fish and renamed it *Knightia*, in honor of Wilbur Clinton Knight (an important figure in the early geological and paleontological studies of Wyoming). Because *Knightia* is well-preserved in great numbers, Grande (1984) writes: "*Knightia* is one of the most common complete vertebrate fossils in the world." Today, *Knightia* is Wyoming's state fossil, and a large slab of the Green River Formation on display in the Fossil Butte National Monument visitor center which contains 356 *Knightia* specimens has been designated Wyoming's centennial fossil. *Knightia* is the most common of roughly a dozen genera of fishes found within the Green River Formation.

In 1972, the National Park Service established Fossil Butte National Monument to commemorate the fossils of the Green River Formation, one of the most extensive concentrations of fossilized fishes in the United States, and one of only a few such areas anywhere in the world. Fossil Butte was first described in Hayden's Survey Report of 1879 by A.C. Peale as the Twin Creek site. Specimens collected by Peale were later described by professors Edward D. Cope, Leo Lesquereux, and Samuel H. Scudder. By 1897, commercial fossil hunters such as Lee Craig, Samuel C. Small, and David C. Haddenham were collecting in the Fossil Butte Member of the Green River Formation. These fossils were sold to museums and private collectors around the world. However, "after 100 years of concerted collecting, there is still an untapped resource to be collected and studied" (Grande 1984).

Fossil Fish

Because of the historical nature of commercial quarrying operations and because of the tremendous numbers in which certain fossil fishes have been found, seven genera of fossil fishes (e.g., *Knightia*, *Diplomystus*, *Priscacara*, *Phareodus*, *Mioplosus*, *Notogoneus*, and *Amphiplaga*) are allowed to be collected from Wyoming public lands for sale by commercial fossil-collecting operations with state permits. In addition, common species of gastropods, bivalves, coprolites, and plant fossils illustrated in Grande (1984) are allowed to be sold. All permitted commercial operations are restricted to the Fossil Butte Member of the Green River Formation in the Fossil Basin area of western Wyoming. Any genera of vertebrate fossil other than the seven listed or those invertebrates and plants not illustrated in Grande (1984) found by collectors must be turned over to the state. Currently, the Geological Museum at the University of Wyoming is the sole repository for fossils found on Wyoming public lands.

Qualified scientists may also be granted permits to collect vertebrate fossils on state public lands. Scientific fossil-collecting permits may be issued if collection and study will be under the auspices of reputable museums, universities, colleges, or other recognized scientific or educational institutions, and can be expected to increase scientific knowledge. The material may be taken out of Wyoming if it will reside in a bonafide public museum or institution where collections are freely available to qualified researchers. The fossils remain the property of Wyoming unless (the board must approve exchanges) the Wyoming State Board of Land Commissioners decides otherwise.

Discussion

The Fossil Basin of Wyoming is the only place in North America where fossil fishes and other vertebrates from the Fossil Butte Member of the Green River Formation can be found. Although seeing the seven common varieties of fossil fishes in stores ranging from gas stations to art galleries is common, finding rare and unusual specimens of fishes, reptiles, mammals, and birds at many of these same outlets is also, unfortunately, possible. These rarer fossils may command prices of many thousands of dollars. Although reputed to come from privately owned lands (from which they can be legally collected and sold) the amount and quality of the material that is found in private quarries versus that found in state quarries makes this claim suspect. Also, rumors from commercial operators, scientists, and members of the public on the illegal collection of rare and unusual fossils on a regular basis raise questions about the level of compliance. Since the current system requires that the collectors report what they find without oversight, regulation enforcement is essentially nonexistent. However, the recent discoveries of Green River Formation turtles, birds, and mammals that have been turned over to the University of Wyoming Geological Museum show that compliance with the existing regulations can provide important fossils to science and to Wyoming.

Scientists are concerned about the loss of important information when fossils are treated as commodities. Probably the greatest current controversy in paleontology is the short-term economic potential of vertebrate fossils. Commercial collectors and scientists often have diametrically opposed views regarding the "value" of fossils. Commercial collectors generally see the importance of fossils in terms of their exhibit quality and monetary value. Most scientists, on the other hand, look beyond the superficial aesthetics of the material to the valuable scientific information that can be attained from fossils.

Paleontological specimens can be considered the books of scientists. A fossil is more than an art object that is pleasing to the eye; it has a story. That story is what generations of the interested public look forward to learning more about. The popularity of paleontology today is not the result of the object's attractiveness, but rather the exciting earth history that can be interpreted from this material. Only through the research that is done on fossilized material can this story be told. The value of scientific specimens, therefore, is not simply that they look attractive, but rather the information that they provide. When one sees a best-selling novel at a bookstore, keep in mind that it did not become popular because of the figures and lettering on the cover, but rather because of the story contained within.

Therefore, if vertebrate fossils are to be protected and managed on public lands, public education and interpretation of the true value of the resource are vital to minimize information loss. Short-term commercial opportunities are often nearsighted in their view of the value of the resource. Privatizing unique, nonrenewable, scientific resources does not conserve the scientific integrity of the resource in the best interest of the public. Cooperation between scientists, public land managers, and collectors allows better understanding and interpretation of vertebrate fossils. Through interagency partnerships, public understanding can be enhanced through involvement in educational and interpretive activities. Clear, consistent legislation should protect vertebrate fossil resources on public lands.

Wyoming is the only state that allows vertebrate fossils to be commercially collected and sold from state lands. Currently, Wyoming has no state paleontologist. The museum curator at the University of Wyoming Geological Museum must function in this capacity, advising the state on matters of paleontological concern. No additional budget or staff are available for curating this material, which creates increased commitments and responsibilities for this museum. However, no other facility currently acts as a paleontological repository in the state.

Conclusions

Compliance with state regulations by both commercial and scientific collectors on state lands within Wyoming can lead to cooperation that will enhance our understanding of past life. However, since Wyoming has difficulty regulating a handful of commercial collectors in one member of one formation on known quarry sites in one of the smallest basins of Wyoming, this system is not a model for emulation in other states or nationally. Apparent violations and noncompliance with existing vertebrate fossil regulations on public lands remain serious problems. Additional enforcement and tighter surveillance are needed to protect Wyoming's nonrenewable, scientific resources. However, the situation will not change until more money and staff are provided. Wyoming's increased support would also allow the material that is turned over to the state to be better curated and help educate the public about the scientific value of fossils. Added resources and stiffer penalties should improve compliance with existing paleontological regulations, enhance preservation of vertebrate fossil specimens, and increase our knowledge of ancient life. Wyoming's permit system for paleontological preservation on state public lands is not a model system; however, the system has been developed over the years to accommodate a diversity of concerns.

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Interpreting In Situ Fossils: Lessons from Dinosaur National Monument

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Dinosaur National Monument is world famous for its spectacular in situ exhibit of dinosaur bones within the Quarry Visitor Center. Some 1,500 bones lie scattered across a river-deposited sandstone just as they were washed in 145 million years ago. This exhibit has proven popular with both the public and the scientific community, and the concept has been used in other state and federal parks, as well as in other countries.

A number of factors were instrumental in developing the in situ exhibit at Dinosaur. The rocks in the quarry area of the monument are tilted at an angle of 70°, which makes the quarry deposit easy to view. The quarry sandstone is well-cemented, so bone preservation is good and bones exposed in high relief do not (usually) fall out of the rock. Earl Douglass, the paleontologist who discovered and directed the excavations at the quarry between 1909 and 1923, wrote about the desirability of building a structure over the quarry so that the public could see the quarry's wonders. When the National Park Service began excavations in 1953, a substantial unexcavated portion of the quarry existed, which was enclosed within the visitor center in 1958.

From the early 1950s through the late 1980s, all of the monument's paleontological activities were focused on excavating the Dinosaur quarry. This work was necessary for the quarry to be developed to its full scientific potential. In addition, the excavations became the focus for visitors and the interpretive program was developed around the quarry and its work. Scientists were pleased with the specimens being exposed and the public stood in awe before the great wall of bones.

Although the NPS vision for the quarry was achieved, downsides to this success were evident. Virtually all other paleontological resources within the park were ignored, and the park did not attempt to gather baseline data, assess significance, or excavate important specimens outside of the visitor center. Thus, the paleontological story at Dinosaur was restricted to the resources within the Dinosaur quarry, and other fossil resources were being lost to erosion.

The monument was advertised as being the place to view dinosaur bones being uncovered daily. An unfortunate side effect was that the preparators on the wall, rather than the spectacular concentration of fossils, became the attraction. Thus, visitors who came and did not see someone working felt cheated, although the dinosaur bones were still there for them to view. Park managers thought that visitors would learn about the process of paleontological excavation and preparation by watching the paleontologists work. However, in most cases, the preparators worked crouched over specimens in the wall, and their work could not be seen. So, while viewing the wall of bones was a powerful emotional experience for visitors, it did little to teach the process of paleontological discovery. Instead of learning about preparation, most visitors simply commented that the work looked tedious and was not something they would want to do. The interpretive program was locked into a set of perceived visitor needs, many of which were not related to the important issues facing the paleontological resource management program. In the mid-1980s, the interpretive program faced rapidly diminishing finances. This situation, coupled with the traditional emphasis on the quarry, resulted in much energy being expended in interpreting the quarry while other critical park resources were given little attention.

Fortunately, things turned around in the late 1980s. The interpretive emphasis shifted from focusing on a single (albeit important) quarry to the entire ecosystem preserved in the rocks of the Morrison Formation. Visitors were encouraged to learn about the entire spectrum of paleontological research and management issues in the monument, rather than focus on the simple story of the quarry's discovery and excavation. Visitors were no longer spoon-fed paleontology by hourly quarry talks. New exhibits were installed that told the story of the quarry and its creatures in detail, much like any other museum. The Dinosaur Nature Association expanded its operations and began offering a wider range of adult and juvenile books and videotapes about the quarry, paleontology, and dinosaurs, and began publishing a park newspaper that featured stories about current research and management issues. Thus, the visitor was exposed to the complexities of managing and protecting paleontological resources as well as the exciting fossil discoveries being made everywhere in the park. The increasing use of nonpersonal interpretation for fossils enabled the interpretative program to use its limited personnel to address other important resources in the park, such as water rights and endangered species--resources that did not have a high-profile focus like the Quarry Visitor Center.

The quarry excavations yielded fewer and fewer bones as the edge of the deposit was approached. An increased emphasis was placed on protecting fossils monumentwide and understanding the extinct ecosystems buried within the rock exposures outside the visitor center. These two factors resulted in the decision to reduce and finally terminate excavations at the quarry in 1992, even though the quarry was only 70% excavated, and begin full time work at some of the more than 400 other fossil localities in the monument. This decision resulted in an explosion of specimens and information about the monument's fossil resources and a spate of scientific publications by park staff and outside researchers.

What are the pros and cons of in situ exhibits such as the one at Dinosaur? These exhibits provide a satisfying experience for visitors, many of whom have seen mounted skeletons in museums but have no concept of what a real fossil site looks like. Visitors have the sense that they are at a special place, even when no excavation is going on. If a preparation lab is viewable, the public can get an appreciation for how preparation is done and the skill involved, especially if video cameras and monitors are used to provide the visitor with close-up views. For scientists, in situ exhibits preserve fossils in their geological context and allow studies that cannot be done with specimens stored in museums. In situ exhibits also provide an opportunity to enhance public understanding and support for important, but less exciting, aspects of the program, such as curation. Finally, in situ displays provide an opportunity to integrate scientific and interpretive skills to help visitors learn about select times in the history of life on earth, to dispel myths about the past, and to bring the excitement of discovery to the public.

Some trade-offs to such exhibits exist, however. Preserving the fossils long-term may be difficult or impossible, depending on the type of matrix enclosing the fossils and the tilt of the fossil-bearing horizon. Bones left in place may not be oriented or exposed so that they can be best used scientifically. Temperature and humidity can reach levels unacceptable for the fossils, especially within small enclosing structures. Visitors are also directed to in situ exhibits, which raises security issues, especially if the exhibit is in a remote area, is not staffed, or if staffing is variable. Developing the exhibit may require a commitment of professional staff that could be spent better on more pressing resource management and science issues. Although the visitor may enjoy the exhibit, good interpretation will be required to ensure that the visitor gets some of the uncommon knowledge needed to appreciate and understand fossil resources.

Fossil parks have a tendency to develop in situ exhibits because they are something that many visitors desire. However, interpretation should not be driven by visitor desires, but rather be directed towards helping the visitor appreciate the resource and the issues associated with it. The crucial question is, what is the issue or experience that I as a manager want to impart to the visitor, and why? Alternatives to in situ exhibits exist, such as at the Royal Tyrrell Museum of Paleontology in Drumheller, Canada, in which a sizeable portion of a dinosaur quarry was brought inside and exhibited.

In situ development was appropriate at Dinosaur and has been a popular and scientific success. Similar development may be appropriate for other parks, but any in situ proposal should be approached with caution, and all of the impacts and ramifications need to be weighed carefully. In situ exhibits are not necessary to do high-quality paleontological interpretation, and other options might be preferable from an interpretive and scientific standpoint.

Some Observations on the Commercial Trade in Vertebrate Fossils

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The commercial trade in fossils is a robust international business with annual retail sales in the tens of millions of dollars (Anonymous 1991*a*). This trade is a big and complex topic that cannot be covered in detail here. However, I would like to make some observations on the trade in vertebrate fossils, based on a perusal of commercial catalogs and newsletters (see Appendix).

1. A broad spectrum of fossil material is available for sale today, from microscopic protozoa to complete dinosaur and mammal skeletons. A wide range of vertebrate fossils can be purchased, including coprolites, footprints, eggs, bone fragments, skulls, and complete skeletons. Prices range upward to $330,000 for a composite hadrosaur skeleton (Anonymous 1990) and $100,000 for an *Allosaurus* skull (Morell 1992). A dinosaur egg from France recently sold at Christie's of London for $11,000 (Anonymous 1992*a*). Small slabs with footprints fetch nearly $2,000 (Anonymous 1992*b*), while composite trackway slabs sold as corporate art can bring $40,000 (Lockley, pers. comm. 1992). Not only are fossils sold in shops and through catalogs, but are now even being offered on cable home shopping programs specializing in paleontological materials.

2. The commercial trade in vertebrate fossils is international (Breining 1991). Although many people know that vertebrate fossils collected in the United States are sold overseas, few realize that fossils collected overseas are sold in the United States. Examples of the latter are bones of cave bears from Austria, dinosaur eggs from France, and complete skeletons of the Mesozoic marine reptile *Guizhousaurus* from the People's Republic of China (Anonymous 1992*b*).

3. While many fossils were once purchased solely by individuals with a curiosity about the past, the present market is driven by a much wider set of forces. Thus, fossils are bought and sold for many reasons.

Fossil bone is used as a component in novelty items, such as the dinosaur bone-handle pen knife sold by the Nature Company for $100. Recently, inquiries have been made by individuals who plan to acquire bulk samples of dinosaur bones to be reduced to fragments (less than 1 in. cubes), to be sold separately in numbers in the hundreds of thousands (J. Madsen, pers. comm. 1992).

Fossils are used as investments and collectibles (Anonymous 1991*b*, 1991*c*, 1991*d*, 1992*c*, 1992*d*). Fossils showed higher growth in price (15 times) between 1970 and 1990 than did other more typical collectibles, such as classic automobiles, English antique furniture, and American folk art (Anonymous 1992*e*). In one case, a skeleton that was sold for $90,000 in 1990 was resold by the investor in 1991 for $190,000. With such value, investors have taken to insuring their collections (Anonymous 1991*e*, 1992*f*).

New Age devotees are interested in fossil vertebrates for their supposed mystical properties. Fossil bone is used as a *grounding medium* by New Age healers and therapists, as a component of spirit bags and healing pouches in *earth preservation* ceremonies, and in jewelry and wands (Anonymous 1992*d*).

Both skulls and skeletons are being used as office art by doctors, including neurologists, orthopedic surgeons, oncologists, and chiropractors (Anonymous 1992*d*).

Implications for Paleontological Resource Management

Although brief, this discussion shows that a strong market exists in fossil vertebrates and that specimens can demand extremely high prices. A survey of catalogs of the major fossil dealers documents a trade in specimens like those found in most national park system areas established for their fossil resources (Agate Fossil Beds, Badlands, Dinosaur, Florissant Fossil Beds, Fossil Butte, Hagermann Fossil Beds, John Day Fossil Beds, and Petrified Forest). Many of the major commercial companies purchase their stock from independent collectors and how the dealers ensure that specimens are legally collected is unclear. Considering that small staffs must manage large parks that have poorly marked or unmarked boundaries, and that fossils are abundant in many of these parks, illegal collection of fossils for commercial resale is far too easy. Unfortunately, even isolated teeth are commercially valuable. An illegal collector may choose to bash the teeth out of a skull because collecting and preparing the skull in its entirety might be too time-consuming. This method of collecting not only constitutes stealing, but destroys any fossil material that is left behind.

A similar problem is headhunting, or taking only the skull from a more complete specimen because it is the most valuable part. An additional threat is stealing specimens from collections and exhibits. High commercial prices for fossils may result in an astronomical increase in the value of existing paleontological collections, with impacts on the costs of security and insurance in museums already suffering tight under budgets.

Illegal collecting presents a major threat to fossil resources. Issues related to preventing theft (such as inventorying, cyclic prospecting, monitoring, and patrolling), as well as providing security for collection and exhibit areas, must be adequately addressed in resource management plans and other planning documents.

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Anonymous. 1992*b*. Prehistoric Journeys Price Catalog. Summer.

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Anonymous. 1992*d*. Who is investing in fossils? Fossil Index, The Newsletter for Collectors 2(2):1-2, 8, 10.

Anonymous. 1992*e*. Collectibles: two decades of growth. Fossil Index, The Newsletter for Collectors 2(1):12.

Anonymous. 1992*f*. Protecting the investment--part II. Insuring your collection. Fossil Index, The Newsletter for Collectors 2(1):6-7.

Breining, G. 1991. Buying time. Audubon, November/December:60-68.

Morell, V. 1992. Dustup in the bone pile: academics vs. collectors. Science 258:391-392.

Appendix

The following list of a few major North American commercial dealers and news letters for collectors in original vertebrate fossil material serves as a starting point for those seeking additional information about the scope of materials commercially available and their prices.

Black Hills Institute for Geological Research, Inc., Box 643, Hill City, SD 57745.

Fossil Finds, Box 35, Pilot Hill, CA 95664-0035.

The Fossil Index, The Newsletter for Collectors, Elan Press, Box 3376, Santa Barbara, CA 93130.

Geological Enterprises, Inc., Box 996, Ardmore, OK 73402.

Green River Geological Labs Inc., 365 N. 600 W., Logan, UT 84321.

Judy Owyang's Fossils/ETC., 1914 Sawtelle Boulevard, West Los Angeles, CA 90025.

Malik's Fossils, Inc., 5514 Plymouth Road, Baltimore, MD 21214.

Missing Link Fossils, 833 Poplar Way, Qualicum Beach, British Columbia V9K 1X8, Canada.

Paleosearch, Box 621, Hays, KS 67601.

Parson's Minerals and Fossils, 2808 Eden Lane, Rapid City, SD 55701.

Phoenix Fossils, 6401 E. Camina De Los Ranchos, Scottsdale, AZ 85254.

Prehistoric Journeys, Box 3376, Santa Barbara, CA 93130.

Southeastern Fossil Supply Co., 1209 N. Eastman Rd., Suite J209, Kingsport, TN 37664.

The Stone Company, P.O. Box 18814, Boulder, CO 80308-1814.

Two Guy's Minerals and Fossils, 1087 Plymouth St., E. Bridgewater, MA 02333.

Ward's Collector's Corner, Ward's Natural Science Establishment, Box 92912, Rochester, NY 14692-9012.

Western Paleontological Laboratories, Inc., 436 N. 1500 S., Provo, UT 84601.

The Importance of Paleontological Research for the National Park Service

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A realization has evolved that the National Park Service needs a strong science program to meet its mission of protecting and preserving the nation's heritage. However, both the NPS 75th Anniversary Symposium (U.S. Department of the Interior, National Park Service 1992) and the National Research Council's review of the NPS Science Program (National Research Council 1992) recognize the need to improve both the professionalism of resource managers and the quality of the science conducted within the parks. *NPS Management Policies* (USDI, NPS 1988:4.2-4.3) gives the following purposes for research in the National Park Service:

> A program of natural and social science research will be conducted to support NPS staff in carrying out the mission of the NPS providing an accurate scientific basis for planning, development, and management decisions. The science program will be focused on applied research necessary to direct management actions in pursuit of park objectives as stated in legislation and planning documents. This research may involve the pursuit of new facts and principles when problems arise for which no current solutions exist or when baseline collection of data must precede the identification of appropriate management actions. Basic research may also be necessary to correctly interpret resources whose functioning and significance are not known. In recognition of the scientific value of parks as natural laboratories, investigators will be encouraged to use the parks for scientific studies when such use is consistent with NPS policies.

This policy is the basis for the extensive *Natural Resources Management Guideline* (USDI, NPS 1991).

Fossils are still a somewhat arcane resource within the National Park Service, in spite of the fact that a number of units have been established specifically for them, and no clearly defined fundamental objective for managing and protecting paleontological resources seems to exist. This situation is in contrast to other types of natural resources where objectives such as preserving ecosystem integrity, preserving natural processes, or preserving biodiversity are widely known and well-understood. I believe that a fundamental objective to managing fossil resources exists and that this objective is comparable with those given for biologic resources. Simply stated,

> Paleontological resources should be managed to protect and understand the ancient communities and ecosystems contained within the rock units. Scientific study should improve our understanding of the structure, diversity, and functioning of those communities and how they relate to other parts of the biosphere of similar age.

This statement recognizes that fossil resources are more than just specimens. Each fossil has an ecological context and is part of a larger community and ecosystem, and these aspects of a fossil are important to understanding the ancient ecosystems that we protect.

Modern paleontological research encompasses a wide range of activities, all of which are important for understanding ancient ecosystems. Among these activities are:

Systematics. What species are present? These baseline data are analogous to biological inventories. Most species in the fossil record are yet to be discovered, and any serious systematic study is likely to uncover new ones. Such work may involve collecting specimens from the field, but studies of existing museum collections can be equally important. Many a new species has been found sitting unrecognized in a museum drawer. Such studies should not only include material in the park collection but also material in outside repositories, including material collected from the area before the park was established.

Phylogenetics. How are the species related evolutionarily to their contemporaries as well as to their ancestors and descendants? Such information may shed light on adaptations, migrations, paleogeography, etc.

Functional Morphology. This activity involves understanding how an organism functioned and lived. Such studies may involve not only analysis of the preserved body parts but also of organism tracks, trails, etc.

Paleoenvironment. What mosaic of environments are preserved in the rocks? What is the distribution of species across this spectrum? What species preserved in a given depositional environment actually lived there and what species are extraneous (i.e., were transported there after death)?

Community Structure. This activity involves identifying what communities are present, what their species compositions are, and reconstructing trophic levels and food chains within the community.

Paleoclimate. What was the climate like and how were animals adapted to it? Was seasonality strong or weak? How did the climate change during the time range preserved in the rocks and how did the flora and fauna respond to it? How was climate controlled and changed by regional and global paleogeography and continental positions?

Correlation. What are the absolute and relative ages of the rock units? How do the ecosystems they contain relate to other similar-age deposits around the globe? What are the similarities and differences and what can account for them?

These activities are only some of the possible studies, but suffice to show that modern paleontological research is a rich, complex, and sophisticated arena. Any of the above areas may include geochemical analysis, isotope analysis, radiometric dating, sedimentologic and stratigraphic studies, petrologic analysis, scanning electron microscopy, or CAT scans. No single earth scientist can, of course, conduct such a range of studies. However, such needs must be identified in the proper planning documents and funds obtained when necessary to support contract work or outside researchers. Many of the units established for their fossil resources are recognized by the international paleontological community as outstanding samples of select times and environments of the past. Protection and study of these ancient ecosystems should be part of the National Park Service mission.

Paleontological Research at Dinosaur National Monument

My experiences at Dinosaur National Monument over the last 13 years provide concrete examples of how a broader view of fossil resources helps achieve a park's mission and improve our knowledge of the resource. This brief review is not intended to be an exhaustive list of paleontological work at Dinosaur, but rather focuses on a single rock unit, the Morrison Formation, which produces the dinosaur fossils for which the monument was established and is famous.

Traditionally, research at Dinosaur has focused on the animals found at the Dinosaur quarry. Many of these studies have been systematic in nature (Britt 1987; Gaffney 1979; Galton 1981*b*, 1982*b*, 1982*c*, 1983; Galton and Jensen 1983*a*, 1983*b*; Galton and Powell 1980; Gilmore 1925*a*, 1925*b*, 1932, 1936; Holland 1915, 1916; 1924*a*, 1924*b*; McIntosh 1981, 1990; McIntosh and Berman 1975; Madsen 1976; White 1958; Yen and Reeside 1950). However, a few studies have touched on other issues, such as functional anatomy (Haas 1963), niche separation (Fiorillo 1991*a*, 1991*b*), pathologies (Rothschild 1990, Rothschild and Berman 1991), paleobiogeography (Galton 1977*a*, 1977*b*, 1980, 1982*a*), and deposition of the sediments exposed in the quarry (Lawton 1977).

Although the quarry provides a spectacular look at the dinosaur community, it is, at the same time, biased strongly toward preserving only the larger members of the animal community. More recent work has focused on the Morrison Formation as a whole, with the goal of gathering a more complete picture of the Morrison community within the monument, both plant and animal, dinosaur and nondinosaur, and small as well as large dinosaurs. This research has been conducted by park staff, outside researchers, and through contracts. The results have been spectacular (over 400 localities have been discovered through paleontological inventories) and have added greatly to our knowledge of the Morrison ecosystem.

Over half of the known species of the Morrison community within Dinosaur have been found in the last 6 years, and when current work on fossil pollen and spores is completed, that figure will probably rise to over 90% (i.e., a tripling in known diversity). Included in this diversity are ostracod crustaceans, conchostracans, amiioid fishes, salamanders, frogs, lizards, sphenodonts, large and small crocodilians, and a wide range of mammals (Chure 1992*a*, 1992*c*, 1992*d*; Chure and Engelmann 1989; Chure et al. 1989; Engelmann et al. 1989; Engelmann et al. 1990; Evans, in prep.; Frazer, in prep.; Henrici 1992,; Lucas, in prep.; Nessov, in prep.). Many of these specimens are still under study and detailed descriptions will continue to be published far into the future. Even for a group as well-known as the dinosaurs, new and important material is being found outside the quarry. Examples include a nearly complete skeleton of a new species of large carnivorous dinosaur, a new species of small meat-eating dinosaur, and an embryo of the plant-eating dinosaur *Camptosaurus* (Chure 1992*b*, Chure et al. 1992, in press).

The fossil record of plants in the Morrison Formation is generally poor, although work in Dinosaur has produced the first extensive pollen and spore floras, as well as leaves, seeds, cones, branches, logs up to 60 ft. in length, and even fossilized cuticle. This material comes from a wide range of plants, including charophytes (green algae), ferns, horsetails, conifers, ginkophytes, and cycads. This material has been only briefly mentioned to date (Tidwell 1990, Tidwell and Medlyn 1992), and with the exception of charophytes (Schudack, in prep.), remains to be studied in detail.

In addition to simple diversity, larger issues are also under investigation. Some of these issues include taphonomy (Hubert and Chure 1992), the pattern of fossil distribution (Engelmann 1991, 1992*a*, 1992*b*; Engelmann and Chure 1992a), paleoecology and paleolimnology of fossil lakes and ponds (Evanoff, in prep.), radiometric dating of the Morrison Formation within Dinosaur (Bowman et al. 1986; Kowallis et al. 1991; Kowallis, in prep.; Turner and Peterson, in prep.), and Morrison sedimentology, stratigraphy, paleoenvironments, biostratigraphy, and intercontinental correlation (Bilbey 1992; Turner and Peterson 1991; 1992*a*, 1992*b*, in prep.).

As a result of this paleontological renaissance at Dinosaur a virtual explosion has occurred in our knowledge of the Morrison Formation within the monument. Today, the exposures of the Morrison within Dinosaur are the most intensively studied, best-understood pieces of this formation, and are a critical reference section for anyone interested in Upper Jurassic terrestrial ecosystems. The reputation of Dinosaur for scientific activities and fossil resources will continue to attract the attention of paleontologists and geologists--much to the benefit of the National Park Service and the sciences of geology and paleontology.

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Paleontological Resource Management, NPS-77, and Practical Applications

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These proceedings on the Third Conference on Fossil Resources in the National Park Service is the first of its kind. Like the meetings, this publication provides a good informal opportunity to review aspects of the National Park Service's fossil management. This paper, and the accompanying essay, are some comments drawn from the cluttered notes I prepared for two of my short presentations at those meetings (see abstracts).

To begin with, I would like to interpret some aspects of NPS policy regarding fossil conservation from the perspective of a field paleontologist. Then I will discuss how these general policies have been put into action via a series of guidelines.

In 1988, the editor of NPS-77, Anne Frondorf, asked Dan Chure and myself to prepare a section in that document on managing paleontological resources. This request was something new; for years Dan and I had been disgruntled by the lack of credible guidance from the Washington office to field areas and regions with fossil deposits. Many colleagues felt that the result was a lack of cohesive, servicewide management vision that could be cited to support actions taken from a paleontological perspective. With Anne's request, for the first time paleontology would be given equal treatment with more traditional considerations, such as vegetation management.

The National Park Service manages more than 360 areas, over 50 of which contain noteworthy fossil localities. The vast majority of these areas were established for primary values that were nonpaleontologic, such as Yellowstone, Big Bend, and Olympic national parks. Over a dozen sites, however, have been established specifically because of certain fossiliferous strata.

In principle, all NPS paleontological resources are supposed to be afforded similar protection. Once an area is authorized (wherever it may be and for whatever reasons), an overlay of policies and guidelines are applied to assure management that the resources are preserved and appreciated. The essence of the enabling legislation is to leave resources unimpaired for future generations. This legislation is meant for generations of scientists, too, because these areas are very much active realms of research.

A Perspective on NPS Management Policies

A perspective was voiced at the first fossil conference in 1986 that illustrates the confusion resulting from a lack of guidance. This curious viewpoint stated that the NPS mission is to allow all natural processes to occur in parks, including the erosion and ultimate destruction of fossil resources! I recall an analogy that fossils are "like petals on a flower" that we allow to drop--and rot. I also recall a sinking feeling.

Clearly, the operative words in our policies are *preservation* and *unimpaired*, which do not imply that scientifically significant specimens are left in the field, lost to investigators forever. We must not allow such material simply to weather away. Not long ago, it was considered part of the interpretive experience to be able to watch fossils erode to dust. Thankfully, these attitudes have changed and efforts are now being made to collect fossils before they erode away.

NPS policy should always have been to preserve important specimens that are threatened (by whatever factors, including weathering, vandalism, and so forth). Preservation is accomplished by stabilization in situ, or by careful, well-documented collection for curation in dedicated, systematically organized museum storage. The National Park Service has literally written the handbook on curating and storing natural history objects and need not look wistfully to other museums for an ideal to follow.

The National Park Service's policy is also to encourage research:

> In recognition of the scientific value of parks as natural laboratories, investigators will be encouraged to use the parks for scientific studies when such use is consistent with NPS policies.

The "consistent" clause is not a catch-22; it simply is not consistent to bulldoze a road to a specimen, or ignore other resource values. Similarly, managers are currently rewriting references in *NPS Management Policies* that appear to discourage paleontological research in parks "if such studies can occur outside." This phrase is misunderstood, to the detriment of responsible scientific investigation (as opposed to mere collecting, which probably should be discouraged) and resource preservation.

In short, modern NPS policies can be interpreted as encouraging positive things: protection and conservation. In my mind, our mandate is clearly one of drawing information out of the ground and protecting data by collecting evidence. This process is done with as much sensitivity as possible to the "neontologic" and cultural resources existing in the same context. Managers need some guidelines to do that.

Guidelines for Managing NPS Paleontological Resources

The chapter in NPS-77 dealing with fossil resources is an attempt to focus attention on historically overlooked fossil localities and data, remind managers of their obligations, and suggest where to obtain assistance. Certainly, no one expects a one-size-fits-all set of guidelines to provide people with much but general guidance. Just as in the living biota they reflect, variability and diversity are two attributes that are hallmarks of all fossil resources. Guidelines cannot offer a cookbook; specific actions are as variable as the sediments that occur within different units. The intent was more to set the parameters within which one should act. The present version of the paleontological chapter of NPS-77 is a first effort, and although it was thoroughly reviewed by all the regions and Washington office staff, we are aware that it could have stood revision before the ink dried.

Synopsis of the Guidelines

The guidelines call for certain kinds of actions for intensive management. Many of these actions may seem to restate the obvious. This information has been surprisingly new, however, for some administrative levels that viewed fossils as (apparently) something less than a manageable resource. The approach can be boiled down to three stages.

First, the resource inventory needs to be conducted, sometimes called baseline studies or other appellations. We suggest four fundamental components for all sites:

1. Literature Surveys. This component involves searches of such databases as *Zoorec* or *Georef*, contracting with a cooperative park studies unit, consulting specialists at the U.S. Geological Survey and elsewhere, or applying for student grant monies and support. Much published material is overlooked by land stewards.

2. Collection Surveys. Beyond the obvious scholarly need for reference to type specimens, a survey of off-site repositories provides added bonuses. Most material collected in an area never appears in the technical literature. Collections must be examined for an overview of the kinds and varieties of fossils. A Collection Survey Documentation Form is provided in NPS-77 as an example, not as a "form." Likely repositories can be found by contacting professional institutions.

3. Identification of Areas. Where is a high potential for significant assemblages? Much of this can be achieved through literature and collection surveys. Special consideration must also be given to what rock formations occur within the park and if they are fossiliferous.

4. Paleontological Surveys. The guidelines call for systematic scientific surveys within the park. A great deal of information is available outside the park, of course, and often is required to analyze sedimentary processes and events. Locality forms and suggested photo documentation are included as examples of park-generated documents.

Second, evaluating significance is needed. In this context, significance refers only to scientific, not interpretive, exhibit, spiritual, or other determining factors. Recognizing the anomalies that often convey research importance to a specimen or context is a matter of informed judgment. When in the field, one often finds new material that is outside one's own specialty; an authority on trilobites is unlikely to appreciate critical features in Neogene paleobotanic localities. Factors such as undescribed taxa or structures, pathologies, aberrant sizes, paleoecologic relations, temporal extensions, and others discussed in NPS-77 are best evaluated by an authority of that subdiscipline. Though a park unit may have an extremely knowledgeable staff, they cannot be masters of all trades. As NPS field people (currently dominated by vertebrate paleontologists) have more access to specialists working in sister disciplines, their knowledge will increase.

Finally, management actions are discussed in NPS-77. A continuum of actions exists, of course, but we compartmentalized them for easy reference. Options range from doing nothing to investing thousands of dollars and person-hours salvaging material for dedicated storage. Decisions should be made in an informed and responsible manner; and ample authority exists for action.

No action is appropriate in many instances (e.g., rugose corals at Timpanogos Cave, archaeocyathids at Glacier) where rocks are well-indurated and significance is debatable.

Monitoring sites for damage is probably the bare minimum of activity suited for several sites (e.g., the historical quarries on Fossil Butte, *Woodworthia* at Petrified Forest).

Closures are necessary where unauthorized personnel could compromise the very resources the area was established to protect (e.g., the *Stenomylus* quarry at Agate, the Blue Basin badlands at John Day).

Stabilization in place is exercised in most parks as needed where collection is inadvisable (e.g., the stumps at Florissant), or shelters have been built at many sites. The latter are enjoyed by the public (e.g, the quarry at Dinosaur) but may receive mixed professional reviews.

Excavation continues in many places (e.g., Hagerman microfossils) and where practiced, cyclic prospecting has proven to be an effective way to prevent significant specimens from being lost (see next essay).

In addition, the new guidelines review intensive management and minimum needs for documentation. Preparation records are reviewed. All of these activities are about conserving the context and meaning of fossils. Recording the framework of burial as precisely as possible is crucial to preserving specimens with information as unimpaired as possible. Finally, the document discusses permitting; although the process for permits is reviewed elsewhere, it needs additional clarification and standardization.

National park system sites are authentic places, worthy of protection. These sites are, indeed, laboratories of scientific discovery containing the essential evidence needed to appreciate the dynamics of change. NPS localities include some key paleobiotas essential to understanding North America's evolution. The manager has an opportunity at these areas to help the public perceive how thin the veneers of modern ecosystems really are, demonstrate how the preceding ones are studied, and protect them at the same time. Guidelines like NPS-77 are intended to help make the most of these opportunities.

Acknowledgements

Thanks to Rachel Benton and Ann Elder for doing a marvelous job hosting the conference and pursuing publication of the proceedings; Dan Chure for writing most of NPS-77 from an outline (all the good parts are mine, though); Tony Knapp for rooting for paleontology from the Washington office; and especially Ben Ladd for enthusiastically placing fossil resources at the top of his John Day Fossil Beds National Monument agenda.

Cyclic Prospecting and Salvaging Fossils

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In the previous essay I discussed aspects of paleontological resource management, the bewildering variety of strata and techniques, and our obligation to protect fossils in erodible sediments. The principles of unimpaired custodial responsibility suggest a program of stabilization, collection, or both. One or more varieties of systematic and repeated locality examination, followed by appropriate action, is required in these circumstances.

A simplistic diagram of some of the thought processes for each specimen found in the field was included in NPS-77 (See Figure 1). While developed for body fossils found in the Turtle Cove Member of the John Day Formation, the diagram is included here because of its general applicability to any type of deposit with a minimum of modifications.

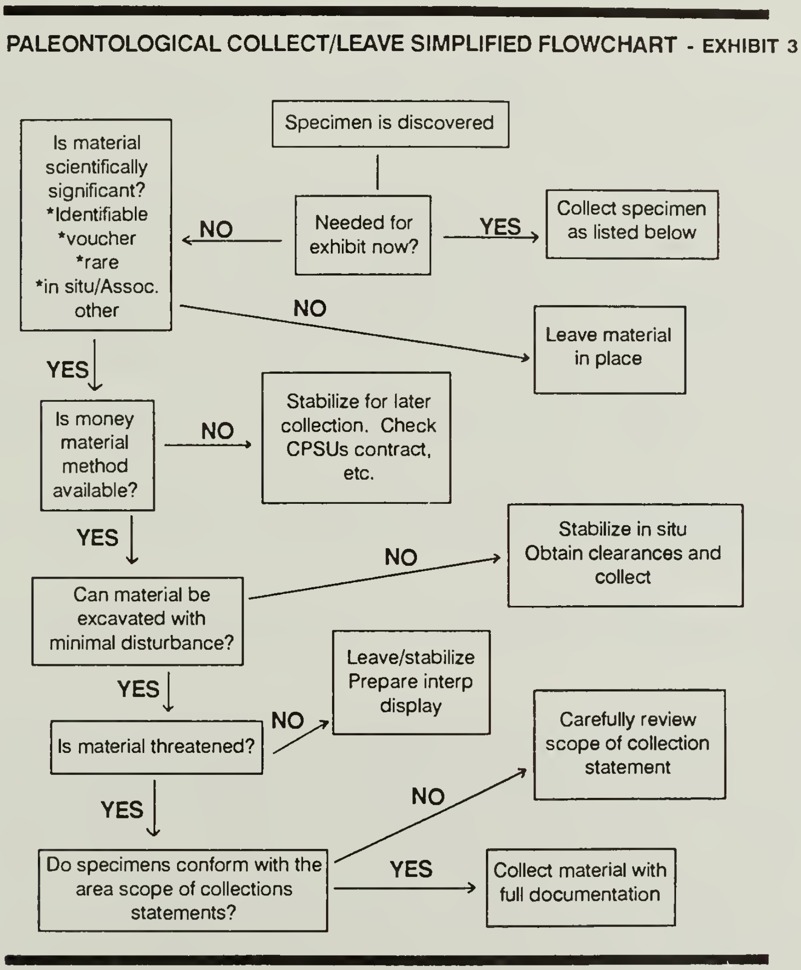

Figure 1. Paleontological flowchart as shown in NPS-77.

1. A specimen is discovered. The park staff should assess the immediacy of action required and proceed accordingly; many materials have been unnecessarily jeopardized by procrastination. Conversely, numerous fossils are so large or inseparable from the matrix that collection is not a reasonable option.

2. Is the specimen needed for exhibit? If the specimen is needed for a visitor center exhibit, it could be collected as long as it is properly documented. However, in most cases "exhibitability" should not be the primary criterion for collecting fossils. If the specimen has little scientific significance, is it disturbed from its original bedding plane and is aesthetically rewarding

from an interpretive perspective, then exhibiting the specimen may be the correct action.

3. Is the material scientifically significant? I emphasize that a qualified specialist familiar with local temporal and taxonomic considerations must be in charge of the collecting. Significance varies widely with the deposits.

   Counterintuitive though it may seem, the park should not always try to err on the side of collecting. It is easy to clutter collections with rubbish or pull material out of the field that might have been of greater value in place. Specimens initially cost at least five dollars for each catalog record to curate in optimal circumstances. If the material is determined to be paleontologically insignificant beyond a reasonable doubt and isn't needed for exhibit purposes, leave it.

4. Are equipment, methods, and monies assured? Just as in medicine, a NPS credo should be first to do no harm. Does the methodology at the park enable scientists to systematically retrieve the fossil(s) with full documentation? Do enough consolidants of the right type exist? Will collectors need a rock saw, a *punjar,* or more delicate probes, or whatever? Does the park have funds to engage a specialist? A fine line may exist between simple procrastination and wise stabilization of a specimen until all is in order.

5. Are permits needed? Can the material be salvaged without requiring a special permit or an Environmental Assessment? Are Archeological Protection Act or Section 106 (XXX) processes needed? That is, do cultural associations exist, or is the area historical? If one has to bulldoze, mitigating and minimizing the impacts on the natural resources must be considered. This situation is more often encountered with outside investigators.

6. Is the material threatened? Is the specimen in danger where it is? With increasing numbers of people viewing fossils as marketable commodities, something left out probably is threatened. But if a threat isn't apparent, the specimen might be better left in place. Perhaps an in situ exhibit can be developed and protected for public enjoyment. In such cases, an analysis of the cost-benefit ratio of leaving items should be conducted, in consultation with specialists working on the taxa.

7. Specimens must conform to the park's scope of collection. This statement may appear incongruous; clearly, if a specimen (following the previously mentioned concepts) is found within the park, is scientifically significant, and is threatened, all options should be open, including collection. Nonconformance suggests the park's scope of collection should be revisited and carefully rewritten to reflect paleontological needs.

8. Specimens designated for collection should be retrieved, with full documentation of the process, following data collection standards.

I would like to draw on an example from a park in the Pacific Northwest Region, John Day Fossil Beds National Monument, and focus on one aspect of paleontological resource management that is pursued in that park: cyclic prospecting. Like several units administered by the National Park Service, John Day Fossil Beds National Monument contains a variety of assemblages. The diversity of problems within the monument parallels the diversity of resources within the entire national park system: over a dozen different fossil assemblages (described elsewhere) exist, each of which requires a somewhat different management approach. (At least four of these strata in and of themselves would merit consideration for national monument status; to have a dozen such beds in a sequence testifies to the wonderful preservation that can occur from volcanoes dumping sediment into rapidly evolving basins.)

When the Paleontological Research Plan was being prepared for the monument, one stratum identified in the John Day Basin for proactive management was a layer that entombs a late Oligocene paleobiota, particularly rich in mammalian species. This layer is a thick sequence of bright-green zeolitized, tuffaceous claystone that envelops one of the finest records of late Oligocene through early Miocene mammals on the planet, with well over 120 species identified.

Splendid specimens weather out. These materials are extremely hard, but brittle; once exposed they may last for only a couple of years. After that, the fossil may be ruined and data are lost. To fulfill our mandate, we established a protocol for performing regularly scheduled prospecting: exposures of large areas of badlands topography are monitored about every four years (based on estimated rates of weathering).

A variety of staff, including trained volunteers, uniformed rangers, and others supervised by the museum paleontology division, carefully prospect the beds under a coordinated schedule. The materials and methods used in the field are too complex to detail here, but include high-resolution (1:1000) color stereopairs to delineate specimen occurrence, and archival polyester processing folders overlaid on the photos to record areas prospected. The aerial photography had to be designed specifically for this purpose.

If a scientifically significant specimen is observed, scientists may take action. This action varies. Protecting or retrieving fossils may be appropriate, which range from tiny teeth that become affixed to the head of a small pin, to items weighing many hundreds of pounds that have to be jacketed and hauled out on litters.

In the museum, 36 in. by 36 in. photo enlargements are used to pinpoint specimens; precise coordinates are entered into the Automated National Catalog System computer records, which permit us to electronically pinpoint the specimen's original location to within a meter. The monument is now developing a GIS system to take advantage of our existing data and evolving technology. A database linked with locality data sheets is kept, complete with the overlays documenting precisely where prospecting was done. Photography in situ of all in place specimens documents things such as orientation and associated paleosol features. At John Day for example, the field notes record data in a format that can be plugged directly into Automated National Catalog System dBASE file formats during cataloging. The resulting database files are then accessible with linkages to Windows software such as IDEALIST, dBASE IV 1.5, and APPROACH. Each field-generated note must have at least the taxon, skeletal determinate, coordinates, and stratigraphic height.

Most specimens (e.g., bone fragments, shells, certain ichnofossils) observed during cyclic prospecting are left in the field because they are not significant. The issue of whether one retrieves a specimen or permits it to be ultimately destroyed is a complex one that requires a solid understanding of the particular strata. Similarly, whether cyclic prospecting may be warranted within a park varies with the facies, lithology, induration, and other factors. For example, at Fossil Butte, a program of canvassing the paludal facies of the Wasatch Formation is appropriate. In the Green River lacustrine members, however, surface prospecting is aimless and active quarrying is required. Monument staff might be wise to encourage a protected, long-term effort developing a narrow quarry, sampling the entire time period of the Fossil Butte Member. This effort would answer broader research questions rather than merely developing another large-scale, temporally static quarry such as those that exist outside the park.

In Oregon, we have observed that numerous benefits result from a well-funded program of cyclic prospecting. The obvious benefits to resource managers (in both the National Park Service and in other agencies) include the abilities to develop baseline data on mode and occurrences of fossils, prepare rates of weathering overlays, document areas of critical concern, and facilitate protection. Curators find that periodic revisits to an area reveal missing parts of a specimen already in the collection. Also, in situ photographs facilitate preparation of complex material, and curators' ability to anticipate research questions is augmented. The big payoff to researchers includes unbiased collecting samples, the abilities to prepare precise faunal lists and analyze proportions of taxa, easier detection of anomalies, and unambiguous locality records for biostratigraphic studies. Interpreters are well-served by their capacity to show these areas to the visiting public not as static monuments, but as places of discovery.

Results and Recommendations of the 1991 Paleontological Resource Survey of the Oglala National Grassland

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Introduction

In early 1991, the U.S. Forest Service asked the University of Nebraska State Museum to assess vertebrate fossil resources on the Oglala National Grassland near tourist-accessible Toadstool Park in Sioux County, Nebraska (Figure 1). The fossiliferous rock units in this area are the White River Group, Arikaree Group, and Quaternary loess (Schultz and Stout 1955). After collecting vertebrate fossils on U.S. Forest Service lands was prohibited in 1986, our special use permit (issued June 1989, User No. 2033) was the only permit of this type active on the Oglala National Grasslands. Therefore, fossil vertebrates taken from the Oglala National Grasslands within the 5 years before our survey were collected illegally. For details of the 1991 survey (including USGS 7.5-minute topographic maps summarizing important data), refer to the report submitted 30 March 1992 to the Nebraska National Forest, 270 Pine Street, Chadron, Nebraska 69337 (LaGarry-Guyon and Hunt 1992).

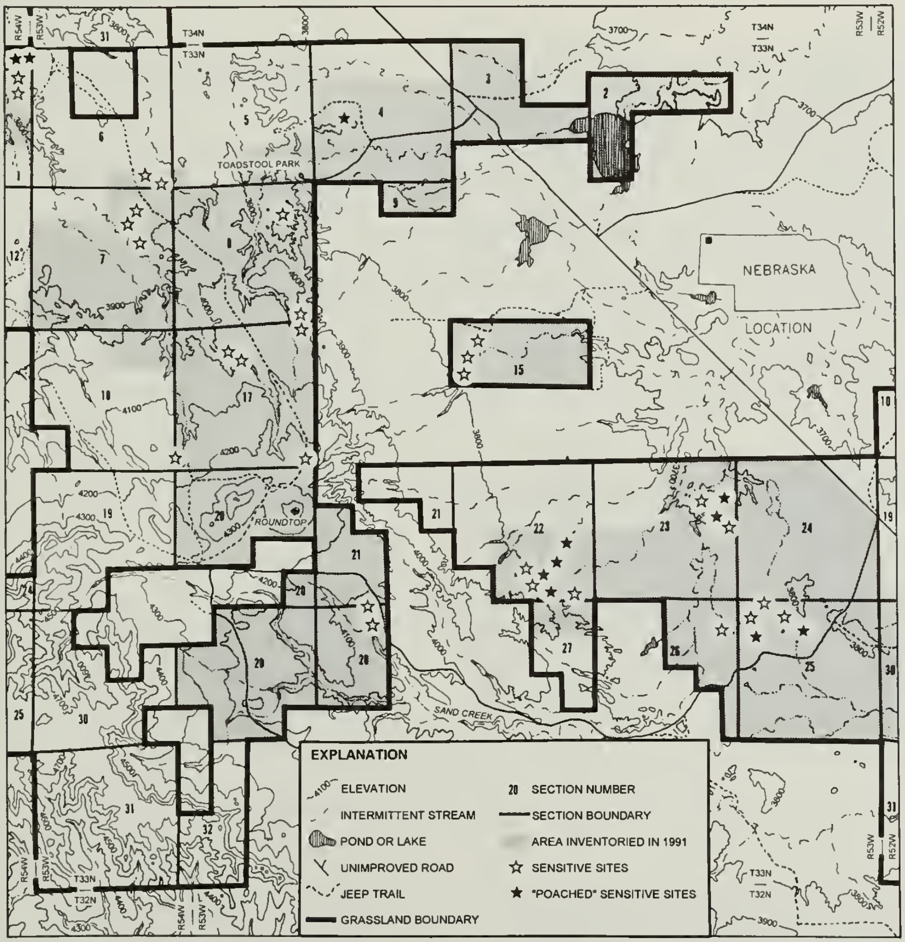

Figure 1. Oglala National Grassland surveyed by the University of Nebraska State Museum in 1991. *Poached* refers to illegally removed vertebrate fossils. The locations of sensitive sites are deliberately vague to protect their scientific value, but indicate areas most heavily impacted by illegal collecting. The Roundtop USGS 7.5-minute quadrangle was used as the base map. Oglala National Grassland boundaries were provided by the U.S. Forest Service.

Requests for more information about the 1991 survey should be addressed to Hannan E. LaGarry-Guyon or Robert M. Hunt, Jr., University of Nebraska State Museum, Lincoln, Nebraska 68588-0514.

Requests will only be accepted from federal agencies, law enforcement officials, and accredited museums.

Results of the 1991 Survey

During the summer of 1991, we mapped the geology of 25.4 sq. mi. within the greater Oglala National Grassland boundary. However, we actually inventoried (walked on) only federally owned lands within this boundary (15.5 sq. mi., Figure 1), 11.4 sq. mi. of which was exposed, fossiliferous loess and bedrock (Figure 2a). We evaluated the nature and extent of vertebrate fossil resources and the frequency of illegal collecting activity. Much of the land surface surveyed showed physical evidence of illegal fossil collecting (Figure 2b) in the form of shallow pits, spilled plaster of paris, discarded burlap, and abandoned or broken tools and flagging.

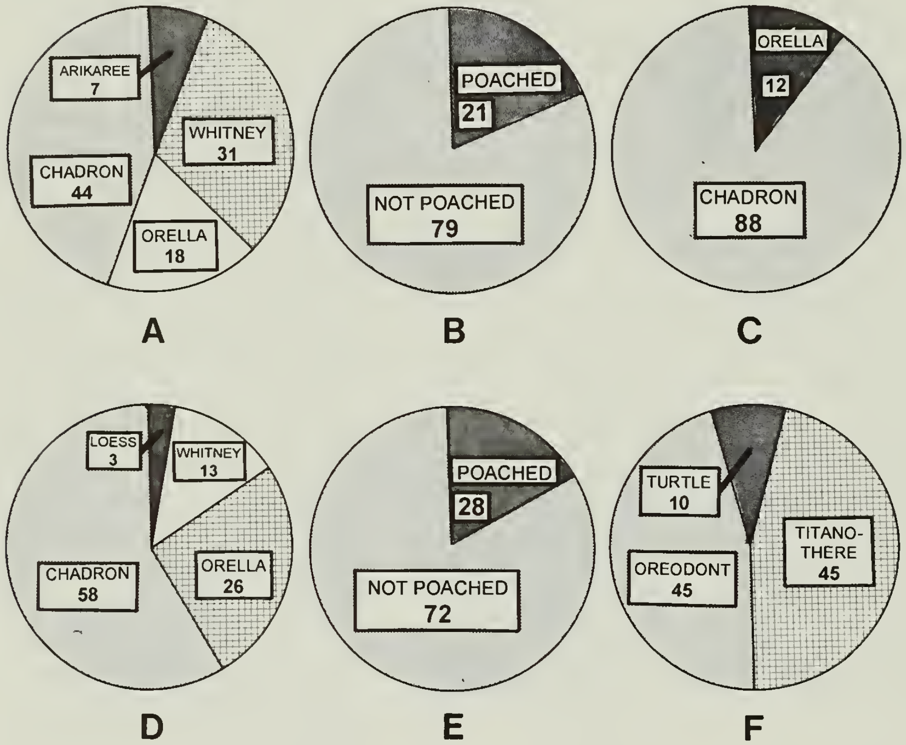

Figure 2. Summary of 1991 paleontological resource survey results (in percents): (A) geological units surveyed, excluding loess (the Chadron Formation, and Orella and Whitney members of the Brule Formation are subdivisions of the White River Group); (B) surveyed land surface showing physical evidence of illegal collecting; (C) geological units affected by illegal collecting; (D) sensitive sites occurring in each geological unit in study area; (E) sensitive sites affected by illegal collecting; and (F) probable taxa collected illegally, based on size of excavation and remaining fragments.

Although White River Group rocks are normally highly fossiliferous (Wood 1949, Schultz and Stout 1955), fossils were infrequently observed during our 1991 survey. The Chadron Formation was most heavily impacted by illegal collecting, although numerous violations were also observed in the Brule Formation (Figure 2c). We suggest that this trend is because the Chadron Formation erodes into low hummocks and is accessible to two-wheel drive vehicles and flatbed trucks via jeep trails (Figure 1). In contrast, the Brule Formation forms steep, relatively inaccessible cliffs.

Although important fossil material weathers from bedrock throughout the area surveyed, we designated some areas as having special importance because of their exceptionally well-preserved or complete vertebrate fossils (sensitive sites, Figures 1, 2d-f). Of the sensitive sites we identified, many showed evidence of illegal collecting (Figure 2e), with skeletons, skulls, and jaws of common mammals and tortoise shells taken most frequently (Figure 2f).

In addition to daily, illegal fossil removal from Toadstool Park, we observed three occasions in which individuals in four-wheel drive vehicles (with ancillary fossil-collecting gear) fled the area upon seeing our survey team. These observations indicate that unauthorized vertebrate fossil collecting in this area warrants increased attention by law enforcement agencies.

The total cost of our 1991 survey of the Oglala National Grasslands was $0.71/acre. This survey included (1) detailed geological mapping of fossil-bearing rock units; (2) detailed documentation and salvage of jeopardized fossil specimens; (3) identification and documentation of areas of special sensitivity; (4) detailed documentation of evidence of illegal fossil collecting; and (5) a report containing detailed maps and descriptions of the paleontological resources of the areas surveyed. The area we surveyed is viewed by the paleontological and geological communities as a valuable scientific resource (Schultz and Stout 1955). Survey costs may be less for areas of different topographic relief or for those having less significant vertebrate fossil resources.

Recommendations

We recommend that vertebrate fossil collecting without special use permits be restricted on the Oglala National Grassland for the following reasons:

1. Vertebrate fossils on federal lands are part of the public trust and should be managed as a valued scientific resource of limited scope.

2. The scientific value of vertebrate fossils collected by untrained or unscrupulous persons is compromised because of poor collecting technique and loss of geological data.

3. Unpermitted collecting violates the intent of the Federal Land Policy and Management Act of 1976, which requires that federal land managers protect the quality of scientific values on lands in their care.

4. The Society of Vertebrate Paleontology, the principal professional organization of vertebrate paleontologists in the world, endorses only permitted collecting on federal or state lands in the United States.

5. Collecting and selling vertebrate fossils for commercial use is not in the public interest and results in scientifically important fossils being removed from the public realm to private collections where access to the fossils is denied or prohibitively difficult.

Based on the results of our survey, we further recommend that the following steps be implemented to better manage vertebrate fossil resources in the Toadstool Park region:

1. Enforce regulations limiting access to federal lands in northwestern Nebraska to eliminate adverse environmental impacts on paleontological and ecological resources.

2. Fossil resources in Nebraska should be periodically assessed by professional vertebrate paleontologists of the University of Nebraska State Museum.

3. Inform U.S. Forest Service officials at the national level of the sensitive paleobiologic resources in the White River Group rocks of Nebraska and South Dakota.

4. Penalize illegal collecting (felony or misdemeanor, as appropriate) with fines, incarceration, or both, confiscate illegally collected fossils, and place them in an accredited, publicly maintained repository of fossil vertebrates (museum or university).

Acknowledgements

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Developing the National Park Service's Paleontology Program

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Paleontological resource management within the national park system has developed dramatically since the first fossil resources conference was held at Dinosaur National Monument in 1986. The most notable achievements include establishing written guidelines and policies for fossil management in national parks, creating new full-time paleontologist positions at key parks, and an expanded network of communication between professional paleontologists and park staff. Additionally, not long ago, the Park Service was debating whether fossils should be recognized as cultural or natural resources.

As an agency dedicated to preserving resources, the National Park Service has not been immune from fossil resource theft. The two national park system units that have apparently experienced the greatest amounts of fossil theft are Petrified Forest National Park and Badlands National Park. However, most of the more than 100 national park system units with significant paleontological resources lack the training and staff to evaluate any impacts from theft.

A number of legal and ethical issues related to managing paleontological resources need to be considered. New pending legislation, along with new research techniques and methods, will impact how these sensitive and nonrenewable resources are managed. The NPS paleontology program needs to continue to grow and develop in new directions. The handful of park paleontologists have reached out to assist other parks with fossil resource planning. Educating superintendents and park managers will continue to be an important responsibility of the park paleontologists.

Some of the landmark developments of 1992 that fossil park managers should be aware of follow:

14 May 1992. The FBI confiscates the *Tyrannosaurus rex* specimen named "Sue" from the Black Hills Institute of Geological Research in South Dakota.

8 June 1992. The Society of Vertebrate Paleontology's Executive Committee presents a resolution pertaining to fossil commercialization.

29 June 1992. The North American Paleontological Convention roundtable discussion entitled "Paleontology on Public Lands" is held in Chicago.

30 July 1992. Senator Max Baucus (Montana) introduces Senate Bill S.3107, the Vertebrate Paleontological Resources Protection Act.

24-26 August 1992. The U.S. Forest Service hosts the Northern Plains Governors' Conference, "Fossils For the Future," in Rapid City, South Dakota.

14-17 September 1992. The Third Conference on Fossil Resources in the National Park Service is held at Fossil Butte National Monument, Wyoming.

The Vertebrate Paleontological Resources Protection Act has been subjected to intense scrutiny. The end product should be a thoughtful document that will provide the legal authority for effective paleontological resource management. This legislation (1) recognizes that the current laws are inadequate; (2) recognizes that fossils are nonrenewable resources that have scientific and educational value and are threatened; (3) clearly states that commercial collecting on federal land will be prohibited; (4) provides authority for vertebrate fossil permitting; (5) recommends that federal agencies recognize paleontological resources separately from cultural resources; (6) recommends the confidentiality of paleontological site data; (7) recommends developing educational programs for the benefit of the public; (8) establishes a mechanism for investigating and prosecuting illegal paleontological collecting on federal lands; and (9) increases the penalties and fines for illegal collecting, which will provide a greater deterrent given the escalating commercial fossil market.

Though in the past, the professional paleontological community has criticized fossil management in some NPS units, today park managers are taking a more active role in protecting fossils. They are conducting more law enforcement operations and encouraging further research. NPS-77 states:

> Paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and developed for public enjoyment, interpretation, and scientific research in accordance with park management objectives and approved resource management plans.
>
> Paleontological research by the academic community will be encouraged and facilitated under the terms of a permit. . .

Over the next few years the National Park Service must recognize critical issues in managing federal lands that contain paleontological resources. The Park Service will need to develop strategies to combat fossil theft, given the difficulties of protecting large expanses of fossiliferous exposures in remote areas with limited staff.

As part of the NPS paleontology program, increased staff training will be necessary for informed decision making and planning. Specialized training for fossil theft investigation should be available (similar to the ARPA training provided by FLETC), and an interagency paleontological theft investigation team should be established. A paleontological theft database should be developed to identify some common denominators of resource theft. Future staffing should include at least one professional paleontologist at the Washington or a regional office level to help support planning and funding of the paleontology program. Thus far, the success of the NPS Paleontology Program has been due to the efforts and insights of a few dedicated paleontologists in the park service.

Work on inventorying national park system units for paleontological resource information will continue to expand the NPS paleontological resource database. The publication *Park Paleontology* will help to keep federal land managers and paleontologists in contact with each other. Continuing the Paleontological Intern Program at a number of parks will enable students to gain valuable field, museum, preparation, and resource management experience. A fourth fossil resource conference will be held in the fall 1994 at Florissant Fossil Beds National Monument.

The National Park Service has taken the lead among the various land management agencies in developing a paleontology program. Through continued dedication, increased interagency cooperation, and potential new legislation, the NPS Paleontology Program will grow even more than in previous years.

Interpreting Paleontological Resources: Personal Services

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Fossils and paleontology are a paradoxical challenge to interpreters. Fossils are familiar and attractive, appealing to children of all ages. At the same time, paleontology is viewed as esoteric and inscrutable, its students widely perceived as eccentrics. This dichotomy can be made to serve interpretation. Exhibits, dioramas, mounted specimens, and audiovisual presentations are all immediately attractive to visitors, but invariably leave them with many unanswered questions. Media, then, becomes the perfect precursor, preparing visitors for direct communication with the interpreter.

A key element of interpretive interaction is initial contact. In the first minute or two the interpreter will evaluate where the visitors are coming from and where the interpreter can likely expect to take them. Limited information can be gleaned from large groups, such as those attending an evening program. Such groups are so heterogeneous that the interpreter must present a hierarchy of information in the program with the hope that most visitors will be neither bored nor left behind. Luckily, many paleontological parks have moderate visitation, often allowing interpreters to engage small groups, families, or individuals. These contacts allow the interpreter to assess the visitor and plan how sophisticated the interaction can be so that the most meaningful interpretation takes place.

Methods

Fossils lend themselves to the full range of personal interpretive services. Guided hikes, regularly scheduled talks at fixed stations, roving contacts, school programs (both in-park and in-school), informal contacts in the visitor center, demonstrations, and living history presentations are all used to communicate with visitors. Each possibility has advantages and disadvantages.

Guided hikes usually lead into the fossiliferous strata or overlooks. Hikes are pleasant as active, outdoor activities but depend heavily on the weather. Most fossil terrain is hot and dry during the peak visitor season, and can be muddy and slippery when wet. Exposure to the parent rock offers the opportunity to demonstrate just how subtle fossil occurrences really are--even in exceptionally rich deposits. This site is excellent for explaining the process of prospecting, field data collection, and excavation.

Scheduled talks at fixed stations provide a reliable, predictable daily offering for visitors. Scheduled talks also offer the opportunity to watch sensitive areas where visitor activity may need monitoring. Traditional programs such as campfire and campground talks, amphitheater presentations, and slide shows have the advantage of reaching large audiences. These talks can appear to be cost-effective. The disadvantage of such interpretation is that the level of presentation necessarily drifts downward and sometimes accomplishes little besides painting the big picture.

Roving interpretation can be extremely valuable. This method allows closer interaction with small groups and offers the best opportunity for the interpreter to tailor the message to the audience. In addition, roving patrol provides random oversight and security in the field--a distinct advantage in these days of personnel shortages. Though denied the technical support of exhibits or audiovisual equipment, the wise interpreter will always have a few teeth, a bit of fossil wood, or a small compression in a pocket or day pack to bring the subject to life.

School programs, both in and out of the park, are a critical element of the interpretive program. Here, the fact that the interpreter is addressing an instructional cohort following a prescribed course of study guides the nature of the contact. The key elements are that the presentation support teacher-established instructional objectives and that the interaction, from previsit through postvisit, not place an unnecessary additional burden on the teacher (who is probably already overworked). The teacher is, however, a full member of the instructional or interpretive team. The teacher and interpreter should cooperate closely, red tape must be kept to a minimum, and special materials and preparatory work should be jointly planned.

Demonstrations offer a unique opportunity to bring fossils to life. A basic challenge to interpreting paleontology is overcoming a habitual preconception of many adults that since fossils are dead, they are mute and unimportant, and that fossil study reached its zenith a hundred years ago and is now only interesting from a historical perspective. Interpreting the ongoing activity of a paleontology laboratory gives visitors a look "behind the exhibit cases" at who paleontologists are, what they do, and how they get the evidence that drives the science. Paleontology labs are noisy, smelly, and dusty--and real. Kids love watching demonstrations because something is happening.

The single most important aspect of this activity is how we handle fossils. Visitors quickly judge the importance of paleontological materials by watching how the staff treats them. Whether the specimens are invaluable holotypes, culled pieces on the touch table, or fragments discovered on a guided hike, visitors will imitate our behavior regarding resources. Therefore, worthless specimens do not exist--and none should be treated as junk. Even the chip along the trail should be attentively replaced after it is used to illustrate a point. Show-and-tell materials taken into the field should be properly handled. Placing a sheet of soft paper between the halves of a compression and slipping it into a plastic bag is a simple matter. Seeing the specimen carefully unpacked in the field may be a stronger resource protection message to the visitor than the discussion that accompanies its display.

The same can be said for situations where specimens are consumptively used or offered for sale. At times, specimens may be used consumptively to make a valid interpretive point, but this situation must be a conscious, well-thought-out decision that the audience clearly understands. The bottom line is that the interpreter did not destroy the specimen because it had no value, but because the value of the learning experience for the visitor outweighed the loss. At John Day Fossil Beds we occasionally had visitors comment on the inevitable wear sustained by *touch table* specimens. That observation opened the door to communicating about the lower value of specimens devoid of collection data, which are usually unauthorized field collections by well-meaning visitors, or confiscations.

Fossils for sale invariably send an unfortunate message. Seeing fossils for sale in a park is a demonstration, too. No matter how well identified, material offered for sale by concessions will be mistaken for resources inside the park. I recently overheard an irate visitor make such a statement, even though the fossil wood he was holding was clearly marked, "Product of Brazil." Sufficient opportunities usually exist for collectors to make purchases in gateway communities. Avoiding semblance of impropriety and hypocrisy is far better than selling fossils to visitors.

Living history and costumed interpretation programs offer an opportunity to recapture some of the historical flavor of the golden age of paleontological exploration in North America, roughly the 1860s through the 1920s. These presentations are popular with visitors since they touch on many attractive themes: the pioneer spirit, cowboys and Indians, and the exploration of the Old West. We must ensure, however, that we understand the difference between these two kinds of presentations.

Costumed interpretation consists of one or more interpreters in period dress, usually surrounded by period accoutrements, providing an interpretive program in third person. The interpreters' clothing and equipment are replicas that are similar to those used historically and explain how early researchers did their work. Old photographs and publications are often shown, and historical perspectives are explored and compared with present knowledge. The interpreters identify themselves as modern-day employees of the National Park Service.

Living history presentations are different. This form of interpretation is much more akin to theater and is presented in first person. The interpreter is also clothed in period dress and operates within a set of period equipment, but acts the role of a historical person. The character assumed can be an actual person known to have been present at the resource or a composite of several individuals. All elements of the presentation are in character. The interpreter does not relate to any objects or information beyond the period world of the character portrayed, and answers all questions in the context of the personality and period knowledge of that character. A uniformed moderator is highly recommended to introduce the presentation and explain the premise to the audience. Without this vital link to the modern world, the audience is often lost and confused--and sometimes alienated. A further complication is that the living historian presents the body of knowledge regarding the fossil resource and paleontology in general that is valid and current only in the historical context of the character portrayed.

Costumed interpretation is much less demanding and less confusing. The interpreter can directly compare modern and historical equipment, techniques, and knowledge, thus clarifying present and past ideas and clearly explaining the premise and scope of the presentation. Both of these program types must have sound themes, goals, and objectives. Living history, especially, should be selected only if it fulfills a management need not accomplishable using other techniques.

Informal interchange at the visitor center is certainly one of the most effective methods of interpreting fossils. This method can be described as an "indoor roving" assignment, which offers some of the best opportunities to contact visitors one-on-one. Picking up on a chance comment made by a visitor examining an exhibit can lead to a rich and personalized interpretive episode, using visitor center displays as instructional aids. We miss an important opportunity if we consider our exhibits to be completely self-service and look at a visitor center as a cash register with an interpreter attached to it.

Topics

Our resources vary widely, and their particular nature suggests the best mix of subjects and methods for interpretation. Story lines usually fall into the broad categories of either ancient environments and life-forms or the science and history of paleontology. Within these categories, certain topics common to all paleontological resources offer convenient points of departure.

Fossils are Familiar. Almost everyone was hooked on dinosaurs as children. Some of us never lose the excitement that ancient life-forms first inspired. For many, that excitement lies dormant, waiting to be rekindled. Fossil interpretation should offer an opportunity for adults to rediscover that excitement and for parents to share that excitement with their children.

Fossils are Exotic. Ancient worlds and strange beasts, which are consistently popular topics in art and literature, are some of the most powerful images in our culture. These images are fantastic to the point of pure escapism, yet are as real as the concrete physical remains upon which our knowledge of them is based. This dichotomy represents a tremendous opportunity to enhance visitors' understanding of the world around them by using illustrative materials that are anything but commonplace.

Fossils are Controversial. Evolutionary biology is still a cultural hot button. Strong emotion is inherent in the way people view their identity and their place in the cosmos, stimulating great interest in paleontological resources. The interpreter's challenge is to channel this interest into a desire for personal investigation and exploration, and to fulfill this desire with the most information possible.

Fossils are Inscrutable. Many people love a detective story. Geological time, evolutionary theory, and biological systematics are nebulous concepts to most of the visiting public. Most will admit that the scientific method is a keystone of our civilization, yet few understand what science is or how it works. The disciplines associated with paleontological resources are far removed from everyday experience yet are the subject of considerable conjecture and sensationalism in public media. Clear, careful presentation is an absolute necessity if understanding is to be fostered and confusion avoided.

Paleontologists are Inscrutable. Scientists who study fossils are often characterized as the epitome of eccentricity. Thanks to Hollywood and Gary Larson, the visiting public often come to the park expecting to find an enclave of absent-minded professor types. This stereotype actually offers an excellent take-off point to interpret contemporary paleontologists and the work they do. The goal is to lead visitors to an understanding of the real nature and complexity of paleontological research, thereby dispelling the mad scientist stereotype.

Fossil Resources are Subtle and Fragile. Most visitors do not fully recognize these characteristics of paleontological resources. They see carefully prepared and restored specimens on display and assume that they came out of the ground that way. Such assumptions lead to serious underestimation of the work entailed in studying and curating such materials. It also fuels visitor misconception that, with a little clandestine pick and shovel work, they could find and extract similar specimens in the field. Since an important goal of interpretation is to discourage such misguided prospecting, care should be taken to present the sophisticated methods and expensive technology necessary to properly locate, document, excavate, and prepare fossil specimens. The opportunity to see actual work being done in a laboratory setting is very helpful in this regard. Such activity is also extremely popular with visitors.

Fossils Depend on Associated Data for Value. This key concept is also poorly understood. The popularity of fossils as hobby materials and art objects adds to the confusion. Interpreters who have received unauthorized field collections from well-meaning, excited visitors know the challenge of turning a potential law enforcement situation into a positive interpretive experience. Interpreters should clearly communicate the need for fossils to be unmolested if their scientific value is to be realized. Again, interpreting research methods and curation help to meet this challenge.

Conclusions

People come to parks to get face-to-face with the genuine objects. They are looking for a hands-on experience. These expectations are challenging to managers of resources as fragile and irreplaceable as fossil remains. The excitement and energy visitors bring to a fossil park must be channeled into opportunities for pleasurable learning. Personal services interpretation is the key ingredient to bring fossils to life. The best way to accomplish this objective is to bring paleontology to life. The result is a visitor who not only understands and appreciates fossil resources, but who better perceives the richness, diversity, and value of the everyday world of the present. Fossils are an exciting part of that world. Exciting, dynamic things are happening in your park right now. If there aren't--start some!

An Interpreter's Guide to Creationists

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A 1991 Gallup Poll found that 40% of the American populace believed that the earth was less than 10,000 years old, and that all life was created instantaneously by a supreme being. An additional 47% believed that, though the earth might be millions of years old, life was created by divine action in more or less its present form. Only 9% of those surveyed expressed a belief in the gradual evolution of present species from simpler forms. The remaining 4% were unsure.

No one need believe in evolution, because evolution is not a belief system. Evolution is a scientific theory, a best working explanation of what we observe in the natural world. We in the National Park Service interpret paleontological resources based solely on current evolutionary theory because we are enjoined by the First Amendment to the Constitution against propounding a religious view--any religious view. This basic tenet is sometimes challenged with the contention that *scientific creationism* is an alternative scientific theory or, conversely, that evolution is itself not a scientific theory but a religious belief. Both of these contentions have been judged without legal merit in federal courts.

The scientific method proceeds from the premise that the natural world is rational and that reality can best be ascertained by observing the world, posing hypotheses suggested by those observations, gathering verifiable evidence, and testing those hypotheses against the evidence. Science intentionally declines to consider supernatural explanations to answer questions for which definitive verifiable evidence is not available. As a scientific theory, Neodarwinian evolution is subject to the following tests. It must be:

1. Guided by natural law
2. Explanatory by reference to natural law
3. Testable against the empirical world
4. Tentative and subject to revision
5. Falsifiable

Scientific creationism fails these tests and displays a number of stigmata characteristic of pseudoscience, including:

1. Anachronistic argument
2. Preoccupation with mystery
3. Acceptance of myth as evidence
4. Selective use of data
5. Irrefutable hypotheses
6. Argument from spurious similarity
7. Explanation by scenario
8. Research by exegesis
9. Refusal to revise in light of valid criticism or new evidence
10. Implying dualism where none exists

This list is not a comment on the value of creationism, or any religion as a valid belief system. These criteria simply verify that creationism is not science.

Anachronistic Argument. This tactic is used to claim that current theory is false by referring to outdated arguments, usually in a disparaging way. People may believe that evolutionary theory is unsupported. Darwin himself admitted he could not explain why individual organisms vary, yet evolution presupposes this variation. In fact, the mechanisms by which individuals vary are now well-understood.

Preoccupation with Mystery. This characteristic is used to cast doubt in general. All theories are incomplete, and so exceptions (or seeming exceptions) to the theory are used as reason to throw out all evidence. People ask, how does the DNA molecule direct the development of a single fertilized cell into a complex organism? It is incredible to say that a foot cell somehow knows it is supposed to be a foot! This concept is very mysterious. Therefore, all concepts are all mysterious. Therefore, we cannot say we know a thing about how this miracle called life works. Life must be a product of divine creation. In science, however, unexplained data are always with us. Over time, we solve some of these conundrums. Others arise, and these are eventually explained. This is how science works.

Acceptance of Myth as Evidence. People reason that millions of people believe that the earth is only 10,000 years old. That many people just can't be wrong. Therefore, the Biblical story of creation must be true. This idea is an example of classic nonscientific reasoning. Many people believe that frogs cause warts. This belief does not provide any evidence that they do.

Selective Use of Data. Data must be accepted or rejected on the basis of validity; that is, its collection is free of bias, inaccuracy, etc. Data cannot be selected simply because they support your argument where other equally valid data do not.

Irrefutable Hypotheses. Another belief is that God produced these things scientists call fossils and purposely gave them the appearance of age to test one's faith. How can such a supposition possibly be verified or disproven? For a theory to be scientific, some definable evidence must exist, which, if it were observed, would prove the theory false. With creationist theories, no evidence can be found.

Argument from Spurious Similarity. This reasoning uses faulty metaphors to cloud issues. For example, flood catastrophism is just an alternate interpretation of sedimentology. In fact, no connection exists between the idea that the sedimentologic record is the result of a single catastrophic flood and the many, long-accepted principles of the science of sedimentology. These ideas both address the same chunk of the natural world, but that is the only common ground.

Explanation by Scenario. This characteristic postulates unproven or unprovable prior conditions for arguments that appear to bolster an unsupported position. Some people may reason that if the "waters above and the waters below" mentioned in the Bible means that there was a membrane surrounding the earth in the upper atmosphere that held up vast reserves of water, then it is a simple matter to see how the Noachian Flood happened, even though not enough water existed on earth to cover all land. These kinds of arguments take off from a hypothetical concept and build castles in the sky from there. A basic scientific principle is that theory must advance on proven evidence. Myth or creative interpretation of mysterious phraseology in ancient texts cannot stand on its own.

Research by Exegesis. This argument confuses scientific writing with scientific evidence. "Creation research" is done by examining scientific statements or simply statements by scientists, as if they are intended to be viewed as scripture. An example would be to cite the opening statement of this paper, "No one need believe in evolution . . ." as a scientific opinion. In this arena, the words become all-important, rather than the meaning of the words.

Refusal to revise in light of valid criticism or new evidence. This characteristic is related to the appeal of myth and selective use of evidence. When a statement is made, it is considered immune to criticism. The burden of proof is pushed onto the audience, rather than the speaker. Even when ample evidence is cited to refute it or supporting data is never provided for confirmation, the statement is taken to gain credence by virtue of repetition and historical longevity. This process is antithetical to the scientific method, in which theory and evidence together are the units on which scientific arguments are built.

Implying Dualism Where None Exists. Creationism often presents (or misrepresents) a scientific argument in the context of either being believable through scientific theory or through belief in God. The premise is that just two sides of the argument exist and you must pick one or the other. The corollary to this belief is that if any aspect of evolutionary theory can be proven false or just shown to be incompletely understood, then creationism is thereby proven true. No such dualism exists in science, in which multiple working hypotheses are the rule rather than the exception and negative evidence carries no weight.

Interpreters and scientists often fail to communicate with creationists because some or all of the parties involved do not recognize the enormous gulf between their diametrically opposed philosophies. The paleontologist proceeds from a rational, mechanistic, empirical position and may find little common ground with the creationist, for whom the acceptance of infallible doctrine is a founding premise. The best tactic for the interpreter is to recognize the philosophic divergence up front, celebrate the democratic heritage that protects and separates both points of view, and discuss relative positions in as open and forthright a way as possible. The prime objective must be maximal exchange of observation and opinion in an atmosphere that permits both parties to maintain self-respect. The most successful interpreters are patient, well-informed, and realistic in their expectation to effect change. Interpreters intent on winning by debate are likely to become frustrated, angry, and ineffective.

To the creationist, armed with a perception of certainty, the eternally contingent world of science is equally frustrating. This differing perception can cause conversation to devolve into a personal attack on the interpreter, replete with accusations of impropriety, conspiracy, and even immorality. No interpreter is obliged to absorb that kind of punishment. A number of tactics can be used to depersonalize such an encounter. In a government setting, the most direct method is to reaffirm your legal responsibilities under the First Amendment. A pragmatic tactic is to check your watch, state your duty to other visitors, and simply break off the contact. When additional staff is available, interpreters should recognize conversational gridlock and rescue the afflicted party. Experience has shown that encounters that approach personal attack often involve young, less experienced, female interpreters, and older, male creationists. A wise supervisor will provide training and preplanning to help staff extricate themselves, and each other, from such situations.

In the fundamentalist world view, science is pilloried from both sides. Science stands accused of overstepping its bounds by subverting the public with a philosophy sometimes described as "godless humanism," yet at the same time is reviled because it offers no guidance or direction for making moral decisions. Since "witnessing for the faith" is a component of some fundamentalist religious groups, we can expect sites of paleontological interpretation to be targets of such activity. This situation occurs because paleontology is sometimes viewed as less empirical and more philosophical than other scientific disciplines. It is unlikely, though not impossible, that fossil resources will become sites of contention similar to family planning clinics. Nonetheless, we will always be viewed as more suspect than hydro-electric plants, automobile factories, and experimental farms (though such places rely no less on the scientific method to yield their products).

As technology becomes more and more marvelous, a finer and finer line seems to exist between the marvelous and the miraculous. As the phrase "anything is possible" moves closer to reality on the material plane, we mistakenly assume this to be similarly true on the philosophical plane. On the contrary, a rather inverse relationship exists between the two. We are able to achieve technical breakthroughs only because we have an increasingly specific understanding of the dynamic physical principles that determine the possible, and we are able to integrate specialized knowledge across disciplines to solve problems. Paleontological parks offer the opportunity to discuss science in a setting where science is actually at work on resources that young and old alike find fascinating. This opportunity to introduce visitors to science in action is an important element in continuously exploring and celebrating our natural and cultural heritage.

In Others' Words

A belated discovery, one that causes considerable anguish, is that no one can persuade another to change. Each of us guards a gate of change that can only be unlocked from the inside. . .

At some point early in our lives we decide just how conscious we wish to be. We establish a threshold of awareness. We choose how stark a truth we are willing to admit into consciousness, how readily we will examine contradictions in our lives and beliefs, how deeply we wish to penetrate. Our brains can censor what we see and hear, we can filter reality to suit our level of courage. At every crossroads we make the choice again for greater or lesser awareness.

Marilyn Ferguson
The Aquarian Conspiracy

Education must, then, be not only a process that transmits culture but also one that provides alternative views of the world and strengthens the will to explore them.

Jerome Bruner
On Knowing

. . . The lack is not in intelligence, which is in plentiful supply; rather, the scarce commodity is systematic training in critical thinking.

Much of human history can, I think, be described as a gradual and sometimes painful liberation from provincialism, the emerging awareness that there is more to the world than was generally believed by our ancestors.

. . . we do not advance the human cause by refusing to consider ideas that make us frightened.

Carl Sagan
Broca's Brain

Suggested Reading

(With a tip of the hat to Ted Fremd for John Day Fossil Beds National Monument library access.)

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Paleontology, Sedimentology, and Paleoenvironments of Eocene Fossil Lake: Field Trip Guide

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The organizers of The Third Conference on Fossil Resources welcome you to our one-day field excursion. After 2 days of sitting and attentively listening to speakers discuss NPS policy, we would like to get the conference participants out in the field to see some real rocks and fossils.

Our goal is to provide a basic understanding as to why Fossil Butte National Monument and the surrounding area is paleontologically and geologically significant. Both the rocks and fossils we will see provide important clues to depositional processes and the paleoenvironments of 50 million years ago. The field trip will last all day and we will travel by bus to various parts of Ancient Fossil Lake (see map in Figure 1 on the following page).

We are fortunate to have two respected scientists lead this field trip:

Dr. H. Paul Buchheim, a geology professor at Loma Linda University, specializes in lacustrine sedimentology and paleoenvironments. He has worked in Fossil Basin for 15 years and has published several papers on the deposition and paleoenvironments of Fossil Lake.

Dr. Lance Grande, a curator of paleontology at the Field Museum of Natural History in Chicago, specializes in morphology and evolutionary systematics of fossil and living fishes. He also teaches at the University of Chicago and the University of Illinois. Lance has done research in Fossil Basin for the past 15 years and has published several papers on the topic.

Special thanks also go to Tom Lindgren and Rick and Gael Hebdon for the use of their quarries and to the Kemmerer School District for the use of their buses.

Introduction

Fifty million years ago, three sizable freshwater lakes covered over 87,000 sq. km or 34,000 sq. mi. of what is today southwestern Wyoming, northwestern Colorado, and northeastern Utah (Schaeffer and Mangus 1965). The North American Plate was slightly south of its present-day position and many of the modern-day mountain ranges had not yet been uplifted. The overall global temperature was generally

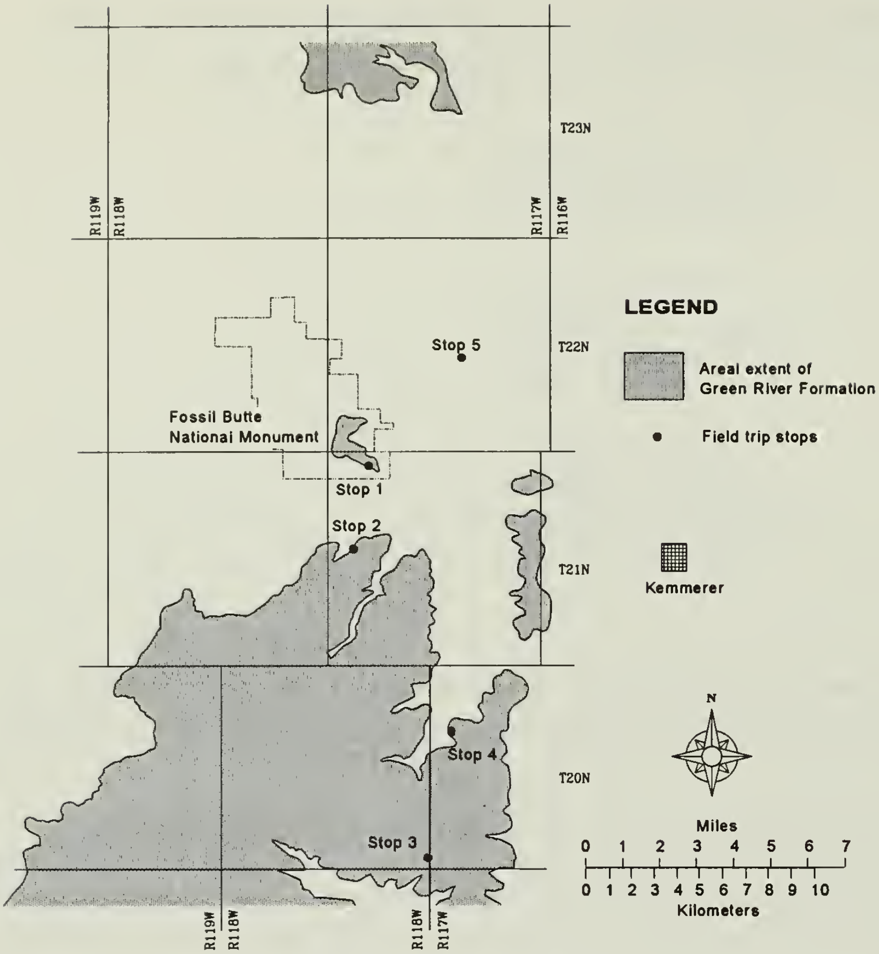

Figure 1. Map of field trip stops and associated geology.

higher during this time period. Due to these factors and a significantly lower elevation, parts of Wyoming, Colorado, and Utah enjoyed a moist subtropical climate, not unlike what is found in the Everglades today. The depositional product of these subtropical and largely freshwater lakes is the Green River Formation (Grande 1984).

Fossil Butte National Monument and the other listed field trip stops are within the ancient boundaries of Fossil Lake, the smallest and shortest-lived of the three Green River Formation lakes. At various points in its history, Fossil Lake contained an incredible variety of fauna and flora, including crocodiles, birds, bats, palms, and several species of fish. The fine-grained sediments, quiet waters, and rapid rates of deposition helped to make possible the detailed preservation of some of the most beautiful fossils in the world.

Because of the excellent preservation of both the fossils and the lake sediments, Fossil Lake has been studied extensively. The fossil fish fauna was first described in detail toward the end of the 19th century (e.g., Cope 1884). Other workers have followed with further systematic descriptions, including the most recent papers of Grande (1979; 1982*a*, *b*; 1984; 1985; 1989; in press; Grande and Bemis, 1991). McGrew and Casilliano (1975) and McGrew (1975) dealt with some taphonomical aspects of fossil fishes in Fossil Basin.

One of the first attempts to develop a depositional model for Fossil Lake was completed by Bradley (1948), providing an explanation for the burial and preservation mechanism of fishes at Fossil Lake. Further depositional models of these units were put forth by Buchheim and Eugster (1986) and Buchheim (in press b).

Present-day research at Fossil Butte involves paleoecological studies (lake depth, turbidity, salinity, alkalinity, and temperature) and paleontology (systematics, evolution, biogeography, and community ecology). Many of the present interpretations are based on changes in thickness and lithology of individual rock units. Also, the interaction of deltas and fluvial inlets with the main lake body provides information on lake evolution and dynamics.

Researchers in the past have interpreted thin laminae found in the Green River shales as *varves* or records of seasonal deposition. Recent studies within Fossil Basin indicate increases in laminae number and thickness towards the basin margins (Buchheim and Biaggi 1988). Sedimentation rates appear to be greater toward the shoreline due to an influx of calcium-rich waters delivered from intermittent storm runoff, river inflow, and possibly calcium-rich springs. As the calcium-rich waters came in contact with the alkaline lake water, calcium carbonate precipitated. A model based on seasonal deposition, as stated by the varve theory, does not appear to pertain to all the Fossil Lake sediments.

Fossil Lake has been considered a classic freshwater lake. However, recent studies have indicated that periods of increased salinity occurred during various times in the lake's depositional history (Buchheim *a*--in press). Saline content is based on variations in calcite-dolomite ratio, the mineral content of tuff beds (ash deposits), and oxygen isotopes. In the saline phases of deposition, the diverse fossilized aquatic organisms are absent from the rock (Grande in press).

The lower two-thirds of the lake sequence is dominated by finely laminated micrites (fine-grained limestones) that are interbedded by a number of massive dolomicrites (fine-grained dolomites). The data indicate that Fossil Lake fluctuated from fresh to hypersaline, probably due to sudden freshwater expansions followed by more gradual regressions. The upper one-third of the sequence is composed of massive dolomicrites containing salt casts, indicating that Fossil Lake was quite salty near the end of its existence (Buchheim and Benton 1992).

Itinerary

0.0 Miles

From Eagles Hall, travel west from Kemmerer on Highway 30 across tilted beds of the Wyoming thrust belt. These rocks were deposited over 80 million years ago from a large inland sea extending from Canada to the Gulf of Mexico (Western Interior Seaway). The rocks were severely folded and faulted about 60 million years ago by the mountain-building Sevier Orogeny. These deformed rocks provide the structural basin in which the Green River Formation was later deposited.

Three and one-half miles west of Kemmerer on Highway 30 to the left is the Pittsburgh-Midway Coal Mine. Owned by Chevron, Pittsburgh-Midway is the largest open-pit coal mine in the United States. The mine is approximately 900 ft. deep, and close to 4,000,000 tons of coal are produced annually. The coal is mined from multiple seams within the Adaville Formation, the remnants of an ancient delta that flowed into the Western Interior Seaway. Within this mine, dinosaur tracks and fossilized wood and leaves have been discovered.

11.5 Miles

Stop 1: Fossil Butte National Monument, Historic Quarry Trail

Fossil Butte National Monument was established in 1972 with a mandate to protect and interpret fossils for the public and for research purposes. Much has happened at Fossil Butte in the last 20 years. The development of a new visitor center has helped increase visitation to almost 30,000 per year. The park staff has grown from 2 people to 8 permanent and 5 seasonal employees. A preparation lab and museum storage area have now been added to the park facilities and are managed by the park paleontologist.

Until the monument was established, commercial quarry activity was extensive at Fossil Butte. During the 1930s and early 1940s the Haddenham family quarried fish in the summer and prepared them in the winter. After World War II, Donald C. Haddenham returned to the quarries and collected and sold fish to some of the leading museums and universities of the world. In 1972, Fossil Butte was closed to commercial collecting. The Historic Quarry Trail leads to the Haddenham quarry and cabin.

After a short hike from the parking lot to the first set of terraces, one has a spectacular view of Fossil Butte, the red-banded hills of the Wasatch Formation and the remnants of the town of Fossil in the river valley to the south. To the northeast are the impressive buff-colored cliffs of the type section for the Fossil Butte Member of the Green River Formation. The buff cliffs to the southeast contain the type section for the overlying Angelo Member. A type section contains the original outcrop for which a particular unit was described. In this case the Fossil Butte and Angelo members were defined by Oriel and Tracey in 1970 as two separate units divided by a sandstone tongue deposit of the Wasatch Formation (Figure 2). This definition is not completely reliable because the sandstone tongue does not extend to the northern part of the lake.

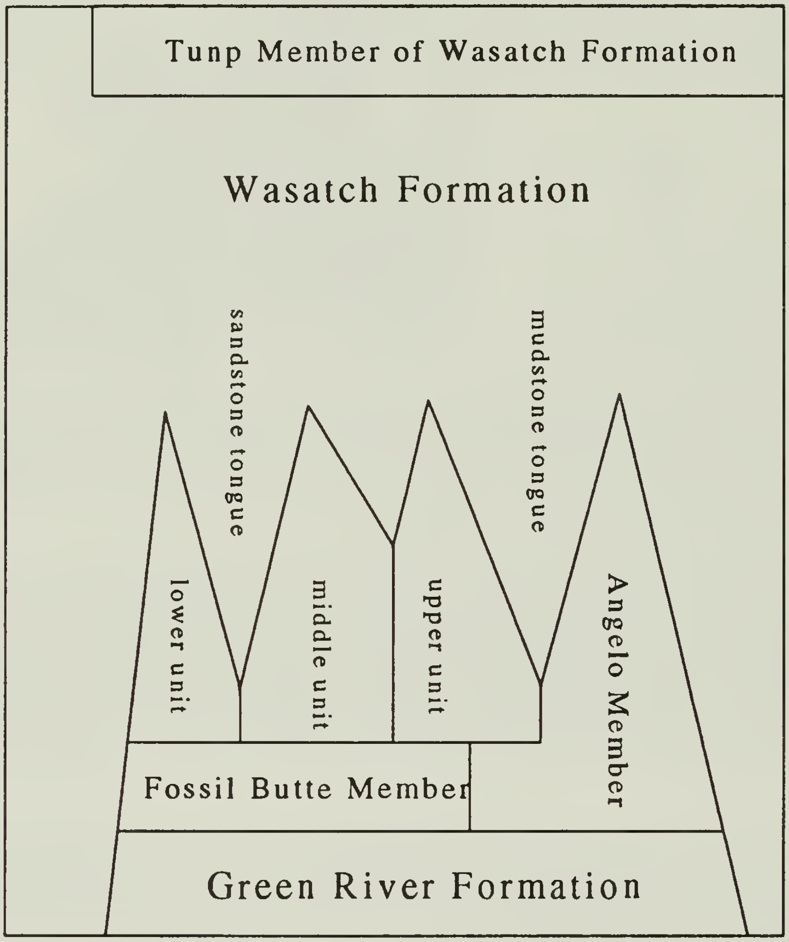

Figure 2. Stratigraphic relationship of the Green River Formation and associated units occurring within Fossil Basin (from Buchheim *a*--in press).

The Fossil Butte Member in turn, has been divided into a lower, middle, and upper unit. The tan-colored talus slopes and the base of the steep cliffs comprise the lower unit. Cyclical sequences of oil shales, laminated micrites, and bioturbated (heavily burrowed) limestones characterize the lower unit. The lower unit was deposited during the freshest stage of the lake.

The middle unit of the Fossil Butte Member is the best developed and is exposed at the Fossil Butte type section. This unit also contains the greatest abundance of fossils and is consequently heavily quarried. A number of distinct lithologies can be found in the middle unit. Laminated limestone with varying percentages of kerogen (organic matter) are interbedded with massive dolomicrites and tuff beds.

Fossil Lake varied from fresh to hypersaline during deposition of the middle unit, but was dominated by generally fresh to mildly saline conditions (Buchheim *a*--in press). Sedimentological evidence (Buchheim *a*--in press) indicates that the lake was more saline nearer its center, becoming fresher toward the margins due to dilution by fresh water. The fresher conditions nearer the lake margins may have been partly responsible for the increased bioturbation in nearshore facies. However, dysearobic to anaerobic conditions nearer the lake depocenter may also have inhibited bioturbation. During lower and middle unit time, fresh to mild saline levels were interrupted by short episodes of hypersalinity.

The most characteristic features of the upper unit are salt crystals, chert nodules, dolomite mineralogy, and a lack of fossils. Beds containing salt casts alternate cyclically with beds lacking these structures. Chert nodules are found near the top of this unit. These structures indicate that the lake was becoming progressively more saline (Buchheim *a*--in press).

The Angelo Member is a continuation of the upper unit in that it is characterized by dolomicrites and dolomitic siltstones and a well-defined chert horizon. Like the upper unit of the Fossil Butte Member, the Angelo Member contains a sparse fossil population.

We will explore these lithologic units in more detail at stop 2.

No mileages are given past this point. This field trip was conducted with the permission from the commercial quarries and private landowners. If you would like to visit these areas, contact the specific landowner or commercial quarry operator.

Stop 2: Lewis Ranch Property, Thomas Lindgren Quarry

Tom Lindgren is the owner and operator of Green River Labs, Inc. and has been in business for about 6 years. His quarry, located on Fossil Ridge, was once operated by Robert Lee Craig, an early quarrier who dug and prepared fossil fish in the early 1900s. The Lindgren Quarry contains an almost complete exposure of the middle unit of the Fossil Butte Member.

Our goal at this stop is to look at the stratigraphic section in more detail and discuss some of the paleoecological ramifications. Please refer to Figures 3, 4, and 5 on the following pages for a stratigraphic column and a facies correlation.

The deposits associated with Fossil Ridge were near the center of Fossil Lake at the time of deposition. Later today we will visit the Thompson Ranch Quarry (stop 4), which was associated with nearshore facies at the time of deposition. Based on the two different zones associated with Fossil Lake, these two localities have a very different paleontological and lithological composition.

Towards the center of the lake, there was a definite lack of benthic fauna (Grande and Buchheim in press). Much of this absence was probably due to higher bottom-water salinity in the deeper, more central parts of the lake and/or low oxygen levels, creating a toxic environment for most organisms (Grande and Buchheim in press). However, toxic areas can be ideal environments for preservation. Once a fish died and sank to the bottom, it was relatively free from scavengers and bacteria that normally would have quickly destroyed the carcass. Burial was quick and the chances of eventual fossilization were greater.

Perhaps for the same reasons, fossils of flying insects are more commonly associated with midlake deposits than nearshore deposits. This association could be linked to the decreased number of benthic organisms that normally fed on the bodies of flying insects that fell through the water column towards the shorelines (Grande and Buchheim in press).

In terms of fishes, the genus *Notogoneus* is relatively abundant in midlake deposits and absent from the known shoreline deposits. Also interesting is that 90% of the specimens are over 250 mm in length but the other 10% fall into the 20-40-mm size range. Fish are noticeably absent within the intermediate size range, possibly due to a collecting bias (Grande and Buchheim in press).

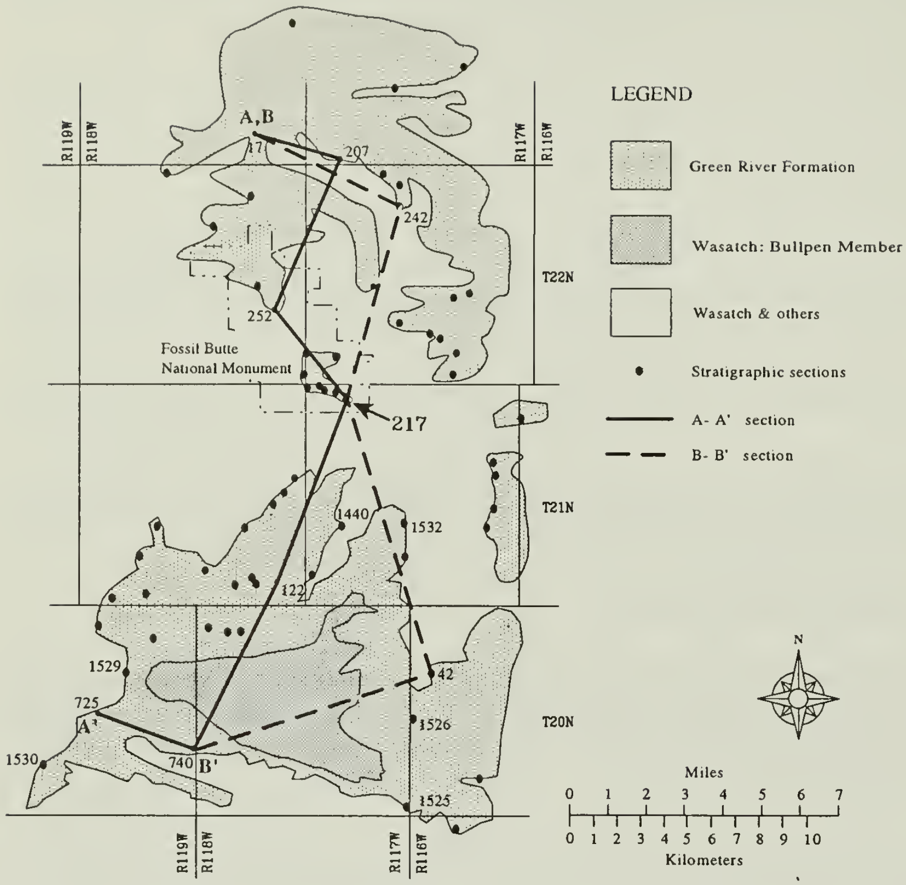

Figure 3. Map showing the extent of the Fossil Butte Member of the Green River Formation and location of measured sections and study locations. See Figure 5 for facies cross section, indicated by cross-sectional line A-A', and Figure 4 for correlated stratigraphic sections indicated by cross-sectional line B-B' (from Buchheim a--in press).

The most common fish genera, *Phareodus*, *Diplomystus*, *Knightia*, *Mioplosis*, *Notogoneus*, and *Priscacara*, were abundant in both nearshore and midlake deposits (see Grande 1984 for a detailed discussion of the listed fish species). However, the juveniles of these taxa, except for *Diplomystus*, were more abundant in nearshore environments (Grande and Buchheim in press).

The lithologies also vary between the nearshore and midlake deposits. Both regions contain laminated micrites, but the kerogen levels are much greater towards the lake center. Due to slower rates and less volume of deposition, the individual laminae are much thinner and less numerous than those found in the nearshore environments (Buchheim *b*--in press). As mentioned in the introduction, an overall thickening of units exists towards the lake margins. Evidence of bioturbation activity also increases towards the lake margins due to a decrease in salinity and/or higher oxygen levels (Grande and Buchheim in press).

The following is a detailed discussion of selected sedimentary units Paul Buchheim will be describing. The numbers correspond to the stratigraphic column found in Figure 6 on page 95.

1. Laminated Clay-micrite Correlative with the Sandstone Tongue of the Wasatch Formation:

   The Sandstone Tongue of the Wasatch has been mapped by Oriel and Tracey (1970) as a thick sandstone that grades northward into siltstone/claystone which alternates with laminated beds composed of alternating clay and micrite laminae (Buchheim *b*--in press). The laminates clay-micrite is interpreted as a pro-delta deposit. The Sandstone Tongue was deposited by a Gilbert-type delta that prograded into the lake basin from the south. The geometry of the delta has provided valuable information on lake depth, shape, and inflow process.

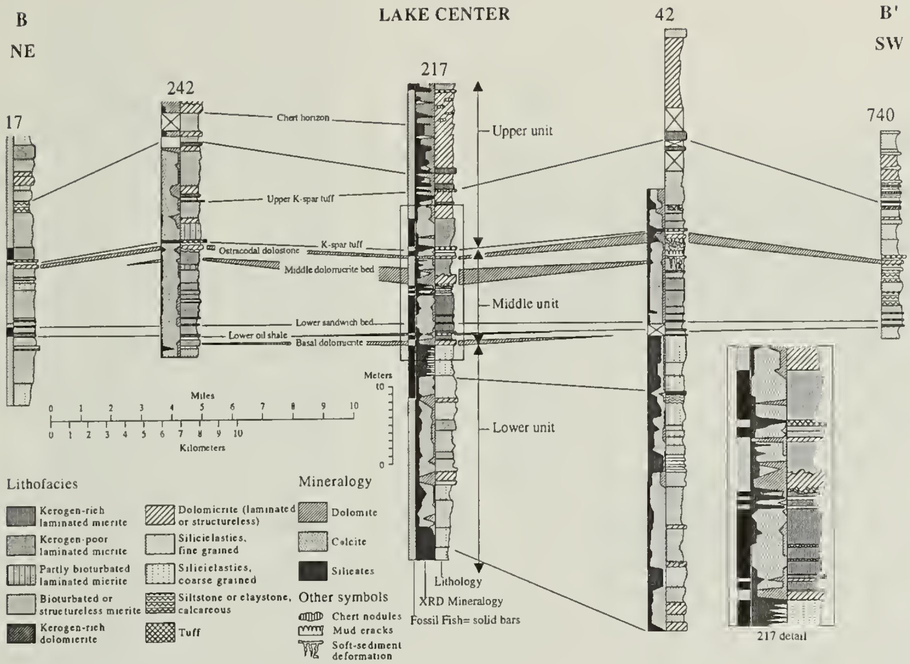

Figure 4. Stratigraphic sections correlated from the northwestern lake margin through lake center to the southern lake margin (from Buchheim *a*--in press).

2. Basal Dolomicrite:

   At the top of the Sandstone Tongue is a massive dolomicrite. Scientists interpret this dolomicrite as having been a shallow hypersaline stage of Fossil Lake. Dolomite is generally thought to be deposited in hypersaline-alkaline lake environments. Interestingly enough, this unit appears to grade laterally into a massive calcimicrite (Buchheim *a*--in press). This relationship has been interpreted as representing a freshening towards the margins of the lake.

3. A dolomicrite which grades laterally into calcimicrites nearer the margins of the basin, indicating fresher lake margins. The dolomicrite indicates hypersaline waters at the lake center.

4. Lower Oil Shale and Coal Unit:

   One of the best-defined and most easily traceable in Fossil Basin, the unit contains an abundance of fishes as well as insect and plant remains and is marked at its base by a coal-to-coaly mudstone. The unit is a dark brown, organic-rich oil shale (kerogen-rich laminated micrite) representing the largest expansion of Fossil Lake and can be traced at least 12 miles south and 10 miles north of Fossil Butte. Deposition followed a significant regression of the lake (represented by the basal dolomicrite).

5. Lower Sandwich Bed and Associated Tuff Beds:

   Buchheim and Biaggi (1988) demonstrated that this unit thickens from about 10 cm at the basin's center to 30 cm at the margin. The tuff is the depositional product of ash erupted from a volcano to the north. As was mentioned in the introduction, laminae counts between these two time-synchronous units indicate that at least some of the laminae are not varves, but were deposited in response to inflow variations (Buchheim *b*--in press).

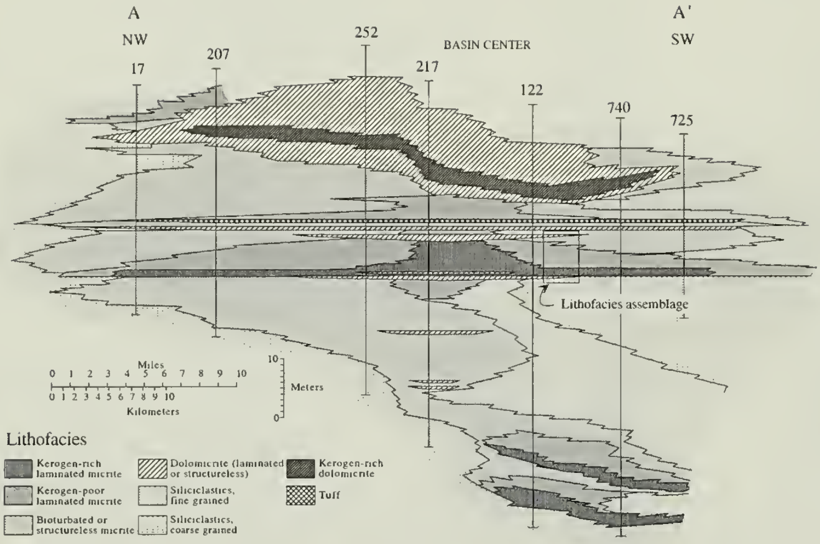

Figure 5. Facies cross section of the Green River Formation, with measured sections indicated by bars headed by locality numbers (from Buchheim a--in press).

6. 18-Inch Layer:

Although this unit contains abundant fish faunas and floras and has been historically quarried, it was deposited during a more regressive stage of the lake than the lower oil shale. The rich fossils of the 18-inch layer were the primary inspiration for establishing Fossil Butte National Monument. The unit is conformably bounded above and below by thin oil shale units (the lowest of which contains abundant plant, insect, and molluscan fossils).

7. Green Mudstone Beds:

Just above the 18-inch layer are four green-to-brown mudstone beds that are curiously discontinuous laterally, making detailed correlation of associated fossiliferous beds difficult. Identification and location of the 18-inch layer has depended largely on the lowest mudstone bed in this group. More recently, precise correlation of this unit has been made possible by a 2 cm-thick tuff near its base. But most importantly, why are these mudstone beds discontinuous? Most sedimentary units can be traced throughout the basin, but these mudstone beds may represent locally derived turbidity flow deposits.

8. Mudstone Bed with Gypsum Veins:

Another mudstone bed between units 7 and 9 which exists at fossil Butte but pinches out about 8 km to the south. It represents turbidites which were deposited within Fossil Basin.

9. Middle Dolomicrite Bed:

A massive dolomite bed similar to the basal dolomicrite that may represent another major regression or contraction of Fossil Lake.

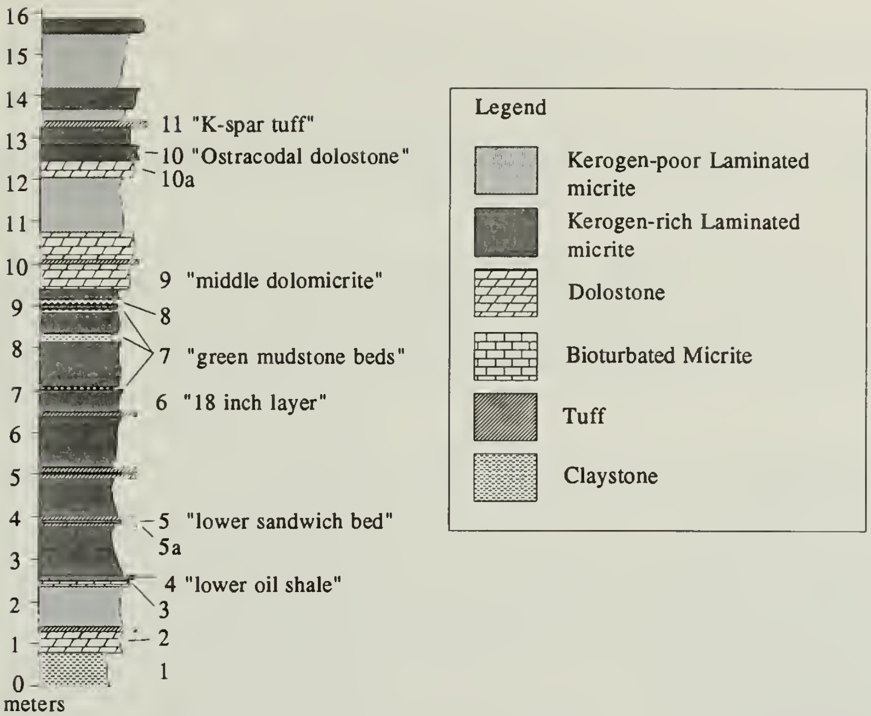

Figure 6. Stratigraphic section illustrating the lithologies associated with the middle unit of the Fossil Butte Member.

10. and 10a. Ostracodal Dolostone:

This unit, as widespread and traceable as the Lower Oil Shale discussed earlier, is basically a coquina of ostracods in a dolomicrite matrix. The parallel relationship of the K-spar tuff (unit 11) to the ostracodal dolostone indicates a nearly flat bottom that was shallow over the entire lake during one period of time. Ostracodal dolostone varies significantly basin-wide in calcite-dolomite ratio, ostracod content, degree of lamination (laminated to massive), and in thickness.

11. K-spar Tuff:

The K-spar tuff is the most easily correlated horizon throughout the basin. The tuff is composed mostly of potassium feldspar, giving it a distinctive pink color. The lower 5-7 cm consist of sand-size particles with abundant biotite. The upper half is essentially clay-size and occasionally contains stringers of sand-size sediments squeezed up from the sandy half. The K-spar tuff represents a short moment in geological time (a few hours to days).

Stop 3: Fossil Bird Site

The fossil bird site is being excavated and studied by Leroy Leggit, a graduate student studying under Dr. Paul Buchheim. His field research area will provide valuable information on the taphonomy (how bones become fossils) of bird bones and depositional environments. The fossil birds occur in an ostracodal limestone within the Angelo Member. The units found here represent a shallow nearshore environment. The fact that a number of relatively complete, articulated bird bones and some skulls are preserved in Fossil Basin demonstrates the significance of this deposit.

Stop 4: Overlook

This stop gives Paul Buchheim a chance to do some serious arm waving (what he does best!). The overlook provides an excellent view of the Angelo and Fossil Butte members of the Green River Formation and the Sandstone Tongue and the main body of the Wasatch Formation. The main divisions of the Green River Formation can easily be seen here. The lower unit of the Fossil Butte Member is the slope above the Wasatch up to the brown sandstone bed. The white cliffs are the middle and upper units. The slope above the cliffs forms the Angelo Member. The overlook provides the opportunity to see the big picture.

Stop 5: Thompson Ranch Quarry

The Thompson Ranch Quarry is owned and operated by Rick and Gael Hebdon of Thayne, Wyoming. The quarry is on the northeast portion of Fossil Basin and provides an excellent opportunity to observe nearshore facies.

In contrast to the lake-center, the nearshore facies contain an impressive amount of crayfish, shrimp, and mollusks. Fossil fish are also represented by two species of stingrays, which are bottom dwellers and more commonly found in nearshore deposits. Juveniles of several fish species are also more common in these types of deposits (Grande and Buchheim, in press).

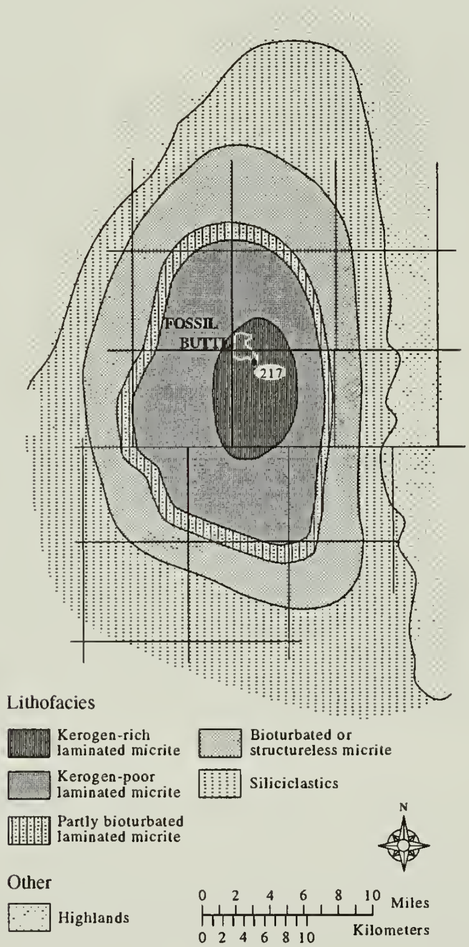

Figure 7. Lithofacies map of Fossil Lake (from Buchheim *a*-in press).

Paddlefishes, which today most frequently inhabit rivers, are rare in all Green River deposits but are relatively more common in nearshore deposits.

As was mentioned at stop 2, deposition rates, salinity levels, and organic content are all quite different in the lake margins. Salinity tends to decrease towards the margins due to an influx of fresh water from the margins that dilutes the existing salts. Because these freshwater streams were saturated with calcium carbonate, they tended to dump their load when they came in contact with highly alkaline lake waters, causing more rapid rates of deposition towards the lake margins (Buchheim *b*-in press). Bioturbation has also increased at the margins due to a decrease in toxic salinity and possibly anaerobic conditions that would discourage biological activity near the lake center (Figure 7) (Grande and Buchheim, in press).

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