National Park Service
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Upper Columbia Basin Network

Paleontological Resource Inventory and Monitoring

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NOTE: This report provides baseline paleontological resource data to National Park Service administration and resource management staff. The report contains information regarding the location of non-renewable paleontological resources within NPS units. It is **not** intended for distribution to the general public.

On the Cover:
Well-preserved skull of the "Hagerman Horse", *Equus simplicidens*, from Hagerman Fossil Beds National Monument. *Equus simplicidens* is the earliest, most primitive known representative of the modern horse genus *Equus* and the state fossil of Idaho. For more information, see page 17. Photo: NPS/Smithsonian Institution.

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INTRODUCTION

Paleontological resources, or fossils, are any remains of past life preserved in geologic context. There are two main types of fossils: body fossils and trace fossils. Body fossils are parts of an actual organism (shells, bones, teeth, plant leaves, etc.) while trace fossils (burrows, footprints, trackways, etc.) preserve evidence of an organism's activity or lifestyle. Fossils are non-renewable natural resources that possess great scientific, educational, and interpretive value.

The establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although more than 170 NPS areas have been identified with paleontological resources, only a small percentage of those parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and NPS Inventory and Monitoring (I&M) Networks, paleontological resource inventories have been initiated in dozens of parks service-wide and are further described in the Methodology and Inventory Strategies section. This report presents paleontological resource inventory and monitoring data compiled for the parks of the Upper Columbia Basin Inventory and Monitoring Network (UCBN).

The Upper Columbia Basin Network includes nine National Park Service areas in four states as shown in Figure 1: Big Hole National Battlefield (Montana), City of Rocks National Reserve (Idaho), Craters of the Moon National Monument and Preserve (Idaho), Hagerman Fossil Beds National Monument (Idaho), John Day Fossil Beds National Monument (Oregon), Lake Roosevelt National Recreation Area (Washington), Minidoka Internment National Monument (Idaho), Nez Perce National Historical Park (Idaho, Montana, Oregon, Washington), and Whitman Mission National Historical Site (Washington). All together, the parks of the UCBN encompass over 850,000 acres and hosted nearly two million visitors in FY2004. The parks of the Upper Columbia Basin Network were primarily established to preserve significant cultural resources relating to the native Cayuse and Nez Perce peoples, and Nineteenth Century settlers from the eastern United States. Nearly all the parks' enabling legislation also includes some level of natural resource protection language. While Lake Roosevelt National Recreation Area lacks specific enabling legislation, other documents provide natural resource management guidance at the park. John Day Fossil Beds and Hagerman Fossil Beds are national monuments established primarily to preserve globally significant paleontological resources.

Even though John Day Fossil Beds and Hagerman Fossil Beds national monuments are the only two parks set aside specifically for paleontological resources, fossils are also known from Craters of the Moon National Monument and Preserve and Nez Perce National Historical Park. Geologic formations that have produced fossils outside of park boundaries, indicating the possibility for future discovery within the park, are mapped within Big Hole National Battlefield, Lake Roosevelt National Recreation Area, and Whitman Mission National Historical Site.

The paleontological resources found within the parks of the UCBN are extraordinarily diverse, and in many cases nationally, or even globally, significant. For example, the well-preserved plant and animal fossils entombed within John Day Fossil Beds National Monument form one of the longest and most continuous paleontological and paleoecological records over nearly 40 of the last 65 million years. Hagerman Fossil Beds National Monument preserves plant and animal fossils from the Pliocene epoch (about 3.5 million years old) such as the oldest member of the *Equus* genus, the "Hagerman Horse". Craters of the Moon National Monument and Preserve contains both the oldest (approximately 340 million year old worm burrows) and among the youngest fossils (tree molds in lava up to 16,000 years old) known from the UCBN parks. In addition, the tree molds found in the basalt represent a rare occurrence of fossils associated with volcanic lava. Significant fossil discoveries have also been made in Nez Perce National Historical Park. For example, the Tolo Lake mammoth site produced one of the most complete mammoth skeletons in Idaho, archeological excavations at Spalding uncovered associated faunal material, and well-preserved Miocene plant fossils found near White Bird Battlefield were described by paleobotanists in the 1920s and 1930s.

Taken together, the paleontological resources of the Upper Columbia Basin Network contribute much to a greater understanding of the history of life on earth. Continued paleontological resource inventories will serve to expand this ever-widening base of paleontological knowledge represented throughout the National Park Service. Although more than 170 parks have already been identified as containing paleontological resources, much of what is to be known about the history of life on earth remains to be discovered.

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May 2005

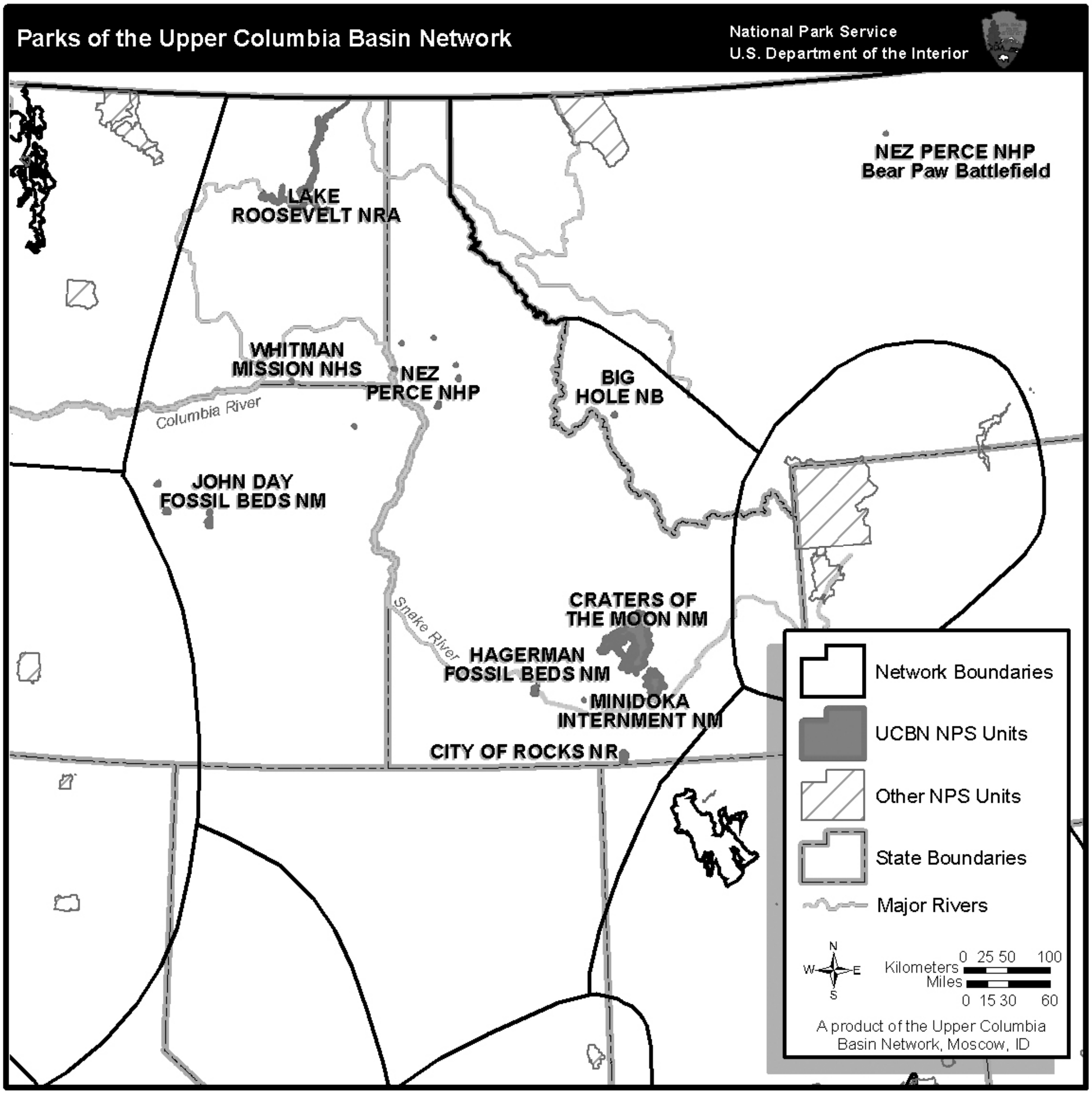

Figure 1: Regional map showing the location of Upper Columbia Basin Network parks.

NATIONAL PARK SERVICE INVENTORY STRATEGIES AND METHODOLOGY

In order to better document fossil occurrences and to provide baseline paleontological resource data in National Park Service areas, the NPS Geologic Resources Division (GRD) and the NPS Inventory and Monitoring Program (I&M) have established three paleontological resource inventory strategies. These strategies include: comprehensive park-specific paleontological resource inventories, service-wide thematic paleontological resource inventories, and Inventory & Monitoring Network based baseline paleontological resource inventories, each established with their own goals and objectives. An article outlining basic paleontological resource monitoring strategies and potential threats to fossil resources is presented by Santucci and Koch (2003).

Comprehensive park inventories are designed to identify all known paleontological resources within a single park unit. Comprehensive park inventories involve the assembly of a team of specialists from within the NPS and from educational institutions and cooperators. These specialists work together with the park to identify and address all aspects of the paleontological resources within the targeted park, including resource management, museum curation, law enforcement, and interpretation. The goals and objectives of a park-specific paleontological resource inventory are detailed by Santucci (2000). An important component of many comprehensive paleontological inventories is to provide paleontology-specific training for park staff. Such park-specific comprehensive paleontological resource inventories have been completed at Yellowstone NP (first park to complete inventory), Arches NP, Bighorn Canyon NRA, Death Valley NP, Grand Teton NP, Santa Monica NRA, Walnut Canyon NM, and Zion NP.

Service-wide thematic paleontological resource inventories are designed to compile data regarding specific types of paleontological resources which occur in parks throughout the NPS. The first thematic paleontological resource inventory accomplished was an inventory of fossil vertebrate tracks from NPS areas (Santucci et al. 1998). Through this thematic inventory, a total of nineteen NPS units were identified as preserving fossil vertebrate tracks. Subsequent discoveries have increased the number of parks identified with fossil vertebrate tracks to twenty-five. Another example of a thematic paleontological resource inventory is the inventory of paleontological resources associated with NPS caves (Santucci et al. 2001). Fossils occur in two contexts relative to caves. First, fossils can be preserved in the marine limestones in which caves develop. Second, the remains of Ice Age animals and plants that lived, died or were transported into caves after death, are common types of cave fossils. The NPS Cave Paleontological Resource study initially identified thirty-five parks with cave fossils.

The third paleontological resource inventory strategy is the Inventory & Monitoring Network-based inventory strategy. Network-based paleontological resource inventories are designed to compile baseline paleontological resource data for each of the parks assigned to a particular network. Network-based inventories have been completed for one-third of the 32 I&M Networks including: the Eastern Rivers and Mountains, Greater Yellowstone, Mediterranean Coast, Mojave Desert, National Capital Region, Northeast Coastal and Barrier, Northern Colorado Plateau, Rocky Mountain, Southern Plains, and Southwestern Alaska networks.

The Network-based paleontological inventories are funded directly by the individual networks. Funds are used to provide stipends or salary for contractors, interns, or paleontological technicians who perform data mining activities. The Upper Columbia Basin Network report is unique in that it represents a multi-faceted approach toward the completion of the report. Two interns were provided with stipends to complete data mining for the two major fossil parks found within the UCBN, Hagerman Fossil Beds National Monument and John Day Fossil Beds National Monument. Data mining for the remaining parks and final report assembly was accomplished via a contractor. A brief summary outlining the basic techniques used to put together an I&M Network-based inventory is presented below.

The most valuable component of any paleontological resource inventory is an intensive literature search. Various databases contain citations for geology or paleontology themed publications. GeoRef, established by the American Geological Institute, is the primary database for geology references and contains millions of references from the mid 1700s through today. GeoRef, available in both online or CD-ROM versions, is accessible at many major university libraries. The NPS NatureBib (which supersedes PaleoBib) is an internet-based database for scientific citations presented as bibliographic references. NatureBib is a work in progress and does not yet contain a comprehensive paleontology bibliography. The USGS Library in Reston, Virginia is a premier repository for geologic publications, and houses most of the publications obtained for the network-based paleontological resource inventories. Additionally, museum libraries such as the Smithsonian Institution's National Museum of Natural History, and university libraries provide access to a wide range of geological and paleontological publications. Individual state geological surveys are also excellent sources of information and geologists familiar with local geology and paleontology.

The literature search also includes gray (unpublished) literature searches of individual park files, museum archives, local newspapers, etc. These are often excellent sources of anecdotal information about park resources. In addition to literature searches, interviews with park staff, university faculty, geologists from the USGS and state surveys, and even local amateur geologists or paleontologists can yield information regarding park paleontological resources. These interviews frequently result in capturing data that may otherwise be undocumented and potentially lost or unrecognized.

As part of the bibliographic searches, a search for geologic maps associated with each park is undertaken. Tim Connors, a geologist with the NPS Geologic Resources Division, maintains a database of geological map coverage for many parks in the NPS. In addition, the USGS National Geologic Map Database (NGMDB; see citation below in Additional References section) lists maps for a given geographic area or place name. The NGMDB also provides information on where to obtain maps. Geologic maps show the type of rocks and the associated geological formations present within a park area. These maps, alone, will often indicate the potential for paleontological resources to occur within a park. Fossils are most commonly found in sedimentary rocks such as sandstones, shales, and limestones. Fossils, with few exceptions, are not found within igneous rocks (volcanic, or of molten origin) or metamorphic rocks (mechanically and chemically altered) due to the extreme heat and/or pressure associated with the origin and history of these rock types. The nomenclature for geologic formations can be confusing. The NGMDB also includes a searchable lexicon of valid geologic formation names. This lexicon provides a basic summary for each formation and summarizes current and past usage of the various formation names found in the literature. It also provides an annotated bibliography for each formation. The lexicon is very useful in cleaning up nomenclatural confusion.

The information from all these various sources for each park is then compiled and summarized in a written report and developed into individual datasets. The reports undergo peer review by professional geologists, paleontologists, and staff from each park for accuracy before being submitted to the network. This report is designed to consolidate baseline paleontological resource data for each park to support management operations and decision-making. Therefore, the reports are written in NPS language and in additional to the scientific information, the reports address issues of resource management, protection, and interpretation.

The paleontological resource inventory reports synthesize information regarding the scope and significance of fossils documented from each park. Fossils are assessed and organized based upon taxonomy, stratigraphy, and paleoecology. Taxonomically, paleontological resources can be divided into four groups: paleobotany (fossil plants), invertebrates (animals without backbones), vertebrates (animals with backbones), and trace fossils (evidence of biological activity such as track, trace, burrow, etc.). Stratigraphically, fossils typically have a finite span and occurrence in geologic time (a geologic time scale is included in Appendix A). The period between the first occurrence and final occurrence of a fossil species is referred to as the stratigraphic range zone. Thus specific groups of fossils may be identified directly with a particular stratigraphic unit or stratigraphic range. Likewise, rock units often represent specific ancient sedimentary depositional environments. Paleoecologically, fossil groups may occur primarily, or in some instances only, in specific environmental conditions (temperature, aquatic, terrestrial, etc.). Thus many fossils may be useful as indicators of past environmental conditions. The reports are organized stratigraphically presenting the geologic and paleontologic information chronologically from oldest to youngest. Important fossils documented from localities outside a park are often reported in the park inventory, as this data may indicate the potential for fossils in similar stratigraphic units exposed in park boundaries.

Given the tremendous diversity of past life, the existence of life for over a billion years, and the range of environments that life has adapted, there is a broad spectrum of research interests in paleontology. It is not surprising that most of what is to be learned about the history of life remains to be discovered. Through research, over 170 NPS areas have been identified as containing paleontological resources. However, the paleontological research for a particular park may vary widely from an incidental fossil discovery to over a century of intensive paleontological investigations. The inventory reports include information on the history of paleontological research, descriptions of current cooperative projects, identification of any museum or universities serving as repositories for park fossils, and a comprehensive list of publications related to paleontological research associated with the park. Organizationally, the reports include any and all bibliographies that may be associated to a park's paleontological resources. However, bibliographic data are subdivided in the report into those cited in the narrative (References Cited) and other associated bibliographies (Additional References). The cooperative projects section highlights projects, if any, that the park has funded or supported relating to paleontological resources. Formal datasets are established for known associated paleontological collections, research, or activities.

I&M Network reports such as this one are meant to provide network parks with sound baseline paleontological resource data. These data can then be utilized to stimulate future research, interpretation, education, or resource management projects. The proper management of resources identified through these inventories is mandated by many NPS policies. For example, the 2001 National Park Service Management Policies (§1.4.6) stipulates that paleontological resources are considered park resources and values that are subject to the "no impairment" standard set forth by the NPS Organic Act in 1916. Another legislative protection afforded to paleontological resources is found in the NPS Omnibus Management Act of 1998. Section 207, with the following statement, "Information concerning the nature and specific location of…paleontological objects within the units of the National Park System…may be withheld from the public source", safeguards paleontological locality information from requests under the Freedom of Information Act. Paleontological resource management issues were the subject of a Report of the Secretary of the Interior in May 2000. That report, an "Assessment of Fossil Management on Federal & Indian Lands" summarized a number of principles relating to paleontological resources and their management from a federal government point of view. The report was also prepared in response to a congressional request for an assessment of the need for a unified federal policy on the collection, storage and preservation of fossils and for standards that would maximize the availability of fossils for scientific study. The Paleontological Resources Management section of Natural Resource Management Reference Manual 77 provides guidance and additional information regarding the implementation and continuation of paleontological resource management programs. Links to the above documents are listed in the Additional References section.

Our knowledge of the fossil record is only a good as our previous field season. The potential for new paleontological discoveries is proportionally related to our understanding as managers and stewards of this non-renewable evidence of life from the past. We believe that the baseline information provided in these reports and the resulting increased understanding of paleontological resources will inevitably result in paving the way for future fossil discoveries in NPS areas.

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Geological Society of America: http://www.geosociety.org

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NPS 1998 Omnibus Management Act (paleontological resource summary):
http://www2.nature.nps.gov/geology/paleontology/paleo_5_1/index.htm

NPS Natural Resource Management Reference Manual #77 (paleontology section):
http://www.nature.nps.gov/rm77/Paleo.htm

Assessment of Fossil Management on Federal & Indian Lands: http://www.doi.gov/fossil/fossil.pdf

NPS Geologic Resources Division: http://www2.nature.nps.gov/geology/

NPS Paleontology Program: http://www2.nature.nps.gov/geology/paleontology/

NPS Park Paleontology Newsletter: http://www2.nature.nps.gov/geology/paleontology/news/newsletter.htm

Smithsonian Institution Libraries Catalog: http://www.siris.si.edu/

Smithsonian National Museum of Natural History Dept. of Paleobiology: http://www.nmnh.si.edu/paleo//

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Upper Columbia Basin I&M Network: http://www1.nature.nps.gov/im/units/ucbn/index.htm

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BIG HOLE NATIONAL BATTLEFIELD

Big Hole National Battlefield (BIHO) is a memorial to those who fought and died in the battle of August 9 and 10, 1877. The battle at Big Hole between the Nez Perce and the United States Army was part of the larger Nez Perce War of 1877. The park was originally established as Big Hole National Monument in 1910, transferred to the National Park Service in 1933, and redesignated Big Hole National Battlefield on May 17, 1963. Big Hole National Battlefield was incorporated as a unit of Nez Perce National Historical Park on October 30, 1992.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

As of the writing of this report, there have been no formal paleontological inventories undertaken for Big Hole National Battlefield. Paleontological scoping sessions have likewise not been completed for the park. However, geological scoping sessions, sponsored by the Geologic Resources Division of the NPS, were held at BIHO during spring 2004 (T. Connors, personal communication, 2004).

Ruppel et al. (1993) mapped two geologic units within the boundaries of BIHO, the Tertiary Bozeman Group and Quaternary alluvium. Fossils are known from the Bozeman Group outside the boundary of the park.

Bozeman Group (Eocene, Oligocene, Miocene, Pliocene)
The Bozeman Group is mapped within BIHO on either side of the alluvial deposits of the North Fork Big Hole River. The Bozeman Group is a heterogeneous assemblage of rocks and rock types that have undergone various nomenclatural changes as geologic interpretations have changed over time. Hanneman and Wideman (1991) present a more in-depth summary of these interpretations for valleys east of BIHO, and include a geologic bibliography of the area. In brief, the Bozeman Group is a collection of strata, found in many basins now contained within present-day valleys of southwestern Montana (BIHO is within the Big Hole Basin). Sediment deposition occurred by wind, lakes, streams, and rivers (e.g. Kuenzi and Fields 1971). These strata are generally characterized by light gray to yellowish brown sandstone and siltstone. Interbeds of limestone and pebble- and cobble-sized conglomerate are also known from the Bozeman Group (Ruppel et al. 1993). Bozeman Group strata are often thinly veiled by Quaternary sediments. Some authors have attempted to divide the Bozeman Group into formations such as the Renova and Sixmile Creek formations (Kuenzi and Fields 1971). However Hanneman and Wideman (1991) and Ruppel et al. (1993) note that it is nearly impossible to distinguish the formations in the field.

Most of the extensive paleontological resources known from the Bozeman Group have been found in basins to the east and southeast of the Big Hole Basin. Fields et al. (1985) provides references for paleontological resources, especially vertebrate mammals, found in the Flint Creek, Deer Lodge, Divide, Grasshopper Creek/Horse Prairie/Medicine Lodge, Salmon-Lemhi, Muddy Creek, Sage Creek, upper and lower Ruby River, Beaverhead, Jefferson, Three Forks, and Smith River basins in addition to the Toston area and the Townsend valley. These basins (or valleys) are shown on Hanneman and Wideman's (1991) index map of southwestern Montana. A number of these citations are also listed in the additional references section of this report. Kuenzi and Fields (1971) present a detailed summary of paleontological finds from the Jefferson Basin near Whitehall, MT (about 100 miles east of BIHO).

Overall, the diverse fossil finds within the Bozeman Group reflect the diverse rock types and depositional environments. Fossils of invertebrates, vertebrates, and plants, have all been found in the Bozeman Group. The invertebrate fossils include a wide variety of gastropods (snails), ostracodes (small aquatic bivalved crustaceans), and pelecypods (clam-like bivalved mollusk) (e.g. Kuenzi and Fields 1971; Roth 1986; VanNieuwenhuise and He 1986). The vertebrates are well-represented and have been extensively studied. The mammals in particular are valuable as biostratigraphic indicators and include many taxa such as rodents, rabbits, early horses, artiodactyls, and rhinoceros (e.g. Kuenzi and Fields 1971; Fields et al. 1985 for summaries and additional references). Other vertebrate fossils include fish and a rare amphibian (e.g. Cavender 1977; Henrici 1994). Well-preserved plant fossils have also been found in various beds of the Bozeman Group (e.g. Becker 1973, 1961, 1969). The Ruby Flora, for example, has produced a diverse assemblage of fossil plants including: *Abies* (fir), *Picea* (spruce), *Pinus* (pine), *Metasequoia* (dawn redwood), *Acer* (maple), *Betula* (birch), *Celtis* (hackberry), *Fagus* (beech), *Fraxinus* (ash), *Mahonia* (Oregon grape), *Populus* (poplar), *Ribes* (gooseberry/currant), *Rosa* (rose), *Ulmus* (elm), and *Zelkova* (keaki tree) (Tidwell 1998).

Limited paleontological resources are known from the Big Hole Basin, however. Hanneman and Nichols (1981) reported fossils from 11 localities on the eastern side of the Big Hole Basin, about 15 miles east of BIHO, near Wisdom, MT (Hanneman 1984; D. Hanneman personal communication, 2005). Vertebrate fossils from these localities included turtle, rodent, artiodactyl, *Dromomeryx* sp. (deer-like mammal), *Merychyus* sp. (dog-sized oreodont mammal), small form of

Merychippus sp. (early horse), large equid, and rhinoceros (Hanneman and Nichols 1981). Hanneman and Nichols also noted abundant fossil wood fragments and vertical animal burrows. This assemblage likely indicates a floodplain-channel depositional environment and an early to late Miocene age (Hanneman and Nichols 1981). The presence of such fossils near Wisdom, indicates the potential for similar fossils to be found within BIHO. However, due to the complex structure of the deposits, it is difficult to ascertain whether the fossil producing layers mentioned above are also the same as those within the park. Fossils are not yet known from the area either within or immediately surrounding BIHO (D. Hanneman, personal communication, 2005). The BIHO Chief Ranger also indicates that fossils have not yet been found in the park and that exposures of the Bozeman Group are limited (T. Fisher, personal communication, 2005).

Bozeman Group sediments (Renova Formation) are also mapped within Grant-Kohrs Ranch National Historical Site, about 70 miles northeast of BIHO, near Deer Lodge, Montana (Koch et al. 2004).

Alluvium (Holocene/Modern)
The alluvial deposits mapped within BIHO are essentially modern silt, sand, gravels and floodplain deposits associated with the channels of the North Fork of the Big Hole River. Some of the deposits in the Dillon 1 by 2 minute quadrangle may be Pleistocene (Ice Age) in age, however, there are no associated paleontological resources as described by Ruppel et al. (1993).

COOPERATIVE PROJECTS

- Geologic Scoping of Big Hole National Battlefield – National Park Service Geologic Resources Division (Spring 2004).

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CITY OF ROCKS NATIONAL RESERVE

City of Rocks National Reserve (CIRO) was authorized on November 18, 1988. The park is jointly administered by the National Park Service and the Idaho Department of Parks and Recreation. City of Rocks preserves a unique landscape of granite rock spires and pinnacles which emigrants on the California Trail likened to a "city of rocks". These dramatic features were found to be "worthy of development and deserving of recognition as a National Monument" at least as early as the 1930s (Anderson 1931). Many recreational opportunities, including rock climbing, are available at the park.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

Geologic scoping sessions for CIRO were held on June 16-17, 1999. However, there have been no formal paleontological inventories undertaken for the park. Paleontological scoping sessions have likewise not been completed for the park and there are no collections of paleontological specimens in the park's museum. Most of the geologic units exposed within CIRO offer essentially no potential for future discoveries of paleontological resources. However, the undivided Quaternary sediments mapped within the park (Miller and Bedford 1999) may contain fossils. The geologic history of the area is summarized in a number of publications including Williams et al. (1974, 1982), Armstrong et al. (1978), Doelling (1980), and Miller and Bedford (1999). Unpublished geologic maps have been prepared for the park and are available from CIRO. Both David Miller (USGS, Menlo Park, CA) and Kevin Pogue (Whitman College, Walla Walla, WA) have produced geologic maps of the park and surrounding areas (K. Pogue, personal communication, 2005). Pogue (personal communication, 2005) is also in the process of writing a book describing the geology of City of Rocks National Reserve and Castle Rocks State Park.

Green Creek Complex (Precambrian) and Almo Pluton (Oligocene)
There are two main geologic units that form the distinctive rock outcroppings at CIRO, the Precambrian Green Creek Complex and the Oligocene Almo Pluton. The oldest of these units is an assemblage of rocks informally known as the Green Creek Complex. The Green Creek Complex is characterized by intrusive igneous granites and metamorphic schists and amphibolites. These rocks, approximately 2.5 billion years old, are some of the oldest rocks in the United States (Miller and Bedford 1999). The lower portion of the "Harrison Series" mapped by Anderson (1931) is equivalent to the Green Creek Complex. The Oligocene-aged Almo Pluton is a granite body that was thrust up into the Green Creek Complex while both units were still underground. The granites of the Almo Pluton have been dated at approximately 28.6 million years old (Miller and Bedford 1999). Rocks of the Green Creek Complex are darker than those of the Almo Pluton, making for the stark contrast of the two rock types at the Twin Sisters (National Park Service, n.d.). Fossils are not known from intrusive igneous rocks due to their molten origin and underground emplacement. Metamorphic rocks also do not typically preserve fossils as the high temperature and/or pressure associated with their formation usually destroys any fossils present in the rock.

While the aforementioned rock units themselves offer essentially no potential for paleontological resources, erosional features, such as alcoves, shelters, etc., in the rocks may provide habitat for packrats (*Neotoma*). Packrats often incorporate material such as small bones or plant material in their middens. Undisturbed middens frequently contain important paleontological material dating back thousands of years. For examples of paleontological resources found in packrat middens of caves throughout the National Park Service, see Santucci et al. (2001). Packrat middens have been found within CIRO, but have not yet been methodically examined (J. Vincent, personal communication, 2005). These middens may contain paleontological resources, although further study is required to determine their presence and extent.

Surficial Deposits (Quaternary)
Surficial deposits including alluvial silt, sand, and gravel can be found in many areas throughout the park. These deposits are modern sediments associated with stream deposits and erosion. Paleontological resources are not common in these deposits and none are known from within CIRO.

A natural resources ranger at CIRO reports a curious, potentially paleontological, occurrence of pelecypod (clam) shells and snails within the park. These shells were discovered in the south end of the park between campsite 1 and the Twin Sisters (J. Vincent, personal communication, 2004). The shells and snails have not yet been identified and the source of the material has likewise not been determined. Miller and Bedford (1999) map Quaternary sediments in the area, which Pogue (personal communication, 2005) indicates may overlie the nonfossiliferous Green Creek Complex. Since pelecypods are aquatic, they may have been buried in the sediments of a small lake present during the Pleistocene (K. Pogue, personal communication, 2005). However definitive evidence of such a lake has not yet been discovered. An alternative hypothesis is that the shells were entombed within limestones metamorphosed (altered by high temperature and pressure) into marble when the Almo Pluton was emplaced. Marbles thought to have formed in this manner are found in road cuts north of

Almo, however the degree of metamorphism is high enough that identifiable fossils are not likely (K. Pogue, personal communication, 2005).

Fossiliferous geologic units such as the Mississippian Brazer, Pennsylvanian Wells, Permian Phosphoria, and the Tertiary Payette/Salt Lake formations are all found in eastern Cassia County, north of CIRO (e.g. Anderson 1931). However, the Tertiary Payette/Salt Lake Formation, mapped east of the Raft River about 4 miles southeast of Almo, is the only formation mapped within 10 miles of CIRO (Anderson 1931). While fossiliferous, the only known fossils include fresh-water gastropods and plant fragments (Anderson 1931).

Another possibility is that the shells were transported to that area by another means, perhaps by Native Americans, California Trail emigrants, or through much more recent human activity. Further investigations including a site visit and photographing of the specimens is recommended to determine the source, extent, and identification of these pelecypod shells. The snails may also be modern specimens, as snails are mentioned in the park's resource management plan (J. Vincent, personal communication, 2005).

COOPERATIVE PROJECTS

- Geologic Scoping of City of Rocks National Reserve – National Park Service Geologic Resources Division (June 16-17, 1999).
- Geologic mapping of City of Rocks National Reserve – U.S. Geological Survey (David Miller, 1990s-2000s)
- Geologic mapping of City of Rocks National Reserve – Whitman College (Kevin Pogue, 1990s-2000s)

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DATA SETS

DS-CIRO-XXX City of Rocks National Reserve Paleontological Archives. 5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

CRATERS OF THE MOON NATIONAL MONUMENT AND PRESERVE

Craters of the Moon National Monument and Preserve (CRMO) was originally established as a national monument by President Calvin Coolidge on May 2, 1924. The monument was established to preserve a portion the remarkable lava flows of the Craters of the Moon lava field. In an effort to preserve all three of the lava fields (Craters of the Moon, Kings Bowl, and Wapi) associated with the Great Rift Volcanic Rift Zone, the monument was greatly expanded and redesignated as Craters of the Moon National Monument and Preserve in 2000 and 2002. CRMO is cooperatively managed by the National Park Service and the Bureau of Land Management (BLM). The National Park Service has primary management authority for the exposed lava fields. The BLM monument, a unit of their National Landscape Conservation System, consists of older lava flows, now covered by sagebrush steppe vegetation, surrounding the three younger lava fields.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for CRMO as of the preparation of this report (spring 2005). Likewise, paleontological scoping sessions have not been completed for the park. Scoping sessions for geological resources (May 12-13, 1999) and human impacts on geological resources (August 31-September 1, 2000) have been completed for the park. These scoping sessions were held under the direction of the NPS Geological Resources Division (T. Connors, personal communication, 2004; National Park Service 1999, 2000). Various geologic maps, listed in the references and additional references sections, have been produced for the CRMO area, however most of the maps were produced before the expansion of the monument in 2000 and 2002.

Nevertheless, diverse paleontological resources are known from within CRMO. These resources occur in the Mississippian Copper Basin Formation, and the Holocene (Recent) lava flows and lava tubes. In addition, mammoth bones were found in an unlikely location within the park, described below.

Copper Basin Formation (Mississippian)
The Mississippian Copper Basin Formation is mapped in the northern reaches of CRMO and also just outside of the park's western boundary (Kuntz et al. 1989). The Copper Basin Formation is characterized by interbedded claystones, siltstones, and sandstones.

The dark gray to black claystone displays the trace fossil *Helminthoida* on some bedding planes (Kuntz et al. 1989). Examples of *Helminthoida*, which is interpreted as the burrows of a marine worm, have been found within the park and may be in the park's museum collection (Owen 2003; J. Apel, personal communication, 2005). The presence of *Helminthoida* was noted during geologic scoping meetings held at the park in 1999 (National Park Service, 1999).

Kings Bowl, Wapi, Craters of the Moon lava flows (dominantly Holocene)
The dramatic black basaltic lava flows found within CRMO erupted onto the surface in the three major geologically-young lava fields of the monument, Craters of the Moon, Kings Bowl, and Wapi. Craters of the Moon lava field is the largest, consisting of over 60 lava flows covering over 618 square miles (Owen 2003). All three of the major lava fields are associated with the Great Rift, an extensive volcanic fissure which fed the major eruptions within what is now CRMO. Owen (2003) presents a summary of volcanic activity and the general geology of CRMO and the relationship with the extensive volcanism of the Eastern Snake River Plain and the Yellowstone "hotspot".

Unlike the Miocene-aged Columbia River Basalt Group found within other parks of the Upper Columbia Basin Network (see Lake Roosevelt NRA and Nez Perce NHP sections in this report), the lava flows of the Snake River Plain within CRMO, and Minidoka Internment NM (see MIIN section in this report) are very young. Lava flows within the Craters of the Moon lava field range in age from about 15,000 years to 2,100 years before present. Eight major eruptive periods are documented, each separated by approximately 2,000 years (Owen 2003; Kuntz 1989a). The lava flows of the Kings Bowl and Wapi lava fields are essentially contemporaneous with an age of about 2,200 years old (Owen 2003; Kuntz 1989a).

While paleontological resources are generally not associated with volcanic activity, the lava flows within CRMO have yielded fossils in two contexts: tree molds and vertebrate remains found in lava tubes.

Tree molds within CRMO were first reported scientifically by Stearns (1928) who described the various types of molds and their general locations within the park. There are two basic types of tree molds, true molds of trees and "lava trees". Actual tree molds are impressions in solidified lava that are formed as lava surrounds a standing tree. As the tree is surrounded, it begins to burn which releases water vapor from the tree's sap. This sap rapidly cools the enveloping lava which then solidifies and leaves behind a hollow mold or impression of the charred tree. Both vertical tree molds, where the tree remained standing as it burned, and horizontal tree molds, where the tree fell as it burned, are found in the park (Owen 2003). The deepest of the known vertical tree molds is some 82 inches while the widest tree molds are up to 35 inches (Owen 2003). Impressions of the tree limbs are occasionally preserved (Stearns 1928; Owen 2003). According to Owen (2003), over 100 tree molds have been discovered and mapped in the northern end of the park. The Blue Dragon and Trench Mortar Flat lava flows have the largest number of tree molds (Stearns 1928; Owen 2003), although Stearns (1928) also reports tree molds within CRMO from the "northwest flow from Big Craters", Owl Cavern flow, and the Black flow. Groups of tree molds are indicated on geologic maps by Kuntz et al. (1989a). Carbonized wood has been found in some of the tree molds and utilized for Carbon-14 dating. Carbon-14 dates obtained from this carbonized wood at many localities in the park vary in age from about 15,000 to 1,700 years before present (Kuntz et al 1982; Owen 2003 referencing Bullard 1970). Tree molds are also found in a number of other NPS units including El Malpais National Monument (New Mexico), Lava Beds National Monument (California), Hawaii Volcanoes National Park (Hawaii), and Pu'uhonua o Honaunau National Historical Park (Hawaii).

While tree molds are impressions or hollow molds within the lava, "lava trees" are vertical features rising one to five feet (e.g. Stearns 1928) from the surface of the lava. Lava trees are usually formed from airborne lava spatter from an eruption. This spatter partially buries the tree, leaving behind a thin conical shell of lava above the main lava flow, with the impression of a tree trunk on the interior surface (J. Apel, personal communication, 2005). A number of lava trees are found in the wilderness area of CRMO, with some only 25-30 yards from an unmaintained park trail (J. Apel, personal communication, 2005). The park had erected a sign at this location and created a spur trail to view the lava trees. Stearns (1928) noted the presence of lava trees in the Trench Mortar Flat and Tree Mold Flat lava flows.

Lava tubes are formed when the surface of a narrow lava flow solidifies, and the molten material underneath flows away. This leaves a cave-like space under the solidified surface which can range in size from a few inches in diameter to over 40 feet high (Indian Tunnel) and over 10 miles long (Bear Trap Cave, not continuously passable) (Owen 2003). Over 290 lava tubes are currently known from the park, but the actual number may be closer to 600 according to CRMO geologist Doug Owen (personal communication, 2001, reported in Santucci et al. 2001). The visitor-accessible caves, Beauty Cave, Boy Scout Cave, Indian Tunnel, and Dew Drop Cave are located in the Blue Dragon Flow (National Park Service 2003).

Modern and ancient animals have utilized the now cool and inviting lava tubes as shelters, thus producing a collection of paleontological resources within the park and the surrounding areas of the Eastern Snake River Plain. Miller (1974, 1989) summarizes many of these paleontological resources. Santucci et al. (2001) also summarized known fossil resources from the lava tubes at CRMO. Lava tubes on the Snake River Plain have produced bones of extinct *Mammuthus* (mammoth) and *Camelops* (camel) along with modern specimens of *Ursus* (bear), *Canis lupus* (wolf), *Bison* (bison), *Cervis canadensis* (elk), and *Antilocapra americana* (pronghorn) (Miller 1989). Remains of smaller animals such as snails, fish, reptiles, amphibians, and birds are primarily known from regurgitated owl pellets found in the lava tubes (Miller 1989). Within CRMO, the first reports of bone material found within the lava tubes dates to the 1880s (Santucci et al. 2001). Stearns (1928) also reports bones found within the lava tubes including a buffalo horn in Buffalo Cave. In 1926, the shoulder bone of a cow was discovered in Buffalo Cave with the name of two early explorers (J.W. Powell and Arthur Ferris) and the date 1885 inscribed upon it (Stearns 1928). Other large mammal material has been found in the park including horns and a skull from *Ovis canadensis* (bighorn sheep), a bison skull, various fragmentary limb bones, and an *Ursus arctos* (grizzly bear) skull and femur (D. Owen and J. Apel, personal communication, 2001; reported in Santucci et al. 2001). The grizzly bear material, found just south of the old monument boundary, was temporarily on display at CRMO, but has since been returned to the Bureau of Land Management collections at the Idaho Museum of Natural History in Pocatello (M. Thompson, personal communication, 2005). Additional grizzly bear bones were also found in a cave on the north end of the monument (J. Apel, personal communication, 2005). A school group found what were initially thought to be *Bison* bones in Buffalo Cave. These bones may be from domestic cows, however a conclusive identification is likely not possible without DNA analysis (J. Apel, personal communication, 2005). Indeed, there is frequent difficulty in identifying the sometimes poorly preserved or fragmentary bones found in the lava tubes. This discovery also highlighted the primary method of finding fossils in the park: discovery by park visitors (J. Apel, personal communication, 2005). A large number of these bones are housed within the park's museum collections and are accessioned into ANCS+ (J. Apel, personal communication, 2005).

Lava blisters, isolated bowl-shaped depressions in lava about 8-10 feet deep, also preserve paleontological material on the Eastern Snake River Plain, although such occurrences are not specifically noted within CRMO. These blisters have a small opening and serve as a natural trap where carnivores are lured into the trap by smaller prey, to their eventual death. Remains of the extinct bison, marten, wolverine, and Canada lynx are reported from such lava blisters on the Eastern Snake River Plain (Miller 1974, 1989).

Packrat middens are also found in many of the lava tube features of CRMO and the Eastern Snake River Plain (Miller 1989). Packrats (*Neotoma*) create nests, or middens, containing a wide variety of material from the surrounding area, such as plant material and small bones which are important paleoecological indicators and valuable tools for dating. Santucci et al. (2001) describes a wide variety of paleontological resources found in packrat middens throughout the caves of the National Park Service. Some middens within CRMO are known to contain the bones of microtine rodents (Santucci et al. 2001) although they have not been methodically studied or documented (J. Apel, personal communication, 2005).

While paleontological resources within the lava flows and lava tubes are relatively diverse, and are represented in the park's museum collections, there is not yet an active monitoring program in place. Indeed, many of the specimens currently in the collection were random discoveries by park visitors (J. Apel, personal communication, 2005). The park, however, has mapped the location of many tree molds, lava trees, and lava tubes. The eventual assembly of a detailed inventory of the tree molds, including photographic records, is one goal of the park (J. Apel, personal communication, 2005).

Mammoth bones from CRMO (Pleistocene)
Mammoth bones were discovered at truly unique locality within CRMO in 1995. During a cultural resources survey performed along Goodale's Cutoff Trail (an alternate route that rejoins the main Oregon Trail), a historic trash dump site was located in the northern reaches of the park (J. Apel and G. McDonald, personal communication, 2005). This dump was likely active during the 1920s and 1930s shortly after the establishment of CRMO (G. McDonald, personal communication, 2005). An excavation of the dump revealed a number of large, charred, partially-buried mammoth bones near the bottom of the trash layers. The discovery initially created a large amount of excitement, and a crew from Hagerman Fossil Beds National Monument excavated the remains including a partial scapula and long bone fragments, among other bones (G. McDonald, personal communication, 2005). These excavations were carried out under the direction of HAFO paleontologist Greg McDonald, now Chief Curator of Natural Resources for the NPS. As the excavations continued, it became apparent that the bones were probably not *in situ*, as was initially thought. Because the bones were charred, one initial interpretation was that they were part of a Paleo-Indian kill/butcher site. Such a site is known at the Wasden site, east of CRMO outside of the Idaho National Laboratory. This site has produced both bison and mammoth material in an archeological context dating back 8,200-12,500 years (Miller 1974). However, it is now thought that the bones were charred during trash fires set in the dump in the early 1920s or 1930s. The bones may have come from a gravel pit elsewhere on the Snake River Plain. McDonald (personal communication, 2005) reports that mammoth bones are relatively common in some Snake River Plain gravel pits. How they ended up in a trash dump within a National Park Service unit, and why such large bones would be transported any distance, let alone discarded, is not known. Perhaps a review of park correspondence from the 1920s and 1930s would provide some insight, although no historical mention of the mammoth has yet been found. McDonald produced a short report on the excavation, which is available in the park's files. The bones were stabilized and, where possible, glued back together. The bones are now curated at Hagerman Fossil Beds National Monument (P. Gensler; G. McDonald, personal communication, 2005).

COOPERATIVE PROJECTS

- Geologic Scoping of Craters of the Moon National Monument and Preserve – National Park Service Geologic Resources Division (May 12-13, 1999; National Park Service 1999).
- Geoindicators Scoping of Craters of the Moon National Monument and Preserve – National Park Service Geologic Resources Division (August 31-September 1, 2000; National Park Service 2000).
- Excavation of CRMO Mammoth – Hagerman Fossil Beds National Monument Staff (1995).

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HAGERMAN FOSSIL BEDS NATIONAL MONUMENT

By Michaleen McNerney

Hagerman Fossil Beds National Monument (HAFO) was established in 1988 to preserve the world's richest known fossil deposits from the late Pliocene epoch. Among these scientifically significant finds from quarries now in the park, is the largest concentration of "Hagerman Horse" fossils in North America. The plants and animals preserved as fossils within HAFO offer a glimpse at some of the first appearances of modern flora and fauna before the Ice Age.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

Geological scoping sessions for HAFO were held on September 18, 2003 under the direction of the NPS Geologic Resources Division (T. Connors, personal communication, 2005). Although no formal, inclusive paleontological resource inventories have been completed for the park, a complete list of fossils identified from the park is included in McDonald et al. (1996). Unlike John Day Fossil Beds National Monument, Hagerman Fossil Beds National Monument only has limited research and interpretation facilities located in the town of Hagerman, Idaho. However, the construction of a new museum and research center is part of the park's long term planning.

Current research within HAFO is conducted and reviewed by the park paleontologist, Phil Gensler. Gensler is one of only 15 paleontologists within the NPS. The primary function of Gensler's research within the monument is periodic monitoring of HAFO's known fossil localities, both "new" and historically significant. Many of these localities were identified during 1999-2001 in a HAFO survey to document all fossil localities within the park. Gensler (personal communication, 2004) estimates at least 100 site visits are made every year. New discoveries are documented as they are discovered and excavated as needed. The limited facilities present at the park preclude large paleontological museum collections on site, however fossils from HAFO are on display or in the collections of over 20 museums worldwide (National Park Service 2003b). As the park has a paleontologist on staff and a paleontological resource inventory and monitoring program in place, this report serves as a brief introduction to the scope and significance of the fossils found within HAFO.

There are a number of resource management issues affecting fossils within the park, with the most significant being landslides, in fact, the "landslide problem" at HAFO may be the worst in the National Park System (Farmer and Riedel 2003). This issue was raised during HAFO's geologic scoping sessions (Covington 2004). As reported by Covington (2004), landslides in the unstable Glenns Ferry Formation have destroyed fossil sites and also present significant safety hazard to paleontological researchers. At least seven major landslides have occurred over the last 25 years in the park that are likely related to irrigation and groundwater utilization in the area surrounding HAFO (Farmer and Riedel 2003). An additional paleontological resource management concern is that of radioactivity. As reported in Covington (2004), uranium and radium are found in the basalt flows of the area and, in some cases, have been concentrated in fossil material. Precautionary measures have thus been necessitated prior to the handling and preparation of some fossil material (Covington 2004).

Hagerman Fossil Beds National Monument is located at the contact between the basalt-dominated Eastern Snake River Plain and the sediment-dominated Western Snake River Plain near the southeastern margin of ancient Lake Idaho. The general geology of the monument consists primarily of stream and lake sediments of the Pliocene Glenns Ferry, early Pleistocene Tuana Gravels, and Pleistocene Yahoo Clay of the Idaho Group. These formations lie unconformably on the siliceous Miocene-aged Idavada Volcanics. The Glenns Ferry Formation contains sediments inter-bedded with occasional basalt flows, silicic volcanic ash, and basaltic pyroclastic deposits, ranging in age from 1.8 - 3.5 million years old. The sediments represent deposition within lake, stream and flood plain environments. The unconsolidated sediments exposed within HAFO have yielded a remarkable diversity and abundance of fossils. Currently there are in excess of 500 known individual fossil localities within the monument, which have produced over 145 separate species of plants and animals, 44 of which are holotypes. Over 100 species of vertebrates, including 18 fish, 4 amphibians, 9 reptiles, 27 birds and 50 mammals have currently been identified, as well as freshwater snails and clams, and plant pollen.

Glenns Ferry Formation (Pliocene)

The Pliocene Glenns Ferry Formation contains several different sedimentary facies including: lacustrine, floodplain, and fluvial. Together, there is at least 600 feet of alternating layers of clays, silts and micaceous channel sands assigned to the Glenns Ferry Formation (Bjork 1968). The Glenns Ferry is highly fossiliferous with a wide diversity of paleontological resources including fossil fish, reptiles, birds, and mammals as well as plant pollen and mollusks. The most significant fossil found within the park is the numerous specimens of the "Hagerman Horse", the most primitive member of the modern horse genus *Equus*. See below for additional details.

The Glenns Ferry Formation has produced many fish fossils, including the western catfish, which survived in southern Idaho until about 1.8 million years ago and then became extinct. Miller and Smith (1967) identified seven new species of fish from the Glenns Ferry, including a catfish (*Ameiurus vespertinus*) and sunfish, (*Archoplites taylori*). A nearly complete skull, perhaps the most complete specimen recovered to date, of *Ameiurus vespertinus* was discovered in the park in 2001 (Gensler 2002).At least five of the seven identified species of fish are now extinct (Malde 1972). Overall, the fish fauna found at Hagerman is dominated by species associated with floodplain facies such as *Mylopharodon hagermanensi*s (Smith et al. 1982). Other fish fossils identified from this unit include *Sigmopharyngodon idahoensis* and *Ptychochilus oregonensi*s (Uyeno 1961; Miller and Smith 1967).

A variety of reptile fossils have also been identified at HAFO. Several snake fossils have been found within the Glenns Ferry Formation including garter snake (*Thamnophis*), racer (*Coluber*), rat snake (*Elpaphe pliocenica* and *E. vulpine*) and milk snake (*Lampropeltis*). (Holman 1968). In 1930, during excavations at the Horse Quarry, C. W. Gilmore (1933) identified a pond turtle, *Trachemys idahoensis* (Jackson 1988). Two additional turtle forms are described by Zug (1969) but only an ancestral pond turtle *Clemmys owyheensis* is considered valid.

Some birds identified within HAFO include: *Colymbus* sp., *Pelecanus halieus*, *Phalacrocorax idahensis*, *Phalacrocorax auritus*, *Chen pressa*, *Gallinula choropus*, *Cygnus* sp., *Querquedula* sp. (Wetmore 1933), *Cygnus columbianus* (Miller 1948), *Porzana lacustris*, *Bucephala* sp., *Phalacrocorax macer*, *Cygnus hibbardi*, *Anas platyrhychus* (Brodkorb 1958), *Olor hibbardi*, *Anser pressus*, *Nettion bunkeri*, *Olor columbianus* (Brodkorb 1964), *Ciconia maltha*, *Grus americana* (Feduccia 1967), *Speotyto megalopeza*, *Asio brevipes* (Ford and Murray 1967), *Pliolymbus baryosteus*, *Podiceps discors*, *Aechmorphorus elasson*, *Podilymbys majusculus* (Murray 1967), *Rallus prenticei*, *Rallus lacustris*, *Rallus elegans-longirostris*, *Coturnicops avita*, *Gallinula* sp. (Feduccia 1968). Selander (1965), using Hibbard's age classification, briefly discussed birds from the Hagerman local fauna. The avifauna is dominated by waterfowl associated with permanent water sources.

Mammal fossils are also quite common within the Glenns Ferry Formation and include a number of significant specimens; the most well known is the "Hagerman Horse" described below. Within Insectivora, five species of fossil shrews have been found at Hagerman, four are in the genus *Sorex* and one in *Paracryptotis* (McDonald 1998). Only two rabbits, *Hypolagus limnetus* and *H. gidleyi*, have been identified within HAFO. Rodentia is strongly represented by many varieties of squirrels, mice, rats, beavers and voles. Samuels (personal communication, 2004), while completing research for his PhD dissertation, determined that of the two beavers found at HAFO, the extinct California beaver, *Castor californicus*, existed over a much greater range of the monument and is the more common of the two. To date over 600 fossil specimens of *Castor californicus* have been unearthed within HAFO compared to less than a dozen specimens of *Dipoides,* the ancestor to the giant beaver, *Castoroides*, of the late Pleistocene. Samuels' dissertation involves the use of functional morphology to understand the evolution of semi aquatic life and tree cutting in beavers. Only one species of sloth is known to the Hagerman region, *Megalonyx leptostomus* (Gazin 1935). Within the Order Carnivora there have been many finds at Hagerman from the following families: Canidae (dogs, wolfs and coyotes), Ursidae (bears), Mustelidae (mustelids), and Felidae (cats). Significant carnivore species include: *Sminthosinis bowleri* (Mustelidae), only known from fossils found within HAFO; *Puma lacustris* (Felidae), originally classified as *Felis lacustris*, has been shown in further studies to belong within *Puma*; and *Canis lepophagus*, ancestor to the modern coyote. Other strongly represented orders at HAFO include Proboscidea (mastodont), Perissodactyla (odd-toed ungulates), and Artiodactyla (even-toed ungulates). Artiodactyla is very well represented with many finds from such families as: Tayassuidae (peccaries), Camelidae (camels), Cervidae (deer, caribou, moose), and Antilocapridae (pronghorns). (D. Ruez, personal communication, 2004).

The most significant fossil found within HAFO is the "Hagerman Horse," *Equus simplicidens.* The "Hagerman Horse" was first identified in 1929 by J. W. Gidley of the Smithsonian Institution in 1929, and is the earliest, most primitive known representative of the modern horse genus *Equus* (McDonald 1993). *Equus simplicidens* was originally described by Gidley as "*Plesippus shoshonensis*". Later work has shown that the horse does belong in the genus *Equus* and, specifically the species *E. simplicidens*. Repenning and others (1995), attempted to justify the validity of the original classification of the HAFO horse, *Plesippus shoshonensis*. However, they did not discuss morphological evidence supporting the continued use of the genus *Plesippus* (D. Ruez, personal communication, 2004). The "Hagerman Horse" is believed to be more closely related to the Grevy's Zebra of Africa than to modern domesticated horses (McDonald 1993). Excavations throughout the 1930s yielded an astounding number of these fossils including five nearly complete skeletons, more than 100 skulls, 48 lower jaws, and numerous isolated bones (National Park Service 2002a). One unique feature of the Horse Quarry is that the horse fossils range from yearlings to adults in age and many of the fossils are complete skeletons. There are several theories as to why the fossils are preserved in this manner. One idea is that a herd of horses clustered around a vanishing water hole during a drought. Another possibility is that the entire herd perished while crossing a flooded river.

Today, specimens of the Hagerman horse are displayed in over 20 museums around the United States including: the Carnegie Museum of Natural History, Cleveland Museum of Natural History, Denver Museum of Natural History, Field Museum of Natural History, Idaho Museum of Natural History, Museum of Comparative Zoology, Museum of Paleontology University of Michigan, Natural History Museum of Los Angeles County, Royal Ontario Museum, National Museum of Natural History, South Dakota School of Mines Museum of Geology, Texas Memorial Museum, University of Kansas, and the Utah Museum of Natural History (National Park Service 2002b). The state of Idaho, recognizing the significance of the "Hagerman Horse," designated *Equus simplicidens* the official state fossil of Idaho in 1988.

Leopold and Wright (1985) interpreted flora of the Pliocene from pollen records and their data shows the abundance of genera in the Glenns Ferry Formation relative to extant natives. Robertson (2002) also described the pollen and spores from the Glenns Ferry Formation in an upland wet meadow and pond environment. Petrified wood is also found occasionally in the Glenns Ferry Formation sediments, including a remarkably well-preserved and unaltered specimen discovered in 1993 as reported in the National Park Service Morning Report for December 23, 1993.Taylor (1966) reported that molluscan fossils of the fluvial facies number approximately 40 species in an assemblage similar to those found in the lacustrine and flood-plain facies.

Tuana Gravel (Pleistocene)
The Pleistocene-aged Tuana Gravel, covering a large area west of HAFO, lies unconformably on the Glenns Ferry formation and contains up to 200 feet of gravel, sand, silt and clay (Malde and Powers 1962). The Tuana Gravels which lies unconformably on top of the Glenns Ferry Formation has only produced a few fossil vertebrates including some unpublished camel material in the park collections.

Yahoo Clay (Pleistocene)
The Pleistocene-aged Yahoo Clay (formerly referred to the Bruneau Formation by Malde and Powers, 1962) consists of a blocky silt that accumulated in a lake formed behind a basalt dam resulting from lava from McKinley Butte flowing into the Snake River Canyon. (Malde 1982) The age of the McKinney Butte lava is about 50,000 years. No vertebrate fossils have been recovered from this formation in the vicinity of HAFO (Bjork 1968). However, *Mammuthus* fossils were noted elsewhere in the Bruneau Formation, thought to be at least partially time equivalent to the Yahoo Clay. This discovery implies that the Bruneau Formation is not older than Irvingtonian or middle Pleistocene (Malde and Powers 1962).

COOPERATIVE PROJECTS

- Geologic Scoping of Hagerman Fossil Beds National Monument – National Park Service Geologic Resources Division (September 18, 2003; Covington 2004).
- Excavation of CRMO Mammoth – Hagerman Fossil Beds National Monument Staff (1995).

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JOHN DAY FOSSIL BEDS NATIONAL MONUMENT
By Kathryn Snell

John Day Fossil Beds National Monument (JODA) was established in 1974 in order to preserve the outstanding Cenozoic fossil localities of northeastern Oregon. The park comprises three distinct units, the Clarno, Sheep Rock and Painted Hills units, and encompasses classic fossil collecting localities in the John Day River drainage. Fossil collecting in these localities began in the late 1800's, and has generated a vast array of Tertiary plant and animal fossils that have contributed to a greater understanding of the climate and biology during that time (Kiver and Harris 1999).

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

This national monument is rich in paleontological resources and fossils have been found within all three of the units that make up the park, as well as in many localities just outside of the boundaries. The well-preserved plant and animal fossils found within JODA, and Oregon's John Day Basin as a whole, present one of the most continuous records in the world of plant and animal life during 40 of the last 65 million years.

Geological scoping sessions for JODA have been completed in April 2004 under the direction of the NPS Geologic Resources Division (T. Connors, personal communication, 2004). JODA has a rigorous science-based paleontological inventory, monitoring, and research program in place. The park is also home to four of the National Park Service's approximately 15 paleontologists, Ted Fremd, Scott Foss, Matt Smith, and Regan Dunn. The paleontological program at JODA also serves as a source of expertise throughout the John Day Basin. The opening of JODA's Thomas Condon Paleontology Center in December of 2003 provides a focal point for research, education, and interpretation of the park's globally significant paleontological resources. The park's museum collections include over 10,000 specimens. Collections at other institutions including: the University of California (Berkeley), University of Oregon, American Museum of Natural History (New York City), Peabody Museum of Natural History (Yale University), Florida Museum of Natural History, and the Smithsonian Institution National Museum of Natural History, house thousands of additional specimens. With a rigorous paleontology program in place, this report serves as a brief introduction to the scope and significance of the fossils found within JODA. As an indicator of the importance of the John Day fossils, the 2001 North American Paleontological Convention (NAPC), held in Berkeley, California included a symposium organized by Ted Fremd, entitled "Cenozoic Paleontology and Stratigraphy of the John Day Basin, Oregon."

Four geologic units within the park are major fossil bearing formations: the Clarno, John Day, Mascall, and Rattlesnake formations. The Cretaceous Goose Rock conglomerate is the base formation in JODA and is overlain, in order, by the fossiliferous Eocene Clarno and Oligocene-Miocene John Day formations. The latter two formations contain the greatest diversity and abundance of fossils in JODA. Overlying the John Day Formation is the Miocene Picture Gorge Basalt, which is in turn overlain by the Miocene Mascall Formation. The Mascall Formation underlies the youngest formation in the park, the Miocene Rattlesnake Formation, and these two formations are the other major fossil bearing formations in JODA.

Clarno Formation (Eocene)
The Eocene Clarno Formation is the oldest fossil bearing formation in JODA and contains an extensive number of plant and animal fossils. This formation is made of nonmarine volcanic and volcaniclastic units that are middle to late Eocene in age and fall into three categories; andesitic debris-flow packages, andesite lava flows and claystones (Bestland et al. 1999). In JODA, fossil bearing localities of the Clarno Formation are from Upper Clarno units within the Clarno area of the park and include the Fern Quarry, Hancock Canyon, the Nut Beds and the Mammal Quarry (Retallack et al. 1996).

The vast majority of the paleobotanical fossils from the Clarno Formation come from the Nut Beds locality and the Mammal Quarry, though the fern quarry has also yield plant fossils. Recent works have attempted to summarize the findings from the Nut Beds and have come up with over 145 genera and 173 species of fruits and seeds (Manchester 1994). In terms of plant parts, estimates suggest over 100 genera of fruiting structures, 80 genera of leaves, and 40 genera of wood (Manchester 1981). Lists of these taxa can be found in both citations. The majority of the flora are angiosperms in the following families: Palmae, Juglandaceae, Menispernaceae, Lauraceae, Sabiaceae and Plantaceae (Manchester 1981). Additionally, horsetails and ferns, especially *Equisetum clarnoi*, are abundant (Manchester 1981). Herbaceous angiosperms are, however, not as common, with *Ensete* representing the only herbaceous genus identified (Manchester 1994). Ginkgo wood is relatively rare in the fossil record and a single specimen of Ginkgo wood, *Ginkgo bonesii,* was recovered from the Nut Beds (Scott et al. 1962). This locality also boasts the only known occurrence of genus *Tapiscia* in North America (Manchester 1988) and wood specimens from the Nut Beds revealed the fungus, *Cryptolax clarnensis*

(Scott 1956). Also, a multiple-organ analysis was performed based on different fossil plant parts from the Nut Beds, allowing several plant parts to be linked and identified as a single species, *Macginitiea angustiloba* (Manchester 1986). The flora represented within the Mammal Quarry are all angiosperms, with six genera identified (McKee 1970). *Diploclisia* was the most common genera from this locality, and all of the genera from the Mammal Quarry were also present in the Nut Beds except genus *Tetrastigma*. The fern quarry is primarily made up of ferns (*Acrostichum hesperium*), but also has horsetails, the common species in the Nuts Beds mentioned above, and dicots (*Joffrea speirsii, Quercus, Cinnamomophyllum "Cryptocarya" eocenica*) (Retallack et al. 1996).

Vertebrate remains from the Clarno Formation have been found in the Nut Beds and the Mammal Quarry. Vertebrates found in the Nut Beds include tortoise (*Hadrianus)*, crocodillian, titanothere (*Telmatherium)*, four-toed horse (*Orohippus major)*, extinct rhino (*Hyrachus eximius*), and an extinct lion-like carnivore (*Patriofelis ferox*) (Retallack et al. 1996). The Mammal Quarry has so far yielded crocodilians, creodont carnivores (*Hemipsalodon grandis)*, Nimravidae, rodents, anthracotheres (*Heptacodon)*, oreodons (*Diplobunops*), rhinoceroses (*Teletacera radinskyi)*, tapirs (*Plesiocolopirus hancocki* and *Protapirus)* and horses (*Epihippus gracilis* and *Haplohippus texanus)*, (Retallack et al. 1996). Of these, *T. radinskyi* is the most abundant vertebrate from the Mammal Quarry (Hanson 1989).

John Day Formation (Eocene-Oligocene-Miocene)

The John Day Formation is the most geologically complex and richest fossil bearing formation in JODA. This formation is composed of rhyolitic ash-flow tuff, dacitic to rhyodacitic tuffs and alluvial deposits. Originally divided into the lower, middle and upper John Day (Merriam 1901), a revision by Fisher and Rensberger (1972) renamed the lower and middle John Day as the Big Basin and Turtle Cove members, respectively. This revision split the upper John Day into two members: the Kimberly Member and overlying Haystack Valley Member. The basal portions of the Big Basin Member are late Eocene in age, the Turtle Cove Member is Oligocene in and the Kimberly and Haystack Valley members are Miocene in age (Bestland et al. 1999). Because the John Day extends through the Eocene-Oligocene boundary, the fossils throughout the formation provide a great record of the climatic changes that occurred during this transition (Bestland et al. 1999). Exposures and fossil localities of the John Day Formation are found in all three units of JODA.

The flora of the John Day Formation in JODA come primarily from the Big Basin Member and are a part of the famous Bridge Creek Flora, which are plant assemblages based on a number of localities. The late Eocene Whitecap Knoll locality however, just outside the north boundary of the Clarno Unit, contains fossils that reflect the climatic conditions before the Eocene-Oligocene transition. This locality produced three species of ferns, three species of monocots, and a minimum of 16 species of dicots (Manchester 2000). Meyer and Manchester (1997) contains a thorough, comprehensive assessment of the Bridge Creek flora and has complete tables of the plant fossils of this assemblage, from the localities within and outside of JODA. Localities within the park or immediately adjacent to JODA include Painted Hills, Cove Creek and Iron Mountain. These three localities encompass the older localities of Allen Ranch, Bridge Creek and Wade Ranch (Painted Hills), Clarno's Ferry, Chapman Ranch, Dugout Gulch and the Slanting Leaf Beds (Iron Mountain), and Knox Ranch and Pentecost Ranch (Cove Creek) (Meyer and Manchester 1997). The Painted Hills assemblage tallies a minimum of 38 plant species dominated by taxa *Alnus, Betula, Quercus,* and *Metasequoia* (Chaney 1925a, 1948a, according to Meyer and Manchester 1997). Fossil plant taxa unique to the Painted Hills assemblage are *Cunninghamia, Menispermum, Liquidambar, Betula, Dipteronia* and *Micropodium ovatum*. *Asterocarpinus* fruits and *Paracarpinus* leaves, common elsewhere in the Bridge Creek assemblages, are absent from this assemblage (Meyer and Manchester 1997). The Cove Creek assemblage covers a minimum diversity of 35 species, dominated by *Alnus* and *Paracarpinus*, with *Pinus johndayensis* occurring in greater abundance in this assemblage than any of the other assemblages. *Quercus* is rare within this assemblage, while *Aeschelus* and unknown leaf type 13 occur only in the Cove Creek assemblage (Meyer and Manchester 1997). The Iron Mountain Assemblage lists a minimum of 44 species, and the most common taxa include *Metasequoia, Alnus,* and *Asterocarpinus/Paracarpinus, Acer* and *Cercidiphyllum*. *Pinus, Quercus* and *Ulmus* are rare and *Toxicodendron*, while not very common, is more abundant in the Iron Mountain assemblage than in any other assemblage. Taxa unique to this assemblage are *Keteleeria, Palaeophytocrene, Aucuba, Rubus ameyeri, Zingiberopsis* and "unknown fruit D" (Meyer and Manchester 1997).

All three units of JODA have produced vertebrate fossils from the John Day Formation, the vast majority of which come from the Turtle Cove Member of the formation. The type locality and source of most of the fossils of the Turtle Cove Member is in the Sheep Rock Unit of JODA. Other vertebrate fossil localities include Iron Mountain in the Clarno Unit, and the Carroll Rim locality within the Painted Hills Unit. A list of "Turtle Cove Fauna" that covers fossils in the JODA collection from JODA localities as well as some outside of JODA contains a vast array of animal taxa. These include species (number of species in class in parentheses) in Gastropoda (many, unspecified number), Insecta (unspecified), Reptilia (5), and Mammalia (126+). This list breaks the classes down into families, genera and species when known. Carroll Rim contains a small assemblage of fossil mammals that include taxa of *Agriochoerus, Hypertragulus, Miohippus,* and *Diceratherium* (Fremd et al. 1994). A partial list of mammalian fauna from the Foree area of the Sheep Rock unit includes genera (number within each family in parentheses) from the families Micropternodontidae (1), Nimravidae (3), Canidae (5), Ursidae (1), Equidae (1), Rhinocerotidae (1), Entelodontidae (1), Agriochoeridae (1), Merycoidodontidae (oreodonts) (5), Hypertiagulidae (1), Aplodontidae (1), Castoridae (1), Sciuridae (1), and Leporidae (1) (Fremd et al. 1994). Included in the family Aplodontidae are *Meniscomys uhtoff, M. hippodus, Allomys simplicidens* and *A. nitens* as well as a few species found nearby but outside of JODA (Rensberger 1983). In addition to the oreodon listed in the Foree area, the oreodont fossils found in JODA include: (number of species in parentheses) *Oreodontoides* (1), *Promerycochoerus* (4), *Hypsiops* (1), *Desmatochoerus* (1), *Pseudodesmatochoerus* (1), *Superdesmatochoerus* (2), *Pseudogenetochoerus* (2), *Epigenetochoerus* (1), *Eporeodon* (5), and *Dayohyus* (2) (Schultz and Falkenbach 1947, 1949, 1950, 1954, 1968). Some of these genera are in the list from the Foree area, but the oreodont fossils were from the Bridge Creek locality (Painted Hills Unit) or Turtle Cove, which covers a large area within the Sheep Rock Unit that includes the Foree Area (Rensberger 1976). Records of camels from the John Day Formation include *Paratylopus sternbergi* and *P. cameloides* from Turtle Cove (Lull 1921).

Mascall Formation (Late Miocene)

Fossils from the Mascall Formation in JODA have primarily come from the type locality in the Sheep Rock Unit of JODA, at the historic Mascall Ranch locality (Rensberger 1976). The Mascall Formation is Late Miocene in age and composed primarily of rhyolitic tuffs with associated sands and gravels (Chaney 1959). There is not nearly as much floral material as faunal material from the Mascall in JODA, but more floral localities exist closer to Dayville, Oregon.

The Mascall Floral assemblages have primarily been found outside of JODA. A few fossils have been recorded as coming from near the Mascall Overlook in the Sheep Rock unit (Rensberger 1976) though specific names were not included. Chaney (1925) compared Mascall flora throughout the west and reported 26 species from the John Day Basin, which includes localities near to JODA and possibly within JODA. These include the genera *Ginkgo, Sequoia, Libocedrus, Populus, Salix, Umbellularia, Juglans, Carpinus, Alnus, Quercus, Ulmus, Berberis, Liquidambar, Platanus, Crataegus, Celastrus, Acer, Ficus, Aesculus, Castanopsis, Grewia, Pinus, Cornus, Cercocarpus, Arbutus, Rhus, Magnolia, Laurus, Odostemon,* and *Persea.*

The majority of the fossils found in JODA from the Mascall Formation are vertebrate fossils. A partial list of taxa includes *Lymnaea stearnsi*, *Plioplarchus septemspinosus*, *Clemmys saxea*, unidentified falconis and over 34 species of Mammalia. The mammalian fauna includes 19 families: Equidae (6),Rhinocerotidae (2), Leporidae (2), Amphicyonidae (2), Canidae (2), Mustelidae (2), Procyonidae (1), Myagaulidae (1), Geomyidae (1), Castoridae (1), Heteromyidae (1), Sciuridae (1), Mammutidae (1), Gomphotheriidae (1), Merycoidodontidae (2), Camelidae (2), Cervoidea (3), Antilocapridae (1), and Tayassuidae (1) (Fremd et al. 1994). A hyaenarctid bear fossil, *Indarctos oregonensis,* was found in the Mascall Formation near the Sheep Rock Unit (Merriam and Stock 1927).

The Rattlesnake Formation (Pliocene)

The Rattlesnake Formation is represented in JODA in the Sheep Rock Unit. This formation is Pliocene in age and consists of fanglomerates (sedimentary rock containing heterogeneous material originally deposited in an alluvial fan, now cemented into solid rock) where most of the fossils have been found, and ash flow tuffs (Fremd et al. 1994). Paleobotanical fossils from the Rattlesnake Formation are limited to sycamore, elm, and willow fossils (J. Morris, written communication, 1986).

Vertebrate fossils are the dominant paleontological resources from the Rattlesnake Formation. A list of fossil from the Rattlesnake fanglomerates includes three classes: Amphibia, Reptilia and Mammalia. Like the Mascall Formation, mammalian fossils dominate with the other two classes containing only one species each. Class Mammalia includes numerous taxa (number of genera in parentheses) in families Megalonychidae (1), Leporidae (1), Vespertilionidae (1), Mylagaulidae (1), Sciuridae (1), Castoridae (1), Cricetidae (1), Ursidae (2), Mustelidae (2), Canidae (2), Gomphotheriidae (1), Equidae (4), Rhinocerotidae (1), Tayassuidae (1), Camelidae (2), and Antilocapridae (1) (Fremd et al. 1994).

COOPERATIVE PROJECTS

- Geologic Scoping of John Day Fossil Beds National Monument – National Park Service Geologic Resources Division (April 2004).

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DATA SETS

DS-JODA-XXX	John Day Fossil Beds National Monument Paleontological Archives. 5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.
DS-JODA-XXX	John Day Fossil Beds National Monument, Museum Records and Collections. 1974-present. (museum specimens; collection records; field notes; photographs; ANCS+ records). Originated by JODA staff; status: Active.

DS-JODA-XXX John Day Fossil Beds National Monument, Natural Resource Files. 1974-present. (reports, maps, publications, photographs). Originated by JODA staff; status: Active.

DS-JODA-XXX Smithsonian Institution National Museum of Natural History Collections. 1929-1930s. (museum specimens; associated specimen notes; collection records; field notes). Originated by Smithsonian scientists; status: Inactive.

DS-JODA-XXX Florida Museum of Natural History Collections. 1980s-present. (museum specimens; associated specimen notes; collection records; field notes). Originated by Steven Manchester; status: Active.

DS-JODA-XXX Peabody Museum (Yale University) of Natural History. Early 1900s. (museum specimens; associated specimen notes; collection records; field notes). Originated by museum scientists; status: Inactive.

DS-JODA-XXX American Museum of Natural History. Early 1900s-present. (museum specimens; associated specimen notes; collection records; field notes). Originated by museum scientists; status: Active.

DS-JODA-XXX University of California (Berkeley) Natural History Collections. Early 1900s-present. (museum specimens; associated specimen notes; collection records; field notes). Originated by museum scientists; status: Active.

DS-JODA-XXX University of Oregon Natural History Collections. Early 1900s-present. (museum specimens; associated specimen notes; collection records; field notes). Originated by museum scientists; status: Active.

LAKE ROOSEVELT NATIONAL RECREATION AREA

Lake Roosevelt National Recreation Area (LARO) is one of only two National Park Service units without specific enabling legislation, although various other pieces of legislation authorize its inclusion in the National Park System. After the completion of Grand Coulee Dam in 1941, the 132-mile-long reservoir was created and administered as Coulee Dam Recreation Area. The Bureau of Reclamation, Bureau of Indian Affairs, and the National Park Service managed the recreation area under a cooperative agreement enacted in 1946. The recreation area became a unit of the National Park Service in 1970 and the original cooperative agreement was revised and renegotiated in 1990. The water and shoreline resources managed by the National Park Service were officially designated Lake Roosevelt National Recreation Area on January 1, 1997. Today a wide variety of recreational opportunities are available at LARO.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

As of the writing of this report, there have been no formal paleontological inventories undertaken for LARO. Paleontological scoping sessions have likewise not been completed for the park. However, geological scoping sessions, sponsored by the Geological Resources Division of the NPS, were held at LARO on September 10-11, 2002 (T. Connors, personal communication, 2004). According to the LARO curator, one unidentified fossil specimen has been collected inside of LARO near Fort Spokane (L. Brougher, personal communication, 2005). The fossil was sent to the NPS Geologic Resources Division for identification, but no consensus was reached as to the identification or origin of the specimen (G. McDonald, personal communication, 2005).

The geological history of the area encompassing LARO is complicated as the recreation area stretches across two major geological provinces, the Okanogan Highlands and the Columbia Basin. This history involves complex tectonic activity, extensive lava flows, massive glacial lakes and equally massive glacial outwash floods. The primary sources of geological information contained in this report are derived from a series of 1:100,000 scale geologic maps produced by the Washington Division of Geology and Earth Resources (Joseph 1990a,b,c; Stoffel 1990; Waggoner 1990) For more information on the geology of the area, the Washington Division of Geology and Earth Resources includes brief summaries of the Okanogan Highlands and Columbia Basin (DGER 2001a,b). Other general sources of information include Alt and Hyndman (1984, 1995).

The waters of Lake Franklin D. Roosevelt make up the vast majority of LARO, however the park also encompasses a narrow swath of shoreline along the lake outside of the Spokane and Colville Indian Reservations. This swath generally includes land between 1,290-foot "full pool" elevation up to about 1,310-foot "taking line" elevation. The width of this strip of land, the "freeboard" lands, thus varies from about fifty to several hundred feet depending on the slope of the shoreline (McKay and Renk 2002). The likelihood of discovering extensive paleontological resources within LARO in such a narrow strip is not high. In addition, only about 10% of LARO shoreline consists of bedrock exposures, while 90% is made up of various ice age (Pleistocene-Recent) deposits (Jones et al. 1961). Most of the bedrock consists of a variety of volcanic and metamorphic rocks which are not known to contain fossils.

However, some of the geological formations exposed along the shoreline have produced fossils in the vicinity of LARO and are described below. The potentially fossiliferous formations listed below are only those that are mapped immediately adjacent to the waters of Lake Roosevelt. The formations are listed in stratigraphic order from oldest to youngest.

Addy Quartzite (Late Proterozoic and Cambrian)

The Late Proterozoic and Cambrian-aged Addy Quartzite is only found along Lake Roosevelt in a few small exposures mapped near Crystal Cove Campground (Waggoner 1990). However, the formation is mapped in more extensive areas approximately 6-10 miles east of LARO on Adams Mountain, Stenegar Mountain, Dunn Mountain, and near the towns of Addy and Chewelah (Lindsey et al. 1990). White, tan, gray, or light brown quartzite (essentially metamorphosed sandstone) characterizes the Addy Quartzite (Campbell and Raup 1964; Waggoner 1990; Lindsey et al. 1990). Although, thin argillitic (containing silt or mud) beds are present in the more extensive exposures east of LARO (Campbell and Raup 1964; Lindsey et al. 1990). Based on the sedimentary structures, of the Addy Quartzite, the sediments were likely originally deposited in a shallow-water, near shore, or inner marine shelf environment (Lindsey et al. 1990). See Lindsey et al. (1990) for a more complete description of the geology and depositional environment of the Addy Quartzite.

Fossils are abundant in the lower portion of the upper Addy Quartzite, east of LARO, as reported by Lindsey et al. (1990). These fossils include two types of vertical worm burrows belonging to the ichnogenus (trace fossil genus) *Scolithus (Skolithos)*, *S. bulbus* and *S. linearis*. Additional trace fossils include a horizontal burrow from the ichnotaxon (trace fossil taxon) *Planolites beverlyensis*, unnamed "randomly meandering trails", and the mollusk-like trace fossil *Hyolithus*.

Trilobite (common Cambrian-aged arthropod) resting traces of the ichnogenus *Rusophycus* and trilobite crawling traces of the ichnogenus *Cruziana* have been found as well. Not only have trilobite trace fossils been found, but trilobite body fossils as well, with *Nevadella addyensis* being the most common. Body fossils of the brachiopod (filter feeding bivalve) *Kutorgina* are also found in the Addy Quartzite. Thin beds of fossil "hash" (broken fossil fragments cemented together) have been found near the town of Addy. The overall fossil assemblage indicates an Early Cambrian age for the fossiliferous upper units. Similar fossils are not yet known from the very limited exposures of the Addy Quartzite within or immediately adjacent to LARO.

Gypsy Quartzite (Early Cambrian)
The Early Cambrian-aged Gypsy Quartzite is mapped in very isolated areas along the shoreline of LARO on the north shore of the Columbia River, southwest of the town of Marble (Yates 1971; Joseph 1990a). Extensive exposures are mapped well east of LARO near the Pend Oreille River (Lindsey et al. 1990). The sandy sediment now known as the Gypsy Quartzite was originally deposited some 540 million years ago. The depositional environment is interpreted to be on an inner shelf of a basin's passive margin (similar to the present-day east coast of the United States) created by the rifting (separation) of the North American continent in the late Proterozoic and early Cambrian (Joseph 1990a referencing Lindsey 1987; Lindsey et al. 1990). These sediments were metamorphosed into the white quartzite (metamorphosed sandstone), brown argillite (weakly metamorphosed shale or mudstone), and purple quartzite of the Addy Quartzite. Various cross bedding structures indicative of wave action are also present. Lindsey et al. (1990) presents detailed explanation of the geology and depositional environment of the Gypsy Quartzite.

Trace fossils are relatively common in some beds of the Gypsy Quartzite. These trace fossils are described by Lindsey et al. (1990) and include the various vertical burrows such as the worm burrows *Scolithus linearis*, *S. bulbus* and *Monocraterion*. The horizontal burrow *Planolites beverlyensis* and the trilobite "resting" trace *Rusophycus* are also reported (Lindsey et al. 1990 referencing Groffman 1986). A few isolated and disarticulated trilobite spines have also been found in the upper beds of the Gypsy Quartzite (Lindsey et al. 1990). Although various assemblages of these fossils are common in some exposures of the Gypsy Quartzite, especially near the Pend Oreille River, similar fossils are not yet known within LARO.

Maitlen Phyllite and Reeves Limestone (Early and Middle Cambrian)
A limestone and dolomitic geologic unit which includes the Early and Middle Cambrian-aged Maitlen Phyllite (and Reeves Limestone Member of the Maitlen Phyllite) is mapped in LARO by Yates (1971) and Joseph (1990a). The Maitlen Phyllite is mapped in small areas along the north and south shore of Lake Roosevelt west of the China Bend area and along the north shore across from Marble. Limestones and dolomites (similar to limestone, but with some magnesium) within the Maitlen Phyllite are white to gray in color and have been metamorphosed (Joseph 1990a). Limestones and dolomites are usually indicative of shallow, warm, marine environments.

Fossils have been reported in the limestones of the Maitlen Phyllite on Colville Mountain, about 12 miles east of LARO near Colville. These fossils include beds of archeocyathids, extinct reef-forming marine organisms with a vase or cup shaped skeleton (Joseph 1990a). Beds of archeocyathids, containing the genera *Ethmophyllum* and *Pseudosyringochema* have been found in the Reeves Limestone Member near Douglas Lake east of Colville Mountain (Joseph 1990a). Joseph (1990a, referencing Hampton 1978) also reports "ghosts" (faint fossil impressions) of archaeocyathids from dolomite of the Maitlen Phyllite. Similar fossils are not yet known within or near LARO.

Metaline Formation (Cambrian and Ordovician)
The Cambrian and Ordovician-aged Metaline Formation is mapped along the shores of Lake Roosevelt in a number of small isolated areas including: near Little Dalles, near the mouth of Onion Creek, west of China Bend (Yates 1971, Joseph 1990a), west shore of the lake opposite North Gorge Campground/Boat Ramp, near mouth of the Colville River (Stoffel 1990), and near Crystal Cove Campground (Wagonner 1990). Additional exposures are mapped east of LARO by various authors (e.g. Yates 1971; Snook et al. 1990; Joseph 1990a, Stoffel 1990, etc.). As described by Schuster et al. (1989), the Metaline Formation is characterized by three units, an upper massive (no bedding planes) gray limestone, a middle gray dolomite, and a lower dark gray thin-bedded limestone. However, only the upper massive limestone and middle bedded dolomite units are exposed along the shores of Lake Roosevelt. The original depositional environments for the Metaline Formation include a shallow subtidal shelf, open marine platform, or shallow marine basin (Joseph 1990a, referencing Bending 1983).

A wide variety of fossils have been found within the Metaline Formation in northeastern Washington. Stromatolites (large mound-shaped algal colonies), for example, are known from Metaline exposures east of LARO (Joseph 1990a). Graptolites, described in the Ledbetter Slate section, have also been discovered near Metaline Falls (Schuster et al. 1989, Carter, 1989). Dutro and Gilmour (1989) listed approximately 15 trilobite species, in addition to brachiopods and primitive mollusks, from the lower unit of the Metaline near Colville. Fossils from the upper massive limestone unit and middle dolomite unit are listed by Schuster et al. (1989) from collections made near Clugston Creek, 10 miles north of Colville and about 6-8 miles east of LARO. These fossils include approximately 26 species of conodonts in addition to a number of unidentifiable conodont elements. Dutro and Gilmour (1989) also report some brachiopods from what they termed "poorly fossiliferous upper Metaline" near Colville. Repetski (1978) and Schuster et al. (1989) report the collection of conodont material and a "few pieces" of one of the earliest known fish, *Anatolepis*, near Clugston Creek. Similar fossils have not yet been found in the limited exposures of the Metaline Formation along Lake Roosevelt.

Ledbetter Slate (Early and Middle Ordovician)
The Ledbetter Slate, of early-middle Ordovician age, is mapped in very isolated exposures along the eastern shoreline of Lake Roosevelt across from Haag Cove Campground (Stoffel 1990). More extensive exposures are mapped in a band about 4-5 miles east of LARO in the Huckleberry Range vicinity (Snook et al. 1990). Additional exposures are also mapped in a band to the east and southeast of Northport outside of LARO (Joseph 1990a). The Ledbetter Slate is generally characterized as a fine-grained black slate or argillite, a weakly metamorphosed shale (Stoffel 1990). Shales are usually indicative of deeper water environments.

Fossils are limited in the Ledbetter Slate and consist chiefly of an odd colonial invertebrate, the graptolite. Graptolites are common in Paleozoic black shales, such as the Ledbetter, and many species are used for biostratigraphic dating. They are small colonial marine organisms in small "cups" arranged along one or more branches. Extensive collections of Ledbetter Slate graptolites have been made in the throughout northeast Washington and are summarized by Carter (1989). No fossil localities are along the immediate shoreline of Lake Roosevelt, but some are located in the Huckleberry Range. From six localities within 4-5 miles east of LARO, Carter (1989) reports approximately 19 species of graptolites, however some specimens are "very poorly preserved".

Covada Group (Ordovician)
The Ordovician-aged Covada Group is mapped in various isolated exposures along Lake Roosevelt. Many exposures are near the Chalk Grade Flat area (Snook et al. 1990; Joseph 1990b), with others near Goldsmith Campground (Waggoner 1990). More extensive exposures around found in the Colville Indian Reservation, with some mapped along the shores of Lake Roosevelt within the reservation (Pardee 1918; Atwater and Rinehart 1984; Joseph 1990b). The Covada Group is a complex assemblage of various metamorphosed sedimentary and metamorphosed igneous rock types. The major components, as mapped by Joseph (1990b) include greenstone, carbonate, and wacke/quartzite, all of which are mapped immediately adjacent to Lake Roosevelt. Other authors including Snook et al. (1990) and Campbell and Raup (1964) utilize more divisions in larger scale maps.

Fossils are not common within the Covada Group. However, the only known fossils from the formation were found in two localities about 3 miles east of LARO on the southern flank of Butcher Mountain, south of Mitchell Lake (Snook et al. 1981, 1990). The two localities produced 4 species of trilobites (*Moxomia* n. sp., *Pliomeroides* sp. indet., *Geragnostus curvata*?, and *Asaphellus* sp.) and approximately 10 species or forms of conodont (Snook et al. 1981) in an early Ordovician-aged assemblage. The trilobite fossils were collected in sandstones, siltstone, and argillite (metamorphosed shale) within the greenstone unit of the Covada Group (Snook et al. 1981, 1990; Joseph 1990b). The conodonts were discovered in the limestone or carbonate unit of the Covada (Snook et al. 1981; Joseph 1990b). Joseph (1990b) reports a collection of trilobites and brachiopod fossils was made on Butcher Mountain. However, there apparently was no formal publication and Joseph (1990b) does not provide additional identification information regarding this collection. No fossils are yet reported immediately along the shoreline of Lake Roosevelt. However, given the proximity of known collections to the lake, there may be potential for similar fossils in the Covada Group outcrops within LARO.

Unnamed Metasedimentary Rocks (Devonian-Carboniferous)
Unnamed metamorphosed sedimentary rocks are mapped by Joseph (1990a) along the west shore of Lake Roosevelt in the Little Dalles area southwest of the mouth to Onion Creek. These rocks were mapped by Yates (1971) as phyllite of the Flagstaff Mountain Sequence. Joseph's (1990a) metasedimentary rock unit contains many rocks of the informally named "black shale belt" including Yates' (1971) Flagstaff Mountain, Pend d'Oreille [sic], and Grass Mountain sequences. Similar unnamed rocks are also exposed within a few miles of LARO, north of LARO along the Columbia River, between the Columbia River and the Kettle River, on Stone Mountain (east of Northport), and in Echo Valley (east of Evans).

Joseph (1990a, referencing Beka 1980) reported fossils from the metamorphosed sedimentary rocks of Yates' (1971) Pend d'Oreille [sic] sequence along the west shore of the Columbia River across from Northport, where the conodont *Palmatolepsis* sp. was discovered. Limestones in Yates' (1971) Flagstone Mountain Sequence have also produced late Devonian-aged conodonts (Joseph 1990a). A fossiliferous black limestone is exposed in Black Canyon southeast of

Northport as part of Yates' (1964) Lime Creek Mountain block. Fossils in that limestone include the coral *Alveolites*, a crinoid coquina (fossil hash), and conodonts (Joseph 1990a). However, fossils have not yet been reported in these metasedimentary rocks within LARO.

Argillite and Limestone ("Mission Argillite", Permian)
Fossiliferous Permian argillite with large limestone "pods" was mapped by Mills (1985) in the Kettle Falls, Evans, and Kettle River area near LARO. These rock units were originally part of the Permian "Mission Argillite" defined by Weaver (1920). However, as Mills (1985) reported, the rock units included within the "Mission Argillite" are of many different lithologies and included rocks now known to be of Devonian, Ordovician, and Triassic age. Therefore, "Mission Argillite" is not an appropriate name for the heterogeneous assemblage. Until further work differentiates the different units and their relationships to each other, no alternative names can be suggested (Mills 1985). The argillite and limestone are found in an isolated mapped unit along the shoreline of Lake Roosevelt immediately east of Lions Island, south of Kettle Falls Ranger Station. Much more extensive exposures of the units are found in three main bodies: immediately east of the Kettle Falls Ranger Station, in a wide band extending northeast from Kettle Falls to just east of Evans Campground, and northwest of Snag Creek Campground continuing west nearly to the Kettle River (Mills 1985).

Both the argillite and the limestone are highly fossiliferous. Just north of Kettle Falls, the argillite surrounds large fossiliferous biohermal limestone (mound like mass of rock constructed by sedentary organisms such as corals, algae, etc). Mills (1985, referencing Dixon 1958), Dutro and Gilmore (1989), and Stoffel (1990) reported fossils from the argillite itself, which contains at least eight species of brachiopods (bivalved filter feeders), pelecypod bivalves (clams), gastropods (snails), and scaphopods ("tusk shells"). Stoffel (1990) also noted the presence of abundant crinoid stems and plant fragments. McLaughlin and Simons (1951) initially reported poorly preserved corals, bryozoans, and brachiopods from the limestones near Kettle Falls. Mills and Davis (1962) and Dutro and Gilmour (1989, referencing Senter et al. 1973) note the massive biohermal banks contain fusulinids, corals, bryozoans, echinodermal debris, and brachiopods. Three species of fusulinids were described by Mills and Davis (1962) from the biohermal bank. Gilmour and Snyder (2000) collected 15 species of bryozoans from the biohermal banks. Thirteen of these were new species, and the entire assemblage was similar to those of the western Pacific Ocean. The biohermal limestone was likely deposited in relatively shallow water (less than 70 meters deep) according to Stoffel (1990, referencing West 1976). Mills (1985) maps include fossil localities, with approximately 24 mapped in an arc from northeast of Kettle Falls to just east of Evans Campground. One additional locality is mapped less than one mile northeast of the Kettle Falls Ranger Station. On the west shore of Lake Roosevelt, Mills (1985) maps at least 15 fossil localities northwest of Snag Grove campground, in a band extending nearly to the Kettle River. Some of these localities represent the unnamed Triassic limestone described below. Stop 12 in Dutro and Gilmour (1989) is at a US 395 roadcut one mile north of Snag Cove Campground. Dutro and Gilmour collected Permian fusulinids from a limestone pod located directly above the roadcut at the 2,000 foot elevation just outside of LARO.

Limestone (Early Triassic)
Located generally to the west of the Permian argillite and limestone of the Kettle Falls area is an Early Triassic-aged limestone unit. Exposures of this unnamed unit are found northwest of Snag Cove Campground on Kelly Hill (Kuenzi 1962, 1965; Mills 1985; Dutro and Gilmour 1989).

Fossils from this medium-brown limestone unit were described by Kuenzi (1965) as containing a molluscan assemblage with ammonites, pelecypod bivalves, and gastropods. Kuenzi's locality was located near LARO, about 1.5 miles west-northwest of Snag Cove Campground. Dutro and Gilmour's (1989) Stop 11 is located at a roadcut on US 395 about a third of a mile south of Snag Cove Campground. The limestone visible at this stop is likely the same geologic unit that produced ammonites at Kuenzi's (1965) nearby locality. However, Dutro and Gilmour (1989) noted that fossils have not yet been found at their field trip stop.

Columbia River Basalt Group (Miocene)
The basalts of the Columbia River Basalt group were erupted during four major periods of extraordinary volcanic activity, corresponding to the Imnaha Basalt (17.5 million years ago, mya), the Grande Ronde Basalt (16.5-15.6 mya), the Wanapum Basalt (15.6-14.5 mya) and the Saddle Mountains Basalt (15.5-6 mya). Collectively, basalts from these eruptions cover more than a third of the state of Washington and are visible from the southern reaches of LARO and throughout the Coulee Dam area.

Only in rare cases are fossils preserved in the basaltic lava, since organic material is frequently destroyed by the molten rock. Examples of these rare fossils include tree molds, which are known from a number of NPS units including Craters of the Moon National Monument and Preserve (see CRMO section in this report). A truly unique fossil is found in the lowest Priest Rapids flow of the Wanapum Basalt along the eastern shore of Blue Lake, about 10 miles southwest of Coulee City.

The "Blue Lake Rhinoceros" was discovered in 1935 (Beck 1935). Chappell et al. (1951) and Kaler (1988) offer the most complete geological and paleontological descriptions. The "Blue Lake Rhinoceros" site consists of a hollow mold formed when a basalt flow surrounded the bloated corpse of a dead rhinoceros. The rhinoceros was likely laying in or near an ancient lake. The lake water and water-rich sediment surrounding the lake, rapidly cooled the advancing lava (forming "pillow" basalt) allowing for the preservation of the rhinoceros mold (Chappell et al. 1951; Kaler 1988). A number of bones, including a jaw fragment with teeth were discovered inside the mold. Although Kaler (1988) reported that not enough material was available to completely identify the rhinoceros, Chappell et al. (1951) tentatively identified the fossil as *Diceratherium*. Some of the bones are on display at the Sun Lakes-Dry Falls State Park Visitor Center. Apparently a number of unpublished reports and manuscripts were submitted to the NPS from 1935-1937 regarding the mold (Chappell et al. 1951). In addition to the rhinoceros mold, a number of tree molds are also present at the site (Chappell et al. 1951; Kaler 1988). Behrens (personal communication, 2005) reports tree molds from Columbia River Basalts about 1.5 miles north of Grand Coulee on state route 174.

Sedimentary interbeds, or layers of sediments that were deposited during the time between lava flows, have also preserved fossils in the Grand Coulee area. The famous flora of the Latah Formation, first described near Spokane, Washington and Coeur d'Alene, Idaho (e.g. Knowlton 1926, Pardee and Bryan 1926) is found in such sedimentary deposits. Berry (1931) reports on an extensive flora from a Latah Formation interbed located very near the present site of the Grand Coulee Dam. According to Berry, the site is near the northern boundary of Grant County, "at the extreme northern end of the [Grand] coulee, just at the top of the hill that leads down to the Columbia River". This site is likely just outside of LARO. In all, Berry (1931) reported 55 species from 34 plant genera representing 25 families and 16 orders. A number of species were new to science. The most common were leaves of birch, chestnut, elm, poplar, and oak. In 1938, Berry added an additional 13 species to the assemblage upon receiving new fossil material (Berry 1938). A similar outcrop was reported by Behrens and Hansen (1989) along state highway 155 just west of the Crescent Bay Overlook at Coulee Dam. This site contains a "variety of fossil leaf and stem fragments" (Behrens and Hansen 1989). According to Behrens (personal communication, 2005), the locality may be very close to Berry's site, and is likely on state land. Localities near Grand Coulee are also noted by Kirkham and Johnson (1929) and Chaney (1959, as reported by Gray and Kittleman 1967). Gray and Kittleman (1967) dated the basalts above and below the Grand Coulee interbed to approximately 15.7 and 16.8 million years ago (early-middle Miocene), thus bracketing the age of the flora.

Petrified wood is also common in the interbeds of the Columbia River Basalt Group. For example, Ginkgo Petrified Forest State Park near Vantage, Washington, preserves an astounding variety of fossil wood (e.g. Beck 1945). This fossil wood includes approximately 50 genera and among the only examples of fossil *Ginkgo* wood in the world (Hindman 1958). The park visitor center displays nearly 200 specimens collected from the surrounding area.

Surficial Deposits (Pleistocene/Ice Age and Holocene/Recent)

As stated earlier, approximately 90% of LARO shoreline is made up of various ice age (Pleistocene-Recent) deposits. These deposits vary greatly and include non-glacial deposits such as alluvium, loess, dunes, and extensive landslide deposits, all of which are essentially modern (Holocene) sediments. The Pleistocene (Ice Age) glacial deposits include drift, till, glaciolacustrine deposits, catastrophic flood deposits (e.g. from glacial Lake Missoula), outwash,. These deposits are more fully described in numerous publications including Flint and Irwin (1939), Atwater (1986), and Kiver et al. (1989) among others.

Fossils were not specifically noted within these surficial deposits of LARO. However, a piece of fossil wood was discovered north of LARO within the Colville Indian Reservation at the mouth of Manila Creek on the Sanpoil River (Atwater 1986). The piece was radiocarbon dated at 14,490+/-290 years before present (Atwater 1986). The wood was found in a unit corresponding to Joseph's (1990b) Pleistocene glaciolacustrine unit. Although only one piece has yet been found outside of LARO, additional material may exist in the extensive glaciolacustrine deposits of the park. Other fossils have been discovered in surficial deposits outside of LARO and may indicate the presence of similar fossils within or near the park. For example, nonmarine mollusks were found in Pleistocene silt and volcanic ash, representing an ancient lake deposit, near present-day Soap and Lenore lakes (Landye 1968). The fossils included at least 13 species of aquatic mollusks with diatoms, ostracodes, and fragmental fish remains also being discovered. The volcanic ash at the site was dated at 12,000+/-310 years before present (Landye 1968). Mack et al. (1976) studied pollen from a core taken near Creston, WA about eight miles south of the Lincoln boat launch. Their results indicate a post-glacial flora dominated by *Artemisia* (sagebrush) on flat lands, with conifers on loess hills. The assemblage, dated as far back as 13,000 years before present, changed over time in response to post-glacial warming. Lyman and Livingston (1983) reported late Quaternary mammal remains from two sites near LARO. One site is apparently located on the Colville Indian Reservation near the confluence of the Columbia and Spokane rivers. This site produced bone fragments from the mountain goat *Oreamnos americanus* that are likely less than 3,000 years old (Lyman and Livingston 1983, referencing Collier et al. 1942). Another site east of Lake Roosevelt near Kettle Falls produced specimens of *Cervus* cf. *elaphus* (elk) dated at approximately 6,000-8,000 years before present (Lyman and Livingston 1983, referencing Grayson 1977).

Paleontological resources may also be found within the surfical deposits in association with archeological material, such as the extensive excavations at Kettle Falls (e.g. Chance and Chance 1979, 1982). Archeological excavations frequently unearth faunal remains, some dating back before the Holocene (~10,000 years ago). The Kettle Falls excavations, however, are likely in much younger material (hundreds of years old). The excavations at the Spalding site (see Nez Perce National Historical Park section in this report) are an example of faunal material in association with archeological material. The museum collections of Nez Perce National Historical Park, housed at the Spalding site, include material from Kettle Falls (B. Chenoweth, personal communication, 2005).

Cooperative Projects

- Geologic Scoping of Lake Roosevelt National Recreation Area – National Park Service Geologic Resources Division (September 2002).
- Archeological excavations of Kettle Falls area – University of Idaho, Moscow, Laboratory of Archeology (1970s).

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DS-LARO-XXX Lake Roosevelt National Recreation Area, Museum Records and Collections. 1946-present. (museum specimens; collection records; ANCS+ records). Originated by LARO staff; status: Active.

MINIDOKA INTERNMENT NATIONAL MONUMENT

Minidoka Internment National Monument (MIIN) was established on January 17, 2001 to interpret the hardships and sacrifices of the nearly 13,000 Japanese Americans interned there during World War II. The monument preserves 73 of Minidoka Relocation Center's original 33,000 acres and is administered through Hagerman Fossil Beds National Monument (HAFO). Currently, there are no visitor services available at MIIN, although the recently completed General Management Plan outlines future visitor services and accessibility.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for Minidoka Internment National Monument as of the writing of this report. Paleontological scoping sessions and geological scoping sessions have likewise not been completed for the park. There are no paleontological specimens in the park's museum collections.

As mapped by Rember and Bennett (1979), the area within and surrounding MIIN is dominated by Pleistocene-aged Snake River Basalts. These basalts can be veiled with a thin layer of modern soil (P. Gensler, personal communication, 2005).

Snake River Basalt (Pleistocene)
Massive amounts of basalt, collectively known as the Snake River Basalt, erupted from volcanoes throughout the Snake River Plain beginning in the late Pleistocene and ending only a few thousand years ago. These eruptions are similar to those of the Columbia River Basalt Group, which erupted much earlier during the Miocene (see the Lake Roosevelt National Recreation Area section of this report). Rember and Bennett (1979) map the oldest Pleistocene flow of the Snake River Basalt in the area surrounding MIIN.

It is extraordinarily rare for paleontological resources to be preserved within the lavas of a basalt flow, due to the extreme temperature of the molten rock. This condition frequently incinerates any organic remains. However, molds of trees surrounded by the advancing lava can be preserved (e.g. Stearns 1928). In addition, lava tubes, essentially caves formed by cooling lava, may preserve paleontological resources of animals that utilize the tube (see CRMO section of Santucci et al. 2001). Examples of these paleontological resources are known from Craters of the Moon National Monument and Preserve (see CRMO section of this report), which is also located on the Snake River Plain.

Similar fossils to those found within the basalts of CRMO are not yet known from the basalts exposed within MIIN. Lava tubes or other cave features are also not present within MIIN. According to Hagerman Fossil Beds National Monument's paleontologist, who has visited MIIN on a number of occasions, there is little potential for future paleontological discoveries within MIIN (P. Gensler, personal communication, 2005). Nevertheless, future field investigations may reveal paleontological resources within the park.

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DATA SETS

DS-MIIN-XXX Minidoka Internment National Monument Paleontological Archives. 5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

NEZ PERCE NATIONAL HISTORICAL PARK

Nez Perce National Historical Park (NEPE) was originally established in 1965 to preserve 24 sites in Idaho that commemorate the stories and history of the Nimiipuu, or Nez Perce, people. Fourteen additional sites in Washington, Montana, and Oregon were added in 1992. Of the 38 sites now included within NEPE, six are on land owned by the National Park Service. These sites include: Spalding, White Bird Battlefield, Canoe Camp, and East Kamiah (Heart of the Monster), in Idaho, and Bear Paw Battlefield and Big Hole Battlefield (addressed in its own section) in Montana. The remaining sites are variously located on other federal, state, local, and private lands. This separation of sites, sometimes by hundreds of miles, creates many administrative and resource management issues unique to NEPE. The NEPE website (http://www.nps.gov/nepe/sites.htm) includes basic information and General Management Plan items for each of the 38 sites.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

Neither geological nor paleontological scoping sessions, sponsored by the NPS-Geologic Resources Division, have been undertaken for NEPE. Formal paleontological surveys have not been completed for any site in the park and there are no specimens cataloged as "paleontology" within NEPE museum collections. Nevertheless, fossils have been discovered within two NEPE sites, White Bird Battlefield and Tolo Lake and paleontological material found in association with archeological material is known from the Spalding site. Both the White Bird Battlefield and Spalding sites are situated on NPS land. Tolo Lake is administered by the Idaho Department of Fish and Game.

This report focuses on the six sites found on NPS land, although the extensive paleontological resources from Tolo Lake are also mentioned here. Many of the NEPE sites on non-NPS land are scattered throughout the Blue Mountains region of Idaho, Oregon, and Washington. This region is very complex geologically and contains a variety of paleontological resources as described in Walker (1990) and Vallier and Brooks (1986; 1994). These resources do not appear to be found within any NEPE sites, but, in a few instances, within their general vicinity.

SPALDING

The Spalding site serves as the headquarters for NEPE and is located approximately 10 miles east of Lewiston, Idaho along the Clearwater River. Geologically, the site is typical of many NEPE areas, with Miocene Columbia River Basalt Group lavas (specifically the Grande Ronde Formation) mapped over much of the site and associated easement (Bush and Garwood 2001). The areas adjacent to the Clearwater River and Lapwai Creek contain Holocene (modern) alluvial deposits associated with the rivers and creeks (Bush and Garwood 2001).

Columbia River Basalt Group (Miocene)

Paleontological resources are generally not found within lava, since organic material is frequently destroyed by the molten rock. However, rare fossils are known from basaltic lavas and include tree molds, which are known from a number of NPS units including Craters of the Moon National Monument and Preserve (see CRMO section of this report). The Lake Roosevelt NRA section of this report also describes a unique mold of a dead rhinoceros preserved in a basalt flow. Fossils are not yet known from the lavas of the Columbia River Basalt Group near Spalding.

Latah Formation (Miocene)

Sedimentary interbeds within the Columbia River Basalt Group, such as the Latah Formation, described in the White Bird Battlefield section, are known to produce fossils. While the Latah Formation is not known to outcrop within the Spalding site, Kirkham and Johnson (1929) report a wide variety of plant fossils found just across the Clearwater River from Spalding. Their Stations 1, 2, 3, 4, and 5 are located about 11 miles east of Lewiston on north bank of Clearwater River, near the highway. These plants are likely from small Latah Formation exposures. Bush and Garwood (2001) map Latah Formation sediment exposures approximately 2 miles east of Spalding on the north shore of the Clearwater River. It is unclear whether these are the same exposures that produced the material recorded by Kirkham and Johnson (1929), as their localities are unfortunately not well defined. Nevertheless these Latah Formation exposures produced fossil plant material from 15 different species of fern, cypress (*Glytostrobus*), poplar (*Populus*), willow (*Salix*), birch (*Betula*), beech (*Fagus*), and oak (*Quercus*) among others (Kirkham and Johnson 1929). Kirkham and Johnson also report that spines, vertebrae and scales from the small freshwater fish *Leuciscus* were found at the same localities. Plant fossils from these localities were also studied and described by Ashlee (1932), Berry (1934), and Olson (1938).

Alluvial Deposits (Holocene)

Limited paleontological resources are known from the Spalding site in association with archeological discoveries made at the site. During extensive archeological studies of the Spalding site in the late 1970s and early 1980s, many faunal remains were found in association with the archeological material. Chance and Chance (1984) describe this material in detail. Their "Lapwai Component" fauna is at least 9,000 years old and includes bone and teeth fragments, often tentatively identified, from: an indeterminate snake, cf. *Marmota flaviventris* (yellow-bellied marmot), *Microtus* sp. (meadow vole), cf. *Erethizon dorsatum* (porcupine), an indeterminate rodent, cf. *Sylvilagus* sp. (cottontail rabbit), an indeterminate carnivore, cf. *Equus* sp. (horse), cf. *Bison* sp. (bison), and a number of indeterminate artiodactyls and other mammals. One other specimen is of particular interest. A charred bone fragment (metatarsal) from a short-faced bear (*Arctodus* cf. *simus*) was also discovered in the Lapwai Component (Chance and Chance 1984). The bone fragment was estimated to be at least 10,000 years old, suggesting an older age for the Lapwai Component material than previously thought. In fact, some of the oldest sediments associated with the Lapwai Component are considered to be approximately 12,000 years old (Chance and Chance 1984). At the time it was discovered, the *Arctodus* material represented the only known short-faced bear remains found charred and in direct association with an archeological site (B. Chenoweth, personal communication, 2005). The bone fragment was on display at the park visitor center, and is apparently now part of the archeological museum collection for NEPE (B. Chenoweth; J. Lyon, personal communication, 2005). Such discoveries are particularly interesting when they indicate the presence of species presently extirpated from the local area. Many other archeological excavations within other NEPE sites may yield similar "paleontological/archeological" material. Kettle Falls, in Lake Roosevelt National Recreation Area (see LARO section in this report) also has a collection of faunal material, although much younger (hundreds of years old), which is housed with the NEPE collections at Spalding.

WHITE BIRD BATTLEFIELD

Columbia River Basalt Group (Miocene), Latah Formation (Miocene)

White Bird Battlefield is located approximately 15 miles south of Grangeville, Idaho between US Highway 95 and the old US 95 grade ("Old White Bird Grade" or "North-South Highway"). The site is geologically similar to Spalding in that the area is dominated by basalt flows from the Miocene-aged Columbia River Basalt Group with interbeds of the Latah Formation. The Latah Formation interbeds immediately adjacent to the battlefield site and also within a few miles of the town of White Bird ("Whitebird" in some publications), are known to be richly fossiliferous. The geology of these deposits has been the subject of some debate as its validity and stratigraphic relationship with the Columbia River Basalt Group has changed over time. For various geologic reviews of Columbia River Basalt interbeds related to the White Bird deposits see Bond (1963; "White Bird Lake Beds"), Gray and Kittleman (1967), Camp et al. (1982), and Smith et al. (1989). Essentially the shale and siltstone deposits within and near the battlefield site are lacustrine or fluvial in origin. Fossils preserved in these sediments record the local flora during the Miocene. Volcanic ash layers are also common in the interbeds.

Although the geologic and stratigraphic interpretations of the White Bird deposits have undergone various iterations, "White Bird" localities continue to produce a variety of plant fossils. The White Bird fossils were first described by Kirkham and Johnson (1929) in their report detailing 40 known Latah Formation sites throughout Idaho. Kirkham and Johnson's Station 14 is located "about 3.8 miles east of Whitebird, Idaho on the north side of the road [likely Old White Bird Grade] where it turns northwest and leaves Whitebird Creek". This locality may be within current park boundaries. Berry (1930) describes a new species of *Cercis* (red bud tree) from the same locality, although he indicates that notes associated with the specimen list the locality as 2.5 miles east of White Bird, not 3.8 as originally published by Kirkham and Johnson (1929). Exact mileage aside, this locality was at the time the "most prolific" and an "especially rich" Latah Formation locality in Idaho (Berry 1930; Brown 1937) and produced 38 species of fossil plants as listed by Kirkham and Johnson (1929). Approximately 25 different genera, including *Acer* (maple), *Betula* (birch), *Laurus* (laurel), *Liquidambar* (sweetgum), *Nyssa* (tupelo/gum), *Pinus* (pine), Populus (poplar), *Quercus (oak)*, *Sequoia*, and *Taxodium* (bald cypress) and a leaf fungus, are represented from well-preserved leaves, stems, and even fruits. This locality is likely the same as USGS Paleobotanical Locality 8444, which is "2.5 miles northeast of White Bird, on road [old US95] to Grangeville". The USGS Paleobotanical Locality database is housed at the Smithsonian Institution's National Museum of Natural History (Paleobotany Division) in Washington, DC.

Kirkham and Johnson (1929) list three other White Bird localities. Their Stations 8, 9, and 12, found "less than a mile", "slightly more than a mile", and "three miles east of Whitebird on the north side of Whitebird Creek, on the North-South Highway", respectively. These localities are all likely within current NEPE boundaries, although Station 8 may be just outside, and produced a more limited collection of plant fossils than those at Station 14. Station 8 is found in primarily ash layers 12 feet thick and produced only one identifiable species of poplar from the poorly preserved fossils. Station 9 is found in ash and shale beds about 25 feet thick, and produced 17 species. Station 12 is found in chiefly ash layers about 15 feet thick and produced only three identifiable species from the poorly preserved material.

Following Kirkham and Johnson's initial description, further research, descriptions, and taxonomic updates of the plant fossils from all four White Bird localities were presented by Berry (1930; 1934), Ashlee (1932), Brown (1935; 1937), and

Chaney (1959). The United States Geological Survey (USGS) Paleobotanical locality database also lists two White Bird localities. USGS Paleobotanical Locality 8445 is “two miles from White Bird, on road [old US95] toward Lucile”. Lucile is approximately 19 miles south of White Bird outside of White Bird Battlefield. The other locality, 8444, is found “2.5 miles northeast of White Bird, on road [old US 95] to Grangeville”. This locality may be the same as Kirkham and Johnson’s Station 14.

Some of the specimens Berry (1934) and Brown (1937) described are the type specimens for their respective species. Type specimens are the original, described specimen, for any given species. The National Museum of Natural History (NMNH) houses the type specimens (and much of the other Latah material) from the White Bird area. For example, over 26 specimens (including type specimens) from the White Bird area, figured in Berry (1934) and Brown (1937), are located in the NMNH Paleobotany Type Room.

Gray and Kittleman (1967), radiometrically dated the tuff beds (volcanic ash) interbedded with the fossil bearing White Bird sediments at approximately 13.5 million years old, in line with the middle or late Miocene age assigned by many of the early authors. Gray and Kittleman (1967), however, do note some of the inconsistencies and differing theories on the age and interpretation of the White Bird deposits.

The White Bird deposits provide not only a rich historical paleobotanical assemblage, but may also present modern resource management issues. Various school groups occasionally visit the White Bird fossil sites, some likely within or immediately adjacent to NPS land, to observe the fossils (W. Rember, personal communication, 2005). Depending on the exact location of the sites, they may be on the state right of way for the old White Bird Grade (J. Lyon, personal communication, 2005). In either case, the White Bird deposits could provide an excellent educational and interpretive opportunity.

The susceptibility of the sediments to landslides is noted by Kirkham (1928), Kirkham and Johnson (1929), and Brown (1935). All of which mention the potential instability of the lake deposits near the fossil beds, and landslides at other interbed localities. Bedrock instability may need to be further addressed from a resource management standpoint.

CANOE CAMP

Alluvial Deposits (Holocene)

Canoe Camp is located adjacent to the Clearwater River along US Highway 12, approximately four miles west of Orofino, Idaho. Geologically, the site consists of Holocene alluvial deposits (sand and silty sand overlying river gravel) associated with point bars and floodplains of the Clearwater River (Othberg et al. 2002). These sediments are older than the alluvium of the present river. Paleontological resources are not known from these deposits. However, as with the faunal remains reported from the Spalding site, paleontological material may be in association with the archeological material found at the site (B. Chenoweth, personal communication, 2005). The bluffs surrounding the site and across the Clearwater River are made up of rocks associated with the Late Cretaceous-aged Kamiah plutonic complex, as mapped by Rember and Bennett (1979) and described as a field trip stop by Hyndman (1989). The Kamiah plutonic complex is characterized by a variety of intrusive igneous rocks, which are rocks of a molten origin emplaced underground, and as such, do not preserve fossils.

HEART OF THE MONSTER (EAST KAMIAH)

Columbia River Basalt Group (Miocene), Alluvial Deposits (Holocene)

Heart of the Monster/East Kamiah is located along US Highway 12 two miles from the bridge over the Clearwater River in Kamiah, Idaho. Geologically, there is little potential for paleontological resources from this site. Rember and Bennett (1979) map Miocene-aged Columbia River Basalt Group lava flows in the bluffs overlooking East Kamiah. The Heart of the Monster rock formation itself was formed from these lava flows. As described in the White Bird Battlefield and Spalding site sections, there is little potential for fossils in these basalts, and fossiliferous interbeds are not yet known from the East Kamiah area. Rember and Bennett (1979) and Weisz et al. (2003) also map Quaternary (Holocene) alluvial deposits along the banks and flood plain of the Clearwater River within the East Kamiah area. These deposits are characterized by silts, sands, and gravels associated with the modern Clearwater River and slightly older river and floodplain sediments. Paleontological resources are not known from these deposits.

Pleistocene-aged deposits near the western edge of the town of Kamiah produced a few bones and a partial tusk from a mammoth discovered in the 1950s and excavated in 1995 (S. Simler, personal communication, 2005). The material, found on private land, was excavated by the University of Idaho under the direction of Lee Sappington and is currently on display at the Lewis County Historical Society Museum in Kamiah. Similar material is not known from the East Kamiah area.

BEAR PAW BATTLEFIELD

Bear Paw Battlefield is located about 16 miles south of Chinook, Montana, along Cleveland Road (County Highway 240). The National Park Service recently (April 2005) completed a land transfer of Chief Joseph Battleground of the Bear's Paw State Monument, from the state of Montana to the NPS, establishing all 190 acres of Bear Paw Battlefield under NPS administration (L. Garrett and R. West, personal communication, 2005). Schmidt et al. (1964) map three geologic units within Bear Paw Battlefield, the Late Cretaceous Judith River Formation, Quaternary (Pleistocene) glacial ground moraine, and Quaternary (Recent/Holocene) alluvium.

Judith River Formation (Late Cretaceous)

The Late Cretaceous-aged Judith River Formation, part of the Montana Group, is mapped by Schmidt et al. (1964) in isolated exposures in the northern and southern reaches of the site. Bergantino and Porter's (2002) smaller scale 1:100,000 map shows the Judith River Formation throughout the vast majority of the site without the glacial deposits of Schmidt et al. (1964). In the Bear Paw Battlefield area, the formation is characterized by a sequence of sandstone, siltstone, and claystone, generally light gray in color (Schmidt et al. 1964). These sediments are associated with the terrestrial "coastal plain" deposits, and some marine sandstones, of the Cretaceous Interior Seaway (e.g. Gill and Cobban 1973, Sahni 1972).

Invertebrate, vertebrate, and plant fossils are known from the Judith River Formation in central Montana. In fact, the Judith River Formation is one of the most well-known fossiliferous formations in the western United States. The Judith River Formation provided some of the first Cretaceous, nonmarine fossils (including dinosaurs) studied by the pioneers of American paleontology, Ferdinand Vandiveer Hayden, Joseph Leidy, Edward Drinker Cope, and Othniel Charles Marsh in the middle-late 1800s. Sahni (1972) and Montenallo (1992) present brief summaries of the early paleontological work performed along the Missouri River between the mouth of Judith River and Armell's Creek.

The invertebrates of the Judith River Formation include approximately 10 species of freshwater pelecypod (clam-like bivalves) mollusks and approximately 15 species of freshwater gastropods (Sahni 1972 referencing Russell 1964). Both Schmidt et al. (1964) and Bergantino and Porter (2002) describe oyster coquina (fossil hash) layers which are common within the upper portion of the Judith River Formation.

The vast majority of paleontological material studied from the Judith River Formation in Montana is from vertebrates. Sahni (1972) summarizes the vertebrate fauna known from the formation at that time and numerous articles have been published in the last 30 years describing vertebrate material from the formation. Sahni's (1972) compendium includes freshwater skates and bowfin, gar, bonefish, and an aspidorhynchiformid fish. Amphibians include toads, frogs, and newts. Softshell turtles, the reptile *Champsosaurus*, a crocodile, an alligatoroid, and a variety of lizards round out the non-dinosaurian reptiles. The dinosaurs found within the formation, like most of the vertebrates, are primarily known from teeth and incomplete skeletons. Coelurosaurs (advanced bipedal carnivores), hadrosaurs (duckbilled dinosaurs), pachycephalosaurs (bone-headed dinosaurs), ceratopsians (horned dinosaurs), and nodosaurs (armored dinosaurs) are all known from the formation. The mammalian fauna of north-central Montana, mostly represented by teeth, is summarized by Montenallo (1992) and includes a diverse assemblage of commonly found multituberculates (extinct, rodent-like mammals) and metatherians (marsupials) and less common eutherians (placental mammals) and "tribotheres" (teeth that do not fit the definition of either eutheria or metatheria).

Fossils from the Judith River Formation are not yet known from within Bear Paw Battlefield, although they have been found in areas surrounding the site (R. West, personal communication, 2005). The topography of the battlefield is mostly rolling hills and grassland prairie with very limited rock exposures (R. West, personal communication, 2005). Generally the extensive paleontological resources of the Judith River Formation are found in highly erosive, "badlands" type topography not found in the battlefield. The Blaine County Museum, which also serves as the interim visitor center for Bear Paw Battlefield, houses a large collection of fossils discovered in the local area.

Glacial Ground Moraine (Pleistocene)

Schmidt et al. (1964) map Quaternary (Pleistocene/Ice Age) glacial ground moraine over most of the battlefield site. The glacial ground moraine is characterized by light gray clay-rich to sandy and pebble till. "Till" is the geological term for material "bulldozed" and ground up by glacial movement and subsequently deposited. Erratics, literally out-of-place rock material, from the Cleveland quadrangle originated in Canada and was brought to the local area by these glaciers (Schmidt et al. 1964). Due to the extreme stresses associated with glacial transport and destruction of the source material, paleontological resources are extraordinarily rare in till deposits, and none are reported by Schmidt et al. (1964).

Alluvial Deposits (Holocene)
The Quaternary (Recent) alluvium deposits mapped by Schmidt et al. (1964) within the park are found along the major creeks and drainages within Bear Paw Battlefield site. As they are modern deposits of gravel, sand, silt, and clay, paleontological material is not known from the alluvium.

TOLO LAKE
Tolo Lake, managed by the Idaho Department of Fish and Game, is located approximately 5 miles west of Grangeville, Idaho. The shallow lake was drained in the early 1990s for rehabilitation (deepening) and restocking with fish. During the fall of 1994, heavy equipment operators unearthed fossil mammoth bones and tusk material. A preliminary excavation began shortly after discovery, with an intensive excavation following during the summer of 1995.

Lake Sediments (Pleistocene)
Miller et al. (1998) present a detailed report on the geology and paleontology of the Tolo Lake fossil site, and unless otherwise cited, the following summary is based on information from their report. Geologically, the lake is surrounded by basalts from the Grangeville unit of the Saddle Mountain Basalt, part of the extensive Miocene-age Columbia River Basalt Group (Gaston and Bennett 1979; Breckenridge et al. 1994; Miller et al. 1998). The sediments of the lake where the fossils were found are sandy, clayey silts likely Rancholabrean (late Pleistocene/Ice Age) in age.

During the course of the 1994 and 1995 excavations, over 400 well-preserved specimens of mammoth (*Mammuthus* sp. cf. *M. columbi*) tusk and bone, along with bison (*Bison antiquus*) bone were discovered. These specimens represent at least 10 different subadult or adult mammoths and at least three separate bison. One of the mammoths (Mammoth #1) was nearly 95% complete, missing only a number of small bones, and is likely the most complete mammoth yet discovered in Idaho. Mammoth post-cranial material, long bones (humerus, femur, etc.), and tusks were common. Bison material included a partial skull, horn core fragments, foot elements, vertebrae and ribs. Interestingly, the many mammoth and bison bones are the only fossils discovered in any significant amount. A few avian bones were discovered during the excavations and sediment cores revealed the presence of gastropods. Poorly preserved pollen was also documented from the lake sediments. The pollen assemblage was dominated by grasses, and indicated a prairie or meadow environment similar to that found in the area today (Miller et al. 1998 referencing Cummings 1995). The excavations at Tolo Lake sampled only a very small fraction of the lake bed, and it is very likely that many more specimens are still entombed in the lake (W. Akersten, personal communication, 2005).

Tolo Lake has since been refilled, making future excavations unlikely. However, the fossils recovered represent the “most important” fossil boneyard in northern Idaho (Breckenridge et al. 1994). The excavations generated considerable public interest (e.g. Tallent 1994a,b,c) and nearly two thousand people visited the interpretive center set up on-site by the National Park Service (E. Gormley, written communication, 1994). The Idaho Museum of Natural History in Pocatello is the primary repository for Tolo Lake fossil material (W. Akersten, personal communication, 2005). The museum’s “Raising the Tolo Lake Mammoth” exhibit includes a reconstruction of the dig and a number of fossils (L. Deck, personal communication, 2005). The University of Idaho (Moscow) also has a number of Tolo Lake fossils on loan (W. Akersten, personal communication, 2005). In addition, the Grangeville Chamber of Commerce Visitor Center has a fossil tusk and humerus on display, along with a life-size mammoth skeleton reconstruction (W. Akersten, personal communication, 2005).

COOPERATIVE PROJECTS

- Tolo Lake Mammoth Excavation – Cooperative effort between University of Idaho (Moscow), Idaho Natural History Museum (Pocatello), National Park Service (NEPE), Idaho Department of Fish and Game, and many local entities (1994-1995).

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WHITMAN MISSION NATIONAL HISTORICAL SITE

Whitman Mission National Historical Site (WHMI) was originally authorized as Whitman National Monument on June 29, 1936. The site was redesignated Whitman Mission National Historical Site on January 1, 1963. WHMI preserves the site of Marcus and Narcissa Whitman's mission at Waiilatpu ("Place of the Rye Grass"). The mission, in addition to bringing Christianity to the Cayuse Indians, was an important way station along the Oregon Trail. Deep cultural differences and a measles epidemic lead to the killing of the Whitmans and other residents of the mission in 1847.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for WHMI as of the preparation of this report (spring 2005). Likewise, paleontological scoping sessions have not been completed for the park. Geological scoping sessions, however, have been completed for the park in spring of 2004. These scoping sessions were held under the direction of the NPS Geological Resources Division (T. Connors, personal communication, 2004). There are no paleontological specimens in the park's museum collections.

Whitman Mission National Historical Site is located within the "Channeled Scabland" of Washington's Columbia Plateau. The unique landforms found throughout the area are the result of two well-documented catastrophic events. The first is the eruption of an extraordinary volume of lava from the Columbia River Basalt Group about 17 million years ago. The second being a series of massive glacial outburst floods beginning roughly 15,000 years ago. Sediments from these glacial outburst floods, formally known as the Touchet Beds, are found within WHMI. Modern alluvial deposits are also mapped within the park. Descriptions of the geology and landforms of the Channeled Scabland are presented in numerous articles. The additional references section lists a sample of those references. J. Harlan Bretz championed the association of large outburst floods to the modern geomorphology, and came up with the "Channeled Scabland" moniker, in a series of papers published between 1923 and 1969.

Touchet Beds (late Pleistocene/Ice Age)
The late Pleistocene Touchet Beds are mapped within WHMI on Memorial Hill by Schuster (1994). Robert Carson (personal communication, 2005; Carson and Pogue 1996) and Patrick Spencer (personal communication, 2005), of Whitman College, also report the likely presence of these beds within the park. Vegetation, however, covers most of the park (R. Trick, personal communication, 2005), and may limit the exposure of the Touchet Beds. The geology, sedimentary features, depositional history, and varied interpretations of the Touchet Beds are described in detail in a number of publications including Flint (1938), Baker (1973), Waitt (1980), Bjornstad (1980), Carson and Pogue (1996), and Benito and O'Connor (2003), among many others. The Touchet Beds are believed to represent slackwater (ponded floodwater) deposits from dozens of massive jökulhlaups (e.g. Waitt 1980). Jökulhlaups are large outburst floods caused when a glacially dammed lake (such as ancient Glacial Lake Missoula) drains catastrophically. These floods are unlike anything in modern history, with estimated flows of 21,000,000 cubic meters per second, or about 18 cubic miles of water per hour (Baker 1973; Carson and Pogue 1996)!

Geologically, the Touchet Beds consist of approximately 40 individual beds, each containing slackwater flood deposits with coarse sediment (pebbles, gravel, sand) near the base, with finer sediments (silt) near the top. This sequence is vertically repeated, and thus, the collective deposits are called rythmites. Each rhythmite is thought to represent a discrete flood event, which probably lasted for only a matter of hours, followed by decades of subaerial environments (Waitt 1980). Many earlier publications interpreted the Touchet Beds as representing one or only a few major floods. An excellent exposure of these beds is located in Burlingame Canyon ("Little Grand Canyon", about 5 miles west/southwest of WHMI south of Lowden) and described in many articles, such as Waitt (1980) and Spencer (1989), listed in Carson and Pogue (1996).

A wide variety of invertebrate and vertebrate fossils are found within the Touchet Beds, and likely represent animals that were living in or on the Touchet sediments during the decades between jökulhlaups. Near Mabton, about 100 miles northwest of Walla Walla, Waitt (1980) described an invertebrate assemblage from a "water-laid dune of sand" in the Touchet Beds consisting of freshwater bivalves (*Pisidium* sp.), gastropods (*Valvata* sp., *Gyraulus* sp. and others), and charophytes (blue-green algae, *Chara* sp.). Waitt (1980) also listed a tentatively identified fish vertebrae from this locality.

Other vertebrates have been found in the Touchet Beds throughout southcentral and southeastern Washington. For example, Waitt (1980) lists six vertebrate localities that have produced partial skeletons, isolated bone fragments, and/or tusk and teeth of birds, rodents, mammoths, and bison. Indeed, mammoths have been found at a number of Touchet Beds exposures summarized by Barton (1999). A partial mammoth skeleton and additional vertebra was found in Yakima Valley about 90 miles northwest of Walla Walla (Waitt 1980). Newcomb and Repenning (1970) found a number of *Mammuthus* bone fragments in Artesian Coulee near Dead Canyon some 80 miles southwest of Walla Walla. At West Richland, about 60 miles northwest of Walla Walla, Martin et al. (1983) reported on a fossil assemblage that included one of the best-preserved mammoth skeletons ever found in Washington. Associated with the mammoth were an amphibian (*Scaphiopus* sp.), snake (*Serpentes* sp.), birds (*Athene* and a Fringillid/finch), rabbit (*Lepus* sp.), rodents (*Spermophilus*, *Perognathus*, *Thomomys*, *Peromyscus*, *Onychomys*, and a Microtinid), an unidentified carnivore, and an unidentified artiodactyl (Martin et al. 1983). Interestingly, some of these smaller remains were found in coprolites (fossil feces) indicating predation of those species. Martin et al. (1983) also investigated fossil pollen from the West Richland site. Closer to WHMI, Scott and Clem (1967) reported a "fairly complete" *Mammuthus* skeleton found about seven miles west of the park.

Spencer (1989) described a small rodent assemblage collected from the Touchet Beds along the Touchet River about three miles north of the town of Touchet. This site is stop 14 of Carson and Pogue (1996). Spencer's (1989) fauna includes two skulls from the Sciuridae family (ground squirrel), one Cricetidae (vole) skull, a partial Heteromyidae (kangaroo rat) skull, and a number of post-cranial remains from at least four other individuals within the Rodentia. One of the ground squirrel skulls is particularly well-preserved. Abundant rodent burrows are reported throughout the Touchet Beds at Spencer's (1989) site as well as at Burlingame Canyon (Waitt 1980; Spencer 1989). Spencer (personal communication, 2005) even discovered an articulated ground squirrel skeleton in one such burrow.

All of the fossils were likely found below a distinctive ash (tephra) layer from Mt. St. Helens ("Set S") which has been dated at approximately 13,000 years before present (Waitt 1980 referencing Mullineaux et al. 1975, 1978). Therefore, the fossil material, and the Touchet Beds themselves are at least 13,000 years old.

Fossils are not yet known from the Touchet Beds within WHMI (P. Spencer; R. Carson; R. Trick, personal communication, 2005). However, future field studies may reveal their presence in the park.

Alluvium (Pleistocene/Ice Age and Holocene/Recent)
As mapped by Schuster (1994) most of WHMI is situated on Pleistocene or Holocene alluvial deposits. These sediments include clay, silt, sand, and gravel of varying sizes and composition.

Fossils are not known from these essentially modern alluvial deposits near WHMI. However Lyman (1986) did describe *Ursus* (bear) material found throughout eastern Washington, some associated with archeological sites. Ages for the *Ursus* material ranges from approximately 500-9,000 years old (Lyman 1986).

COOPERATIVE PROJECTS

- Geologic Scoping of Whitman Mission National Historic Site – National Park Service Geologic Resources Division (Spring 2004).

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DATA SETS

DS-WHMI-XXX Whitman Mission National Historical Site Paleontological Archives. 5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

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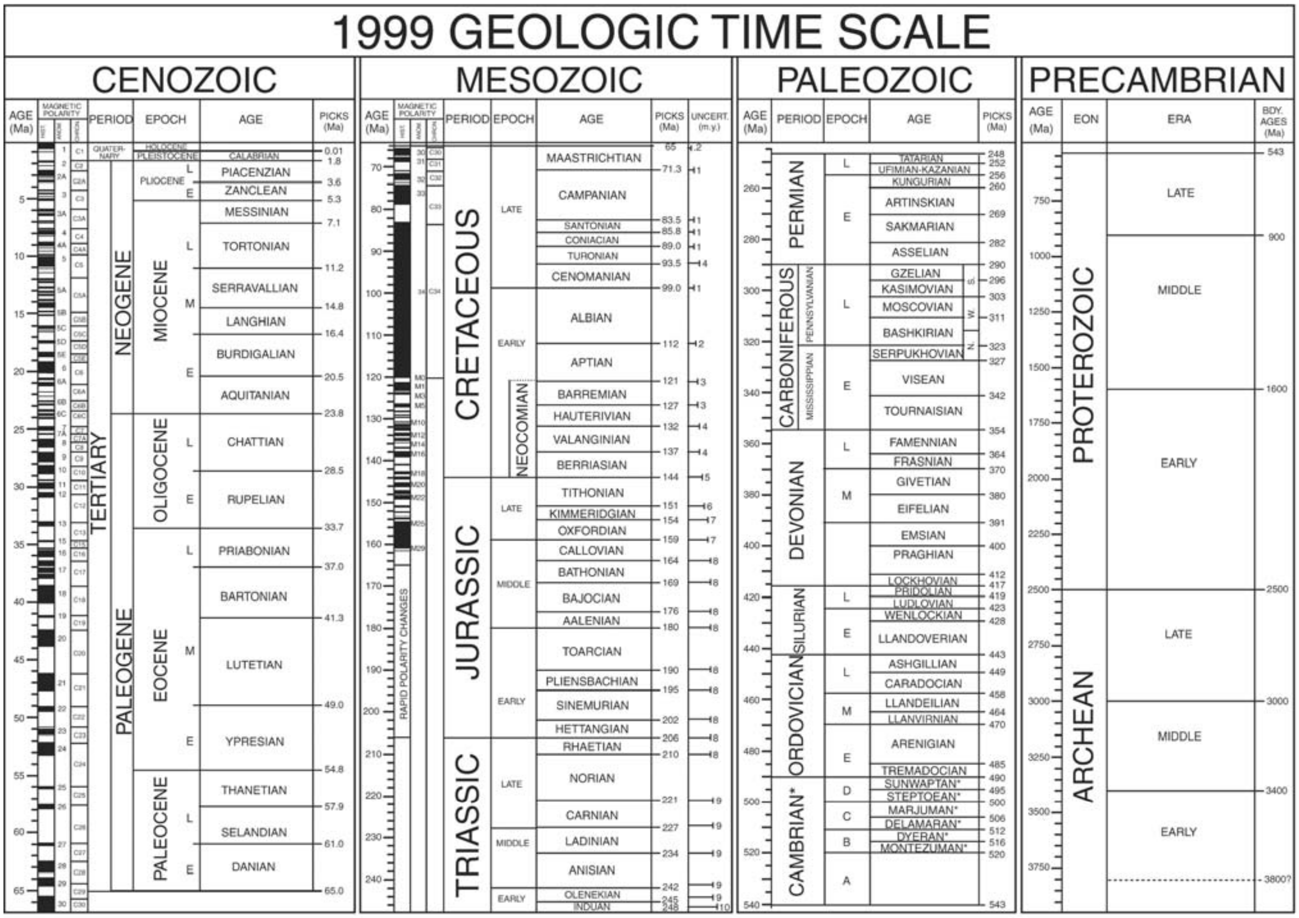
APPENDIX A: GEOLOGIC TIME SCALE



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*International ages have not been established. These are regional (Laurentian) only. Boundary Picks were based on dating techniques and fossil records as of 1999. Paleomagnetic attributions have errors, Please ignore the paleomagnetic scale.

Sources for nomenclature and ages: Primarily from Gradstein, F., and Ogg, J., 1996, *Episodes*, v. 19, nos. 1 & 2; Gradstein, F., et al., 1995, SEPM Special Pub. 54, p. 95–128; Berggren, W. A., et al., 1995, SEPM Special Pub. 54, p. 129–212; Cambrian and basal Ordovician ages adapted from Landing, E., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 329–338; and Davidek, K., et al., 1998, *Geological Magazine*, v. 135, p. 305–309. Cambrian age names from Palmer, A. R., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 323–328.

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Note: Picks (Ma) = age of the geologic time unit boundary in millions of years (Ma).

This timescale is available online as a PDF: http://www.geosociety.org/science/timescale/timescl.pdf