AN INVENTORY OF PALEONTOLOGICAL RESOURCES ASSOCIATED WITH NATIONAL PARK SERVICE CAVES

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Technical Report NPS/NRGRD/GRDTR-01/02

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Cover Illustration
Photo of bear claw marks in the cave wall at Oregon Caves National Monument, Oregon.

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This publication was inspired by
and is dedicated to our friend

Bob Higgins

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Abstract

More than 3,600 caves and karst resources have been identified in at least 79 units of the National Park System. In 1998, the National Park Service Geologic Resources Division initiated a servicewide inventory of paleontological resources occurring in association with these caves. The inventory documented at least 35 park areas that preserved fossils within cave resources.

Cave-paleontological resources are identified in two categories: 1) fossils preserved within the cave-forming bedrock, and 2) fossils accumulated within the caverns, chambers, or other openings in karst systems.

Caves occur in both karst and non-karst areas. Karst caves, and features within them such as stalactites and stalagmites, are formed by a variety of processes. These processes include the dissolution and erosion of sedimentary and evaporitic rocks, and later deposition of minerals from the dissolution process. Within limestones, the remains of marine invertebrate and vertebrate fossils are typically preserved. Paleozoic limestones constitute the parent rock in which many cave and karst features develop in NPS administered areas. Therefore, the fossilized remains of Paleozoic fauna are often the most common types of paleontological resource associated with caves. Caves also form as the result of lava flows (lava tubes), wave action (littoral caves), and by the fracturing of rock (earth cracks).

Cave feature development is documented from the Holocene back to the Eocene. Caves, sinkholes, solution tubes, and other karst features attract and can trap animals. Pleistocene and Holocene vertebrate remains are abundant in many caves. Rich deposits of fossil bone can develop either through the accumulation of remains associated with organisms inhabiting the cave, such as *Neotoma* (packrats), or through a variety of transport mechanisms.

INTRODUCTION

In an effort to better document occurrences of paleontological resources within units of the National Park Service (NPS), two inventory strategies were developed and implemented during the late 1990s. The primary objective for each of the inventory strategies is to compile baseline paleontological resource data to enhance the scientific understanding and management of these non-renewable resources.

Fossils, the remains of life preserved in a geologic context, have been identified in over 150 units of the National Park Service. Collectively these fossils provide a detailed story for the history of life. The fossil record preserved within the national parks, monuments, and other designated areas ranges from Precambrian stromatolites at Glacier National Park to the ice age mammals buried in cave sediments at Guadalupe Mountains National Park.

The first inventory strategy implemented by the National Park Service Geologic Resources Division was directed to individual parks. This strategy was designed to survey all occurrences of fossils, including fossil plants, invertebrates, vertebrates, and trace fossils, within each park. This comprehensive park-level inventory strategy was piloted at Yellowstone National Park in 1996 (Santucci, 1998). The Yellowstone Paleontological Survey involved literature reviews, examination of museum collections, and extensive field inventories. Over twenty stratigraphic units were identified in Yellowstone that preserved fossils. The data presented an opportunity to view the ancient ecosystems of Yellowstone.

Perhaps one of the most significant aspects of the survey is that it addresses the paleontological resources and the paleontological resource management issues from the perspectives of park managers. In addition to their scientific values, park fossils are considered in terms of their educational values, protection strategies, curatorial requirements, research potential, and other management concerns. The final published report not only consolidates the comprehensive baseline paleontological resource data for the park, in the form of fossil locality maps and fossil species lists, but also provides guidance and recommendations for park staff to integrate paleontological resources into park planning and operations.

Park-specific paleontological resource inventories have been accomplished for two large parks, including Yellowstone National Park and Death Valley National Park (Nyborg and Santucci, 1999), and two smaller parks, including Bighorn Canyon National Recreation Area (Santucci et al., 1999) and Walnut Canyon National Monument (Santucci and Santucci, 1999). Similar park-specific paleontological resource surveys are underway in various parks in Alaska, Arches National Park, and Zion National Park.

The second inventory strategy involved the development of thematic paleontological resource inventories throughout the National Park Service. Thematic inventories focus on one category of fossils, for example fossil plants, and attempt to locate which units of the National Park Service preserve these specific resources. The first thematic resource inventory accomplished involved a servicewide survey of fossil vertebrate tracks occurring in NPS units (Santucci et al., 1998). This report constitutes a thematic paleontological resource inventory of fossils associated with National Park Service caves.

Thematic paleontological resource inventories present many challenges to undertake. Seldom are there easily searchable sources of information that compile this specific resource information for the parks. Typically, these labor-intensive inventories involve searches of individual park records and museum collections, along with searches of outside institutions and museum repositories. Phone and electronic mail interviews with park staff and scientists also helped to elucidate information. These thematic inventories also serve to uncover information that is often not published or documented, and frequently lost.

The data compiled through the thematic paleontological resource inventories sometimes inspires further scientific research and helps to link specialists with park staff. More typically the new information increases park management's awareness of the scope and significance of fossils within their parks, and in turn promotes increased levels of protection and interpretation.

THE SIGNIFICANCE OF PALEONTOLOGICAL RESOURCES ASSOCIATED WITH CAVES

As a result of this servicewide inventory of paleontological resources associated with National Park Service caves, a number of significant observations were noted. Caves provide opportunities for, or conditions conducive to, the exposure and/or preservation of fossils. Although caves have long been recognized by paleontologists as valuable sources for fossils, there has been little research related to taphonomy and caves.

One of the most obvious features shared by both karst and non-karst caves, including caverns, fissures, fractures, shelters, tubes, and other rock cavities, is that they all provide windows into rock units. In some cases, a cave may provide the best or only exposure of a subsurface geologic unit. Likewise, fossils preserved in a cave-forming rock unit may in turn become exposed through cave-forming processes.

The relatively constant temperature, humidity, and other environmental conditions often associated with caves are conducive to long-term preservation of organic material. The reduction or absence of direct sunlight in caves ultimately reduces the adverse effects of radiation on fossil remains. Fossils within caves are typically sheltered, to some degree, from the forces of weathering and erosion. In a few rare cases, footprints and claw marks are preserved in cave dust and sediments exposed on the cave floor for thousands of years. The ancient remains may be transported into inaccessible cavities that can provide refuge from trampling, scavenging, scattering, or other disturbances.

Within caves in arid regions, where humidity is usually very low, preservation of remains can occur through desiccation or mummification. This scenario enables the preservation of soft tissues, hair, dung, and other remains that normally decay rapidly. Caves in humid regions may contain mineral-rich waters that aid in preservation of fossil material.

Caves sometimes preserve deposits of ancient dung. Occasionally these deposits are stratified. Dung deposits often yield extremely valuable information for paleontological research and paleoenvironmental reconstruction. Fossilized dung from herbivores may contain pollen and plant fragments that indicate both diet and past floral assemblages. Carnivore and raptor scats or pellets may contain the remains of microvertebrates or insects. Dr. Paul Martin (written communication, 1975) reported that of the 10 caves known worldwide that contain sloth dung, six of these caves are within national parks of the United States (two in Grand Canyon National Park and four in Guadalupe Mountains National Park).

Although the fossil record of bats is extremely limited, large collections of fossil bats have been recovered from Pleistocene and Holocene cave deposits. Caves obviously provide the most important localities for preservation of cave-dwelling organisms, especially bats. The small and delicate bones of bats are almost unknown from environments outside of caves.

The occurrence and accumulation of Pleistocene and Holocene fossils present some interesting taphonomic interpretations. Fossil remains can accumulate in caves as organisms die in the cave or are transported into the cave. The mechanisms of transport can be attributed to the behavior of other organisms or a variety of sedimentary processes. Collections of fossil mammals are often associated with features called natural traps. These animals fall into and become trapped in these openings in the ground surface. Raptors and predators frequently transport prey species into caves and generate accumulations of bones. *Neotoma* (woodrat), also referred to as packrats, are responsible for the redistribution of fossil material in the building and dismantling of their nests in caves and shelters. These accumulations of bones and plant material, called middens, are important sources of paleontological data for researchers. Emslie (1998) presents a discussion of cave taphonomy and the composition of vertebrate fossil assemblages.

Fossils recovered from stratified deposits in caves can yield successional and paleo-biogeographic data. Stratified cave deposits sometimes provide sequences of microvertebrate remains that show successional relationships relative to glacial advance and retreat during the ice ages. The transition of boreal and temperate species assemblages in the stratified cave deposits has been interpreted as periglacial displacement during the Pleistocene (Guilday and Hamilton, 1978). Occurrences of extralimital species, species that are outside of their normal biogeographic range, can provide significant information about past changes in climate, habitat, species distribution, or behavior.

Normally, most caves have a relatively short life span. Data available from paleontological resources can yield information regarding the cave's longevity and may aid in reconstruction of the cave history. Similarly, fossils found in association with archeological resources can provide archeologists with valuable information.

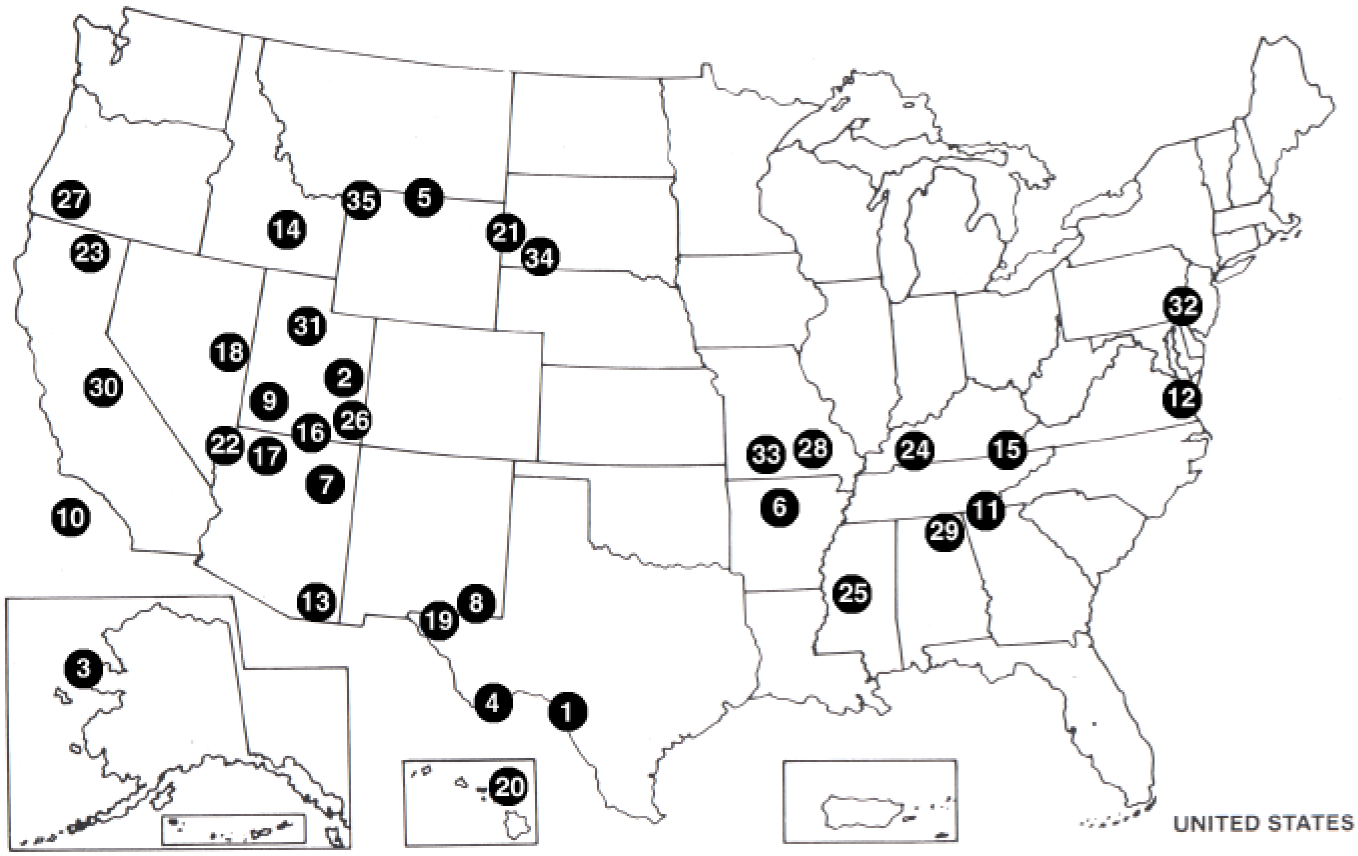
PROTECTION OF PALEONTOLOGICAL RESOURCES WITHIN NATIONAL PARK SERVICE CAVES

During this thematic paleontological resource inventory, thirty five units of the National Park Service were identified with paleontological resources associated with cave/karst resources (Figure 1). Presumably, over time additional paleontological resources will be identified in association with park caves.

Generally locality information and other data related to paleontological and cave/karst resources data are considered sensitive. Specific locality information and the names of certain caves are not provided in this report. Federal laws and National Park Service regulations and policies support restricted access to sensitive natural and cultural resource localities.

There are a number of documented incidents where paleontological resources within NPS caves have been stolen or vandalized. Perhaps the best-known example of paleontological resource loss in a NPS cave occurred at Rampart Cave, Grand Canyon National Park. In 1976, the extensive fossiliferous dung deposits were almost completely destroyed by a human-caused fire. Recent work by Mary Carpenter (Northern Arizona University) reveals some bone material survived the devastating fire.

We believe that a strong resource protection message should accompany this report. Our goal is to help promote responsible stewardship of nonrenew-



1 Amistad National Recreation Area
2 Arches National Park
3 Bering Land Bridge National Preserve
4 Big Bend National Park
5 Bighorn Canyon National Recreation Area
6 Buffalo National River
7 Canyon de Chelly National Monument
8 Carlsbad Caverns National Park
9 Cedar Breaks National Monument
10 Channel Islands National Park
11 Chicamauga/Chattanooga National Military Park
12 Colonial National Historical Park
13 Coronado National Memorial
14 Craters of the Moon National Monument
15 Cumberland Gap National Historical Park
16 Glen Canyon National Recreation Area
17 Grand Canyon National Park
18 Great Basin National Park
19 Guadalupe Mountains National Park
20 Haleakala National Park
21 Jewel Cave National Monument
22 Lake Mead National Recreation Area
23 Lava Beds National Monument
24 Mammoth Cave National Park
25 Natchez Trace Parkway
26 Natural Bridges National Monument
27 Oregon Caves National Monument
28 Ozark National Scenic Riverway
29 Russel Cave National Monument
30 Sequoia/Kings National Park
31 Timpanogos Cave National Monument
32 Valley Forge National Historical Park
33 Wilson's Creek National Battlefield
34 Wind Cave National Park
35 Yellowstone National Park

FIGURE 1. Map identifying National Park Service units referenced in this paper that contain paleontological resources associated with caves.

able cave fossils. This can be accomplished through management of fossils *in situ* within caves or through strategic sampling techniques that minimize adverse impacts to other resources.

AMISTAD NATIONAL RECREATION AREA

Amistad National Recreation Area (AMIS) is a reservoir on the Rio Grande River. The site is managed under a cooperative agreement with the International Boundary and Water Commission.

Cueva Quebrada and Conejo Shelter are two caves located within Amistad National Recreation Area. Cueva Quebrada is a small cave measuring approximately 30 feet (9 meters) by 15 feet (5 meters) located on the north side of a small tributary canyon of the Rio Grande. Cueva Quebrada is immediately east of the larger Conejo Shelter, which has been the focus of archeological excavations. A number of stratigraphic layers have been identified within Cueva Quebrada. Layer I, the surface of the cave, consists of a white limestone dust with no bones or archeological artifacts. Layers II through IV are made up of brown and gray limestone dust, receiving its coloration from the varying amounts of charcoal in the dust. Layer V is similar to the above layers, but has a light yellow color. Faunal remains are found in layers II through IV.

A wide variety of taxa have been described from within Cueva Quebrada. The described taxa include an unidentifiable chiropteran, *Spilogale* sp. (spotted skunk), *Mephitis mephitis* (striped skunk), *Canis* sp. (dog), *Urocyon cinereoargenteus* (gray fox), *Bassariscus* cf. *astutus* (ringtail cat), *Arctodus simus* (short-faced bear), *Ammospermophilus interpres* (Texas antelope squirrel), *Thomomys bottae* (Botta's pocket gopher), *Pappogeomys castanops* (Mexican pocket gopher), *Perognathus* sp. (pocket mice), *Baiomys taylori* (northern pygmy mouse), *Onychomys leucogaster* (northern grasshopper mouse), *Peromyscus* sp. (deer mice), *Neotoma* sp. (packrats), *Sylvilagus* sp. (cottontails), *Lepus* cf. *californicus* (black-tailed jackrabbit), *Equus* cf. *scotti* (horse), *Equus francisci* (horse), cf. *Camelops* (camel), *Navajoceros fricki* (American mountain deer), *Stockoceros* sp. (antelope), and *Bison* sp (bison). (Lundelius, 1984).

Lundelius (1984) reports three radiocarbon dates (one from charcoal and two from wood) from layers yielding bone fragments. The dates yielded from the samples were 12,280 years B.P., 13,920 years B.P. and 14,300 years B.P., indicating a Late Pleistocene assemblage. The fauna exhibits an interesting taphonomy. Much of the bone is burned, often to such a degree as to remove all organic material and in some cases plastically distorting the bone (Lundelius, 1984). This burning of the material seems to indicate human activity in the cave, although evidence of butchering and fire pits is not prevalent (Lundelius, 1984).

ARCHES NATIONAL PARK

Arches National Park (ARCH) was established to preserve the extraordinary products of erosion including arches, windows, pinnacles, pedestals, and other landforms in southeastern Utah.

Within Arches National Park is a rock shelter known as Bison Alcove. Bison Alcove is a large south-facing dry rock shelter carved into the Jurassic Entrada Sandstone. The entrance to the shelter is approximately 33 feet high by 72 feet long (10 meters high by 22 meters long) (Mead et al., 1991). While much of the interior is taken up by large roof spall boulders, which have fallen from the ceiling, approximately 43 feet (13 meters) of horizontal distance can be traveled with relative ease.

Neotoma (packrat) middens are common throughout Bison Alcove and contain Pleistocene-age needles from *Pinus flexilis* (limber pine), *Pseudotsuga menziesii* (Douglas fir), and *Ceratoides lanata* (winterfat) (Mead et al., 1991; Sharpe, 1991). The most abundant large mammal remains in Bison Alcove are those of *Ovis canadensis* (bighorn sheep) (Mead et al., 1991). The remains include a horncore with sheath and a number of additional skeletal remains and fragments. Based on the number of sacra found, at least two individuals are represented at the locality. Charring and fragmentation of some remains provide evidence for human interaction (Mead et al., 1991). In addition, *Bison bison* (bison) remains were found in the alcove. These remains represent at least one individual, possibly a young adult based on size of the recovered remains. The remains include a hornsheath (apparently part of an artifact) as well as additional skeletal remains, and one keratin hoof. These do not show evidence of butchering. Radiocarbon analyses yield dates of 1405-1420 A.D. and 1535-1605 A.D. (Mead et al., 1991). All specimens are curated in the National Park Service repository at Northern Arizona University.

A mammoth mandible was discovered in a separate, shallow alcove in the park (Figure 2). No additional mammoth remains have been reported. The mandible is currently curated into the National Park Service collections of the Southeast Utah Group (S. Duffy, personal communication, 2001).

FIGURE 2. Mammoth mandible discovered in a shallow alcove at Arches National Park, Utah.

BERING LAND BRIDGE NATIONAL PRESERVE

Bering Land Bridge National Preserve (BELA) was established to preserve a remnant of the land bridge that once connected Asia with North America more than 13,000 years ago. The Preserve has an abundance of both archeological and paleontological resources. The area has been designated as a National Historic Landmark.

Within Bering Land Bridge National Preserve is an assemblage of caves referred to as the Trail Creek Caves. There are many caves in the Trail Creek area, which range from small solution cavities to some shelters large enough for human occupation. The features are found within a 300 foot (91 meters) tall limestone escarpment along the ephemeral Trail Creek. The limestones along Trail Creek are part of a Cambrian-Ordovician unit dominated by marble and quartz-graphite schist. Recrystallized radiolarians can be found locally and Ordovician conodonts have been obtained from the upper part of the unit.

The Trail Creek Caves have been the subject of much archeological interest with sites dating from the early Holocene (9,100 years B.P.) to very recent times (100 years B.P.). Helge Larsen excavated 13 caves in 1948 during archeological inventories of the caves. Subsequent archeological excavations have revealed paleontological resources in association with the cultural resources. Preliminary excavations of five caves yielded 2,581 bone fragments (Vinson, 1988). The remains represent taxa that range from the Late Pleistocene through the Recent. Mammalian fauna include *Lemmus, Microtus, Sorex* (shrew), *Spermophilus, Lepus, Vulpes*, *Equus*, *Ursus*, *Rangifer*, and *Mammuthus* (Vinson, 1988). *Rangifer* (caribou) remains are common in the caves and probably are relatively recent in age (Schaaf, 1988; Vinson, 1988). *Vulpes* (fox), *Spermophilus* (ground squirrel), and *Lepus* (hare) remains are also common (Vinson, 1988). *Ursus* (brown bear), *Ovis* (sheep), *Equus*, *Bison*, and *Mammuthus* (mammoth) specimens are rare, often represented by only a few bone fragments (Vinson, 1988). Avian remains are also rare. A *Mammuthus* scapula was radiocarbon dated to approximately 11,360 years B.P. A *Mammuthus* vertebral column yielded a radiocarbon date of approximately 14,270 years B.P. (Vinson, 1988). Worked bison and horse bone from the cave site has been dated to 15,750 years B.P. (Kurtén and Anderson, 1980). The sheep, bison, and horse remains may date to the late Pleistocene or Holocene (Schaaf, 1988). Some of the faunal remains may have been introduced into the caves by predators or by humans (Schaaf, 1988).

BIG BEND NATIONAL PARK

Big Bend National Park (BIBE) was established to preserve the desert and mountains within the great bend of the Rio Grande River. The Park was established as a Biosphere Reserve in 1976. Significant Cretaceous and Early Tertiary fossil plant and vertebrate localities are preserved in the Park. Paleontological research has been conducted in the Park since the 1930s.

Many of the Cretaceous limestones of Big Bend are cavernous, notably the Upper Cretaceous Santa Elena Formation. The caves generally are small in size and somewhat inaccessible.

In the Chisos Mountains there is an important paleontological locality within Mule Ears Peak Cave. This cave is formed within a cluster of Tertiary intrusive dikes associated with the Chisos Formation. In 1933, Mule Ears Peak Cave #1 was excavated by Frank M. Setzler from the U.S. National Museum (D. Corrick, personal communication, 2001). The remains of twenty-seven *Gymnogyps californianus* (California condor) were collected during the excavation. Radiocarbon analysis of condor material from Mule Ears Cave yielded a date of 12,580 years B.P. (Emslie, 1987).

A cave survey is currently underway at Big Bend National Park. This survey is designed to more fully document both the paleontological and archaeological resources within the caves of Big Bend (D. Corrick, personal communication, 2001).

BIGHORN CANYON NATIONAL RECREATION AREA

Bighorn Canyon National Recreation Area (BICA) encompasses approximately 120,000 acres (486 square kilometers) within the Bighorn Mountains of north-central Wyoming and south-central Montana. The northwestern trending Bighorn Mountains consist of over 9,000 feet (2,743 meters) of sedimentary rock. The Mississippian Madison Limestone is a 705 to 740 foot (215 to 226 meters) thick marine unit that is well exposed in the recreation area. The Madison Limestone is highly fossiliferous and contains a diversity of marine invertebrates including horn corals, bryozoans, brachiopods, molluscs, snails, gastropods, lithopods, and crinoids (Santucci et al., 1999).

Numerous caves have been documented within the Madison Limestone in the Bighorn Mountains. Bighorn Cavern and Natural Trap Cave (located just outside of BICA) are two of the more well known caves formed in the Madison Limestone. Bighorn Cavern is approximately 12 miles in length (19 kilometers) and may be the longest cave in Montana, Wyoming, and Idaho. Bighorn Cavern is located on Little Mountain near the north end of the Bighorn Mountains in the national recreation area. Corals, clams, and brachiopods are found within the walls of Bighorn Cavern as part of a 350 million year old reef (Chadwick, 1999). The cavern has a sinkhole type entrance with a debris pile that could likely contain paleontological resources (J. Staebler, personal communication, 2001).

Additional information on Natural Trap Cave can be found in the section on Caves Near National Park Service Areas at the end of this paper.

BUFFALO NATIONAL RIVER

Buffalo National River (BUFF) was established to preserve one of few remaining unpolluted, free-flowing rivers in the lower 48 states. The National Park Service manages a 135 mile (217 kilometer) stretch of the river that includes multi-colored bluffs and numerous springs.

There are approximately 300 caves within Buffalo National River ranging in size from small shelters to caverns with passages over 12 miles (19 kilometers) in length (C. Bitting, personal communication, 2001). Caves are formed in many of the fossiliferous Paleozoic formations within the park. The Middle Ordovician Everton Formation is a 250-350 foot (76-107 meters) thick sandstone unit cemented by carbonate cements. Localized alternating beds of dolomite, limestone, and sandstone are present in the formation (McFarland, 1988). Stromatolites have been reported in the Everton Formation (C. Bitting, personal communication, 2001).

Crinoid fossils are known from a number of limestones in the park including the Ordovician Fernvale and Kimmswick formations, the Silurian St. Claire Formation and the Mississippian St. Joe Formation (McFarland, 1988). The Mississippian Boone Formation is quite fossiliferous containing corals, bryozoans, blastoids, crinoids, and occasional shark's teeth (C. Bitting, personal communication, 2001). The Mississippian Pitkin Formation and the Pennsylvanian Hale

Formation preserve the bryozoan *Archimedes*, crinoids, and the ammonite *Goniatites* (C. Bitting, personal communication, 2001). The Pennsylvanian Bloyd Formation has the ancient plant *Lepidodendron* and the Pennsylvanian Atoka preserves a variety of fossil plants (C. Bitting, personal communication, 2001).

Conard Fissure is a limestone fissure-fill feature in the Boone Limestone of the Ozark Mountains. Although the fissure is approximately a quarter-mile (0.4 kilometer) north of Buffalo National River, there is high potential for similar fissures to exist within the park boundary. The fissure is an important Pleistocene (Irvingtonian) locality, producing a large vertebrate fauna, similar to those described from Cumberland Cave, Maryland and also Port Kennedy Bone Cave in Valley Forge National Historical Area (see section on Valley Forge National Historic Park in this paper). Additional information about Conard Fissure can be found in the section on Caves Near National Park Service Areas at the end of this paper.

Ursus Tomb, located about 6 miles (10 kilometers) north of Conard Fissure, is a 140 foot (43 meter) deep pit within Buffalo National River. The pit is the only known cave at BUFF that preserves a bear skeleton (Figure 3) (C. Bitting, personal communication, 2001).

FIGURE 3. Bear skeleton preserved *Ursus* Tomb at Buffalo National River, Arkansas.

CANYON DE CHELLY NATIONAL MONUMENT

Canyon de Chelly National Monument (CACH) was established to preserve a scenic canyon of sheer red cliffs with caves containing the remains of American Indian villages built between 350 and 1300 A.D. Today Navajos live and farm in the canyon. The remains of a mylodontid are reported from a cave in Canyon de Chelly National Monument (Lindsay and Tessman, 1974; Harris, 1985).

CARLSBAD CAVERNS NATIONAL PARK

Carlsbad Caverns National Park (CAVE) was established to preserve a series of connected caverns, which contain one of the world's largest underground chambers. The park contains 94 known caves consisting of over 136 miles (219 kilometers) of passages and rooms. The park includes the deepest (Lechuguilla) and third longest cave (Carlsbad Cavern) in the United States (Vequist, 1997).

The geology of Carlsbad Caverns is very similar to nearby Guadalupe Mountains National Park (Hayes, 1964). Hill (1987) provides an excellent review of the geology of Carlsbad Cavern. Karst features have developed primarily in the Permian Capitan Limestone, with some cavern formation in the Artesia Group limestones. The Capitan Limestone is an enormous reef consisting of a framework of algae, sponge, and bryozoan fossils supporting a matrix of unbedded fine-grained limestone. This barrier reef formed around the perimeter of the Delaware Basin during the Permian, continuing for over 300 miles (483 kilometers). The back-reef limestones of the Permian Artesia Group (including the Tansill, Yates, and Seven Rivers Formations) are prominently bedded and contain a high percentage of locally eroded silt as well as gypsum (A. Palmer, 1995b).

Unlike many other caves that are formed through dissolution of limestone by carbonic acid from surface sources, Carlsbad Caverns was dissolved chiefly by sulfuric acid. This sulfuric acid was created when hydrogen sulfide rising from depth reacted with oxygen near the water table (A. Palmer, 1995b).

The cave-forming limestones in the park contain a rich assemblage of marine invertebrate fossils. Some of the limestones within the reef contain such an abundance of fossils these zones have been referred to as "fossil hash", or coquina. Algae, sponges, and bryozoans are abundant throughout the reef. Fusulinids, brachiopods, scaphopods, cephalopods, and crinoids are documented from the Permian limestones in the park (Black, 1953). Two species of trilobite have been identified at Carlsbad Caverns. A fine specimen of the trilobite *Anisopyge perannulata* is exposed near the elevator lobby at the park.

Rocks near the entrance to Carlsbad Cavern yielded the largest fossil sponge yet known from the Permian (Vequist, 1997). Dr. Kevin Rigby (Bringham Young University) discovered and described a number of new fossils from the park that are not previously known from the Permian of North America.

A large diversity of Pleistocene/Holocene vertebrates have been documented from the caves within Carlsbad Caverns National Park. Fossil remains are known primarily from Carlsbad Cavern, Lechuguilla Cave, Slaughter Canyon Cave, and Musk Ox Cave. Thirty-six species have been identified from the park caves including 16 species representing now extinct or locally extirpated taxa. Pleistocene shrub oxen, pronghorn, an extinct cheetah-like cat, mountain goat, dire wolf, shrew, marmot, horse, an extinct vulture, and numerous other vertebrates are among the bones found in the cave and identified by Lloyd Logan and other Smithsonian Institution personnel.

Many species of fossilized bats, a Pleistocene jaguar, and recent mountain lion bones have been discovered in Lower Cave and the Big Room within Carlsbad Cavern (Baker, 1963). The location of these bones indicate that the animals could not have entered the cave through the present-day entrance.

The remains of a juvenile ground sloth *Nothrotheriops shastensis* (Shasta ground sloth) were discovered in Lower Devil's Den of Carlsbad Cavern in 1947. Disarticulated ribs, vertebrae, and foot bones were identified by paleontologist C. Gazin (Smithsonian) in 1948. Additional juvenile ground sloth bones were collected from the same location in 1959 and believed to be part of the same individual. Uranium series dating of the bone material provided a date of approximately 111,900 years B.P. (Hill and Gillette, 1987). Although the remains of ground sloths are known for nearly two million years in the American southwest, the Carlsbad specimen has provided the oldest absolute date for any sloth material. Further, the sloth remains provide the oldest absolute date for any vertebrate remains from the Guadalupe Mountains (Hill and Gillette, 1987).

Fossil vertebrates are reported from Lechuguilla Cave. During January 1988, members of the Lechuguilla Cave Project expedition discovered an articulated and extensively calcified small mammal skeleton. The skeleton was identified by Pat Jablonsky as *Bassariscus astutus* (ringtail cat) (P. Jablonsky, personal communication, 1993).

Fifteen complete or partial bat skulls were collected from Lechuguilla Cave between December 1990 to January 1991. These bat bones date to less than 10,000 years B.P. Ten other bat specimens were left in the cave due to either the fragility of the skeletons or their cementation to formations. Four species constituting three genera were collected and identified. All of these specimens were members of the family Vespertilionidae. One of the species, *Lasiurus cinereus* (hoary bat) is not commonly found in caves. *Plecotus townsendii* (western big-eared bat) prefers shallow gypsum caves or roosts in entrances of caves or mines. *Myotis volans* (long-legged bat) prefers rock crevices or trees. *Myotis leibii* (small-footed myotis) was the most abundant inhabitant of Lechuguilla Cave. Interestingly, *Myotis leibii* has not been found at Carlsbad Cavern which is three miles southeast of Lechuguilla Cave.

The extinct species of bat *Tadarida constantinei* (Constantine's free-tailed bat) is known only from Slaughter Canyon Cave (New Cave). The remains of *Navahoceros fricki* (mountain deer) and other vertebrates have also been collected and identified from Slaughter Canyon Cave.

An important vertebrate fauna has been reported from Muskox Cave (Logan, 1977, 1979). The fossil material represents an assemblage of Late Pleistocene vertebrates that apparently died after being trapped in a large sinkhole. This modern cave was apparently first discovered and entered in 1954. A small group, led by Park Ranger Patterson, collected a number of bones from within Muskox cave during this first reported entry. This material was examined by paleontologist Lewis Gazin who identified the remains of a horse, a small artiodactyl, a bovid, a large dog, and a bobcat-like cat. The cave was revisited in February 1969 by a small group led by Park Naturalist Bullington. Bullington prepared a trip report detailing the visit to Muskox Cave and reported "literally thousands of small disassociated bones." A few fossil vertebrates were collected from the cave and forwarded to paleontologist Ernest Lundelius, at the University of Texas, Austin. Dr. Lundelius identified the remains as a shrubox (possibly *Euceratherium*), a horse, and a small antelope (Logan, 1979).

In November of 1975, members of the Cave Research Foundation began mapping Muskox Cave. The mapping continued into 1976 with to the discovery of numerous new passages. During this mapping project, a skull and associated skeleton was found in a small pool at the base of a breakdown slope in a virgin passage. A second skull was found embedded in the floor of the cave near the pool (Logan, 1977, 1979). These discoveries prompted another trip into Muskox Cave in March 1976, led by NPS Cave Resources Specialist Ronal Kerbo. Kerbo photographed the skulls and skeleton, later identified as *Euceratherium* cf. *sinclairi* (bush ox) and dire wolf (Figure 4). Other skeletal remains were observed during this trip including elements identified as *Equus, Bassariscus*, *Spilogale*, and *Neotoma.* A joint field party from the Smithsonian Institution, Texas Tech University, and the National Park Service spent ten days during July 1976 collecting the skeleton in the pool and other vertebrates from the cave (Logan, 1979). A follow-up trip collecting trip was undertaken in April 1977. Jass and others (2000) report on an *Oreamnos harringtoni* (Harrington's Mountain Goat) from Muskox Cave.

FIGURE 4. Skull and skeleton of a shrubox (*Euceratherium* cf. *sinclairi*) from Musk Ox Cave in Carlsbad Caverns National Park, New Mexico.

CEDAR BREAKS NATIONAL MONUMENT

Cedar Breaks National Monument (CEBR) was established to preserve a huge natural amphi theater eroded into the variegated Pink Cliffs of the Claron Formation in south-central Utah. The Claron is Eocene/Paleocene in age (previously assigned to the Wasatch Formation) and consists of red, orange, and white fluvial and lacustrine beds eroding into cliffs and hoodoos. The beds alternate between sandy limestone and calcareous sandstone. Although this unit is poorly fossiliferous, rare pelecypod and gastropod fossils are preserved (Hatfield et al., 2000). The basal part of the Claron is a 65 foot (20 meters) thick limestone bed that locally contains shallow caves, sinkholes, and springs (Hatfield et al., 2000). Arch Springs Cave is formed in this basal limestone bed.

Arch Springs Cave is the only known cave at Cedar Breaks National Monument (S. Robinson, personal communication, 2001). An amateur group initiated a preliminary survey of the cave during the 1970s, but the survey was not completed due to a lack of proper equipment. Thus, very little is known about this cave (S. Robinson, personal communication, 2001).

CHANNEL ISLANDS NATIONAL PARK

Channel Islands National Park (CHIS) consists of five islands off southern California including Anacapa, San Miguel, Santa Barbara, Santa Cruz, and Santa Rosa. The islands provide habitat for nesting birds, sea lion rookeries, and unique plant communities.

The geologic history of the Channel Islands is quite complex and extends back over 160 million years (D. Palmer, 1995). The islands geologic record reveals extensive volcanism and sedimentation during the Miocene. The Blanca Formation consists of Miocene lava flows, breccias, and pyroclastic flows which measure to nearly 1,400 feet (427 meters) thick in some areas (D. Palmer, 1995). The Monterey Formation consists of Miocene continental shelf deposits with some volcanic beds (Beecher Member).

There are both sea caves and terrestrial caves formed within the Channel Islands. There are over

380 sea caves documented in the island chain (Kiver and Harris, 1999). The Anacapa Islands alone have 135 documented sea caves. The sea caves form primarily in the uplifted Blanca Formation. Some of the sea caves are extremely large. Painted Cave, on Santa Cruz Island, may represent the world's longest sea cave recorded at over 1,215 feet (370 meters) long and nearly 130 feet (40 meters) tall (Kiver and Harris, 1999). The terrestrial caves form in the sedimentary deposits.

The paleontological resources of CHIS have been documented from a number of the islands. Extensive Pleistocene assemblages of foraminifera, corals, bivalves, gastropods, and ostracodes have been reported from Santa Barbara Island (Lipps et al., 1968). Vertebrate remains on the island include mammoth, *Haliaeetus leucocephalus* (bald eagle) and *Zalophus* sp. (sea lion) (Lipps et al., 1968). In 1988, the remains of the extinct *Desmodus stocki* (vampire bat) were recovered from an archeological site on San Miguel Island. The material from the site containing the vampire bat dated to no older than 5,000 years B.P., perhaps representing the youngest record for this extinct species (Ray et al., 1988). Nine paleobotanical taxa have been reported from Santa Cruz Island, ranging from fossil logs to microscopic seeds (Chaney and Mason, 1930).

The Channel Islands contain the remains of the only island dwelling pygmy mammoths (*Mammuthus exilis*) in the world (Agenbroad and Morris, 1999). During the Pleistocene (Rancholabrean) mainland mammoths (*Mammuthus columbi*) colonized the islands. At the end of the Pleistocene, with glacial melting and eustatic sea level rise, the terrestrial portions of the islands were reduced in size. The diminished range and resources resulted in an approximately 50% decrease in size of the mammoth. The remains of pygmy mammoths have been found on San Miguel, Santa Rosa, and Santa Cruz Islands (Stock and Furlong, 1928; Stock, 1935; Agenbroad and Morris, 1999).

While the paleontological resources are known from throughout the various islands, there have been no formal inventories of resources in the caves of Channel Islands. However, because of the wide range of fossil material present on the islands, the caves may preserve some of the paleontological record of the Channel Islands. Many of the terrestrial caves have deep debris deposits and may house paleontological material (D. Morris, personal communication, 2001). In addition, some of the caves may be developed within fossiliferous formations. Public access has been limited to Santa Rosa and Santa Cruz islands, which were privately owned until recently. Access to San Miguel Island is also limited to protect visitors from unexploded naval ordinance.

CHICKAMAUGA / CHATTANOOGA NATIONAL MILITARY PARK

Chickamauga/Chattanooga National Military Park (CHCH) spans the Georgia-Tennessee border. The park was established to preserve a major Confederate victory on Chickamauga Creek in Georgia on September 19 and 20, 1863. This battle was countered by Union victories at Orchard Knob, Lookout Mountain, and Missionary Ridge in Chattanooga, Tennessee, between November 23-25, 1863.

Nine caves have been documented at Chickamauga/Chattanooga National Military Park. Many caves are cut into the limestones associated with Lookout Mountain, some of which have entrances outside park boundaries, however, the subsurface features of the caves may extend into the Park. The Bangor Formation (Mississippian) and Mont Eagle Formation are two Paleozoic limestones exposed in the park. The Mont Eagle Formation contains numerous Paleozoic invertebrates (D. Curry, personal communication, 2001). Both formations are prominent throughout the park and contain numerous large pits.

Two caves, Kitty City and 27 Spider, are solution caves in the Cumberland Plateau Cave Area. Kitty City Cave has casts of big cat paw prints and claw marks on the walls. Preliminary assessment of the fossil remains suggests the cats apparently fell into the pit, attempted to climb out, and subsequently died. 27 Spider Cave is located three miles (5 kilometers) north/northeast of Kitty City Cave and is the longest cave in the park with a 1,000 foot (305 meter) passage. The lower part of the cave was mapped by the National Speleological Society. Twenty-seven Spider Cave contains a large cat skull and vertebral column which are partially exposed in a mud bank. There are also felid canines exposed in the cave wall. In 1995, a large oil spill in the park forced the closure of all of the caves (D. Curry, personal communication, 2001).

COLONIAL NATIONAL HISTORICAL PARK

Colonial National Historical Park (COLO) preserves two important historical sites in eastern Virginia. These sites include Jamestown, the first permanent English settlement, and Yorktown, the scene of the culminating battle of the American Revolution in 1781.

Originally, a small natural cave feature formed in cliffs through wave action along the coast. This natural feature was then excavated to its current size in the 1780s to make a storage shelter. The cave was named for Lord Charles Cornwallis, the British general defeated by Colonial and French forces in the Battle of Yorktown in 1781 and who may have sought shelter in the cave.

The cliffs at COLO are composed of a limestone coquina. This coquina is comprised of sand-sized fragments of mollusk shells, with lesser amounts of arthropod, bryozoan, and echinoid fragments. Coquina, however, is very susceptible to granular disintegration. A National Park Service Mining Engineer estimates that approximately five tons (4.5 metric tons) of coquina has crumbled off of the walls of the excavation during the past 210 years (P. Cloues, personal communication, 1999). One possible cause of the disintegration may be the differential dissolution of the shell fragments in the limestone. Most of the fragments are composed of aragonite, which is more soluble than calcite, which forms the remaining shells and cement. Other causes of the deterioration of the cave include natural freeze/thaw cycles, vegetation growth, and human impacts.

The main cave entrance is currently barred by an iron gate to prevent visitor entry. A second smaller entrance is also sealed. Many suggestions for preventing further collapse have been proposed, however, none of these have been implemented (D. DePew, personal communication, 2001).

CORONADO NATIONAL MEMORIAL

Coronado National Memorial (CORO), Arizona is a site commemorating the first European exploration of the Southwest, undertaken by Francisco Vasquez de Coronado between 1540-1542. The park is located near the area where Coronado's expedition entered into territory that eventually became the United States.

In 1992, a preliminary cave inventory was conducted for National Park Service areas in the Western Region (now Pacific-West Region). During this inventory ten limestone/gypsum caves were identified within Coronado National Monument. Two fossiliferous limestones, the Devonian Martin Formation and the Permian Colina Formation, occur at Coronado that may represent the units in which the caves have developed. The Martin Formation contains brachiopods and coral. The Colina Formation contains gastropod shells and sea urchin spines.

Resource inventories for each of the ten caves have not yet been completed. However, geological surveys and maps of three caves, Coronado Cave, Slickenside Cave, and Still Cave have been undertaken. Two other caves in the park listed on the inventory, Water Cave and Mesa Cave, have since been closed and are no longer accessible. The remaining five caves, Fly, No Name #1 (Road Cave), No Name #2 (Joe's Canyon Trail Cave), Hairpin Cave, and George's Tank Cave have been identified as potentially having geological, mineralogical, or paleontological significance, but additional work on these caves has yet to be completed (B. Alberti, personal communication, 2001).

CRATERS OF THE MOON NATIONAL MONUMENT

Craters of the Moon National Monument (CRMO) was established to preserve a volcanic lava field made up of at least 60 lava flows and covers 618 square miles (1600 square kilometers). The monument contains three recent lava fields (Craters of the Moon, Kings Bowl, and Wapi lava fields) while older flows comprise the land between and around them. All flow names are mapped as informal stratigraphic units. Flows in the Craters of the Moon lava field range in age from about 15,000 to 2,100 years before present. Kings Bowl and Wapi are both about 2,200 years old. Older flows within the monument, surrounding the three young fields, are Pleistocene in age (D. Owen, personal communication, 2001). In an effort to preserve all of the Craters of the Moon lava fields, as well as the entire Great Rift zone, the monument was greatly expanded on 9 November, 2000, from approximately 53,000 to 754,862 acres (215 to 3055 square kilometers) (including state and private in-holdings).

Caves at Craters of the Moon represent Pleistocene or Holocene basaltic lava tubes (Figure 5). The number of documented caves currently exceeds 170 and with further exploration and inventory a realistic estimate of the number might exceed 600 (D. Owen, personal communication, 2001). Along the Great Rift, the volcanic rift zone in which the lava fields formed, are additional cave features termed "fissure caves". These fissure caves are present in much fewer numbers that the lava tube caves. Some of these fissures are quite sizeable, including one particular fissure that may be passable to a depth of 650 feet (200 meters) from the surface (J. Apel and D. Owen, personal communication, 2001).

The earliest report of bone material within the lava tubes dates to the 1880s. A variety of bovine-like bones were collected from the lava tubes, but are too fragmentary or poorly preserved for definitive identification. A school group found some possible *Bison bison* bones, which later turned out to be bovine, in one of the lava tube caves now referred to as Buffalo Cave. The remains of *Ovis canadensis*, including a horn, have also been reported from the monument. Packrat middens within the lava tubes contain bone material including the remains of microtine rodents. An *Ursus arctos* (grizzly bear) skull and femur were found just south of the old monument boundary. These remains were temporarily on display at CRMO but have been returned to BLM (J. Apel and D. Owen, personal communication, 1998.).

In a rare example of fossils preserved in igneous rocks, dozens of tree mold impressions are preserved in the basaltic flows and in lava tubes at Craters of the Moon (Figure 6). These impressions were formed as lava flowed around a fallen tree. The molds typically show shrinkage cracks. Moisture in the wood may have prevented incineration of the trees. Similar tree molds are known from other NPS areas including El Malpais National Monument, Hawaii Volcanoes National Park, Lava Beds National Monument, and Pu'uhonua o Honaunau National Historic Park.

CUMBERLAND GAP NATIONAL HISTORICAL PARK

Cumberland Gap National Historic Park (CUGA) is a mountain pass on the Wilder ness Road explored by Daniel Boone. The Gap was developed into a main artery of the great trans-Allegheny migration for settlement of the "Old West". The Gap was also an important military ob-

FIGURE 5. View from within Indian Tunnel lava tube at Craters of the Moon National Monument, Idaho.

FIGURE 6. Tree mold impression preserved in basaltic lava at Craters of the Moon National Monument, Idaho.

jective during the Civil War.

The Middle and Upper Mississippian Newman Limestone, the Upper Mississippian Pennington Formation, and the Middle Pennsylvanian Lee Formation are three fossil-bearing units exposed at Cumberland Gap National Historic Park. The Newman Formation is a limestone unit composed mostly of the sand-sized skeletal remains of marine organisms (skeletal calcarenites). Complete fossils are uncommon in the Newman due to the lack of horizontal bedding planes. Caves have been found in the Newman, but are not described in the park. The Pennington Formation is composed predominantly of shale and represents marine and marginal-marine environments. Because it is composed largely of soft shale, it is easily eroded and covered. Hence it is rarely exposed at the surface, however, lower parts of the unit contain marine fossils like those found in the underlying Newman Limestone. The Lee Formation is a coarse-grained, conglomeratic, cross-bedded sandstone representing the channels of an ancient braided stream. Although fossils are rare in the Lee Formation a few fossil plants are preserved. Petrified log jams have been found in these ancient stream deposits (F. Ettensohn, personal communication, 2001). A 4,600 foot (1,400 meters) road-tunnel excavation through the Lee, Pennington, and Newman formations in the park have yielded a few plant and animal fossils which have not yet been identified (R. Collier and F. Ettensohn, personal communication, 2001).

GLEN CANYON NATIONAL RECREATION AREA

Glen Canyon National Recreation Area (GLCA) includes 186-mile-long (300 kilometer) Lake Powell, which was formed by Glen Canyon Dam. GLCA includes more than one million acres (>4,000 square kilometers) of rugged canyon country on the Colorado Plateau in southern Utah. Santucci (2000) provides a comprehensive overview of paleontological resources from the recreation area.

The Navajo Sandstone is widely exposed at Glen Canyon National Recreation Area. The Navajo is a massive cross-bedded, eolian sandstone unit in which alcoves commonly form (Anderson et al., 2000). A large west-facing shelter formed in the Navajo Sandstone, named Bechan Cave (Figure 7), is an important Pleistocene paleontological locality (Mead et al., 1986a).

National Park Service personnel first entered Bechan Cave in November 1982. During 1983, a research team visited the cave (Davis et al., 1984). An enormous organic layer, with a volume of approximately 390 cubic yards (300 cubic meters), dominated by dung, was discovered in Bechan Cave (Figure 8). The name Bechan comes from the Navajo word for "big feces" (Mead et al., 1986a). Remarkably good preservation enabled recovery of a few complete boluses, which were used for plant and microfossil paleoenvironmental analyses (Davis et al., 1984). The majority of the dung in the cave was identified as mammoth (probably *Mammuthus columbi*) based on similarities to modern African elephants and differences from *Nothrotheriops shastensis* dung. Other coprolites discovered in the cave include dung from rabbits, rodents, mountain sheep or deer (*Ovis canadensis* or *Odocoileus* sp.), Shasta ground sloth, and a large unidentified artiodactyl (Mead et al., 1984). Six samples of mammoth dung, and a number of plant fossils from the dung were radiocarbon dated, producing an age of occupation ranging from about 11,070 to 14,665 years B.P. (Mead et al., 1986c; Mead and Agenbroad, 1992).

The only skeletal evidence of a large mammal found during Bechan Cave excavations is a tooth of *Euceratherium collinum* (shrubox) (Mead and Agenbroad, 1992). Quantities of hair are also preserved in the cave. The very coarse hair is nearly identical to mammoth hair recovered from carcasses in the permafrost of Alaska and Siberia (Mead et al., 1986a). Other hair in the cave has been identified as ground sloth, artiodactyl, *Equus*, and a number of small mammals (Davis et al., 1984). Remains of *Scaphiopus intermontanus* (Great Basin spadefoot toad), *S.* cf. *bombifrons* (Plains spadefoot toad), *Pituophis melanoleucus* (gopher snake), *Crotalus* cf. *viridis* (prairie rattlesnake), a grouse-sized bird, *Brachylagus idahoensis* (pygmy rabbit), *Marmota flaviventris* (yellow-bellied marmot), *Spermophilus* sp., *Thomomys* sp. (pocket gopher), *Lagurus curtatus* (sagebrush vole), *Microtus* sp. (vole), and *Neotoma cinerea* (bushy-tailed packrat) have also been found

FIGURE 8. Dung pellets in Bechan Cave, Glen Canyon National Recreation Area, Utah.

in the cave (Mead et al., 1993). Packrat activity has produced middens in the cave, and it appears that packrats have been active at the site for about 12,000 years (Davis et al., 1984).

In addition to Bechan Cave, nine other alcoves and shelters have been studied in Glen Canyon and summarized by Mead and Agenbroad (1992). BF Alcove contains *Pseudotsuga menziesii* (Douglas fir) needles and *Acer* spp. (maple) material associated with dung from megafauna as large as *Camelops.* Radiocarbon dating of two fir needles produced ages of approximately 11,790 and 12,130 years B.P. Grobot Grotto is a large alcove with 20 feet (6 meters) of stratified eolian sand and roof spall with interspersed layers of dung and leaf-litter. Numerous coprolite remains were found at this locality. Dung samples were radiocarbon dated directly yielding the following dates: *Mammuthus* (28,290, and 26,140 years B.P.), *Bison* (15,270 B.P.), and "*Euceratherium*" (20,930 and 18,320 B.P.). The "*Euceratherium*" notation indicates a dung pellet morphology similar to that of *Ovibos moschatus* (living muskox) and *Symbos* (extinct muskox). Hooper's Hollow is a wide alcove upstream from Grobot. Laminated fluvial sediments block much of the alcove, however, it is otherwise similar to Grobot with eolian material and roof spall accumulations. Radiometric dates were also obtained from a packrat midden (13,110 B.P.), oak twigs (10,630 and 12,010 B.P.), and *Bison* dung (18,840 B.P.). Mammoth Alcove is a medium sized shelter, on a perched bedrock meander, with laminated lacustrine and fluvial sediments. Skeletal remains of a mammoth were recovered near the base of the sedimentary sequence and was dated by Uranium/Thorium to approximately 19,300 years B.P. Dung boluses of *Mammuthus* (16,630 B.P.), *Bison*, and cf. *Ovis* were also found in the alcove. Oak Haven is a small shelter directly across from Mammoth Alcove that preserves a stratified sequence of sediments. A near-surface sample of *Quercus gambelii* (Gambel oak) (9,180 B.P.) and a lower sample of *Rosa woodsii* (Woods rose) twigs (11,690 B.P.) provide radiocarbon dates bracketing the layer containing dung of *Mammuthus*, *Bison*, and "*Euceratherium*". These megafaunal dung deposits were not dated directly, but the material is available for further work. Oakleaf Alcove is now submerged under Lake Powell. Prior to its submergence, the alcove was a site for a number of archaeological excavations during the 1960s. Unfortunately, the site received considerable vandalism. Human coprolites have been reported and described from the site. One bolus, tentatively identified as *Equus*, was radiometrically dated to approximately 24,600 years B.P. Withers Wallow, a small sandstone shelter with

FIGURE 7. Bechan Cave, Glen Canyon National Recreation Area, Utah.

laminated fluvial and lacustrine sediments, was also studied. Plant debris and dung of cf. *Ovis*, *Bison*, and *Mammuthus* were found. One fragment of mammoth dung produced a radiocarbon date of approximately 12,010 years B.P. Cottonwood Alcove is a sandstone alcove visited during the late 1980s as part of an archeological survey of the Anasazi peoples. Isolated dung pellets (assigned to "*Euceratherium*") from Cottonwood Alcove were dated to about 12,510 years B.P. Withers Wallow and Cottonwood Alcove have never been formally excavated. Shrubox Alcove contains laminated lacustrine and fluvial sediments in addition to eolian and roof spall sediments. Dung samples of "*Euceratherium collinum*", *Bison*, *Oreamnos*, *Ovis*, and *Mammuthus* have been identified from Shrubox Cave, but have not been dated. A number of *Quercus* (oak) twigs were radiometrically dated, yielding ages ranging from approximately 8,330 to 23,100 years B.P.

GRAND CANYON NATIONAL PARK

Grand Canyon National Park (GRCA) was established to preserve the world-famous Grand Canyon of the Colorado River. The park encompasses 277 miles (446 kilometers) of the river, with adjacent uplands, from the southern terminus of Glen Canyon National Recreation Area to the eastern boundary of Lake Mead National Recreation Area. The canyon has been shaped by the forces of erosion and river-cutting to expose Precambrian and Paleozoic strata.

The extensive Muav and Redwall limestones of the Grand Canyon contain hundreds of caves and shelters. Significant paleontological and archeological resources are associated with many of these caves. The earliest report of fossils from Grand Canyon caves dates back to 1936 when NPS employee Willis Evans located a rich cave deposit of late Pleistocene fossil bones and sloth dung in Rampart Cave (Martin et al., 1961).

The Cambrian Muav Limestone is part of the Tonto Group and represents an off-shore marine unit. Deep channels, carved by streams or marine scour, developed in the upper portion of the Muav (Harris et al., 1995). The Mississippian Redwall Limestone lies unconformably on top of the Muav where the Devonian Temple Butte Limestone is absent. The Redwall is a bluish gray limestone stained red by water dripping down from the overlying Supai and Hermit Shale redbeds. Marine fossils within the Redwall are common and include bryozoans, brachiopods, and other marine organisms. Chambered nautiloid fossils are a recent discovery in the Redwall Limestone of the Marble Canyon region (Harris et al., 1995).

In addition to the modern caves documented today in the Grand Canyon, the Redwall Limestone also contains evidence of caves formed during the Mississippian and were subsequently filled with sediments. Fossils have been reported from cave-fill deposits within paleo-karst features formed within the Mississippian (Osagean and Meramecian) Redwall Limestone at Grand Canyon National Park (Billingsley et al., 1999). These paleo-karst features were developed in the Mooney Falls and Horseshoe Mesa members of the Redwall Limestone. The caves are believed to have formed during the Mississippian based upon the age of the sedimentary cave fill and the associated fossils. The cave fill deposits have been mapped and identified as the Upper Mississippian (Chesterian) Surprise Canyon Formation (Billingsley et al., 1999). The Surprise Canyon Formation was originally described by Billingsley and Beus (1985) and occurs within erosional depressions, stream valleys, sinkholes, and solution caves formed in the Redwall Limestone. The Surprise Canyon Formation consists of a lower fluvial unit and middle and upper marine units. Fossil plant material, especially *Lepidodendron* logs, and vertebrate bone fragments are common in the fluvial facies. The marine component contains an abundance of marine invertebrates including corals, bryozoans, molluscs, brachiopods, trilobites, echinoderms, and condonts (Beus, 1999).

Considerable research has been directed towards packrat middens within the caves of Grand Canyon. Today, there are eight species of *Neotoma*, all of which collect seeds, leaves, flowers, twigs, bones, and other small objects to incorporate into dens or nests (Mead, 1980). The packrats periodically clean their dens, producing piles or middens of discarded material. Repeated trampling and urination compact the midden into a hard sometimes well-cemented accumulation of waste. The middens are quite durable, especially in the arid Grand Canyon, where they date back more than 30,000 years. This longevity provides an excellent resource for paleoecological reconstruction of the cave and the region around the cave.

MUAV LIMESTONE CAVES

Vulture Cave is a small limestone cave in the Spencer Canyon Member of the Muav Limestone located in the far western portion of Grand Canyon. Vulture Cave consists of three major conduits that come together forming a large room. Fifteen packrat middens and a *Bassariscus astutus* "refuse area" were collected and examined from within Vulture cave. Forty-seven plant taxa were identified from the middens, with twigs and seeds of *Juniperus* sp. being the most abundant identifiable plant fragment (Mead and Phillips, 1981). Bones and teeth of 37 vertebrate taxa were also identified including one tortoise, eight species of lizards, ten snake species, three bird species (also one unidentified shell fragment and one member of the Fringillidae), one shrew species, nine rodent species, four artiodactyl species, and one carnivore species (Mead and Phillips, 1981). The remains of *Lampropeltis pyromelana* (Arizona mountain kingsnake) represents the first Pleistocene find of the snake in the Grand Canyon. The remains of *Trimorphodon biscutatus* (lyre snake) found in Vulture Cave represent the first record of the snake in the Grand Canyon. Likewise, the Vulture Cave remains of *Microtus* (vole) are the only known remains of that taxa in the Grand Canyon. The single shrew found in Vulture Cave, *Notiosorex*, represents the first late Pleistocene occurrence within Grand Canyon. The tooth of *Camelops* represents the largest mammal recovered from Vulture Cave. Insects were also recovered, but specific identification is not yet available (Mead and Phillips, 1981). Radiocarbon dates in Vulture Cave reveal a history dating back over 30,000 years. The oldest dated obtained from Vulture Cave is from a *Juniperus* (juniper) twig recovered from a packrat midden which yielded a date of 33,600 years B.P. (Mead and Phillips, 1981).

While packrats form middens, *Bassariscus astutus* forms similar accumulations known as ringtail refuse deposits. One such deposit, encompassing approximately 11 square feet (one square meter), was discovered and studied in Vulture Cave (Mead and Van Devender, 1981). The deposit consisted mostly of small animal bones and scat. In total, 540 elements representing 22 taxa were recovered from the ringtail refuse deposit (Mead and Van Devender, 1981). The vertebrate taxa represented include seven lizard species, six snake species, three bird species, and six mammalian species. The most common of the vertebrate remains were that of *Neotoma*, with a minimum number of individuals (MNI) calculated to be 40 or more. Lizards (1-4 MNI) were more common than snakes and birds, both with an MNI of one (Mead and Van Devender, 1981). Arthropods, mostly members of the Diplopoda, were also recovered from the ringtail refuse deposit. Radiocarbon dates yield an approximate age of 1,930 years B.P. for the ringtail refuse deposit. The Late Holocene remains in the refuse deposit were interpreted as being dietary remnants.

Oreamnos harringtoni (Harrington's extinct mountain goat) skeletal remains, found in many GRCA caves, are also reported from Vulture Cave (Mead et al., 1986c). Emslie (1987) reports the remains of *Gymnogyps californianus* in Vulture Cave.

Rampart Cave, located near the base of the Muav Limestone, was one of the first caves to be studied in Grand Canyon National Park. In 1936, Willis Evans, a Park Service employee, first entered Rampart Cave and discovered the extensive Shasta ground sloth dung deposit and a number of scattered bones (Figure 9) (Martin et al., 1961). Rampart Cave, like the nearby Muav Caves, was originally within the boundaries of Lake Mead National Recreation Area, but was incorporated into Grand Canyon National Park in January, 1975 (Kay Rohde, personal communication, 2001; Hansen, 1978). Rampart Cave contains rich organic layers which are uncommon in the frequently dry caves of the arid southwest (Mead, 1981). Until 1976, when a fire destroyed much of the sample, Rampart Cave contained the thickest and least disturbed deposit of stratified *Nothrotheriops shastensis* dung known from any locality (Figures 10, 11, and 12) (Long and Martin, 1974; Hansen, 1978). Martin and others (1961) report radiocarbon age dating of three sloth dung samples to >35,500, 12,050, and 10,050 years B.P. Later radiocarbon dating of sixteen dung bo-

FIGURE 9. Stratified sloth dung deposit prior to fire in Rampart Cave, Grand Canyon National Park, Arizona (photo - Jim King, 1969).

FIGURE 11. Paleontology team view charred sloth dung deposits in Rampart Cave, Grand Canyon National Park, Arizona (photo - Mary Carpenter, 1999).

FIGURE 10. Fireman responding to fire in Rampart Cave in July 1976, Grand Canyon National Park, Arizona (photo - Tom Van Devender).

FIGURE 12. Rampart Cave during the July 1976 fire (photo - Tom Van Devender).

luses and two trampled dung mats of *N. shastensis* yielded dates discontinuously ranging from greater than 40,000 years B.P. to approximately 11,000 years B.P., similar to the dates reported by Martin and others (1961) (Mead and Agenbroad, 1992). Additional radiocarbon dating has been performed by Long and Martin (1974), yielding a similar range of dates from more than 40,000 years B.P. to approximately 10,035 years B.P. Recent research by Mary Carpenter (Northern Arizona University) has generated additional radiocarbon dates from the cave and will be reported in her thesis. Within the dung, 72 genera of plants were found enabling paleoecological reconstruction over that extensive time span (Martin et al., 1961; Hansen, 1978). Pollen from these plants revealed seasonal variation in the sloth's diet (Mead, 1981). No direct skeletal association of the ground sloth and the dung has been reported, although over 200 bones of *Nothrotheriops shastensis* have been found in Rampart Cave (Hansen, 1978).

Although the sloth remains and dung deposit are among the most well-studied aspects in Rampart Cave, other paleontological resources are also known from the cave. Packrat deposits are well known from the cave. One such deposit is a 13 inch (33 centimeter) unindurated (uncemented) "seam" separating the two major dung layers in the cave. The seam is made up of plant material such as twigs and other macrofossils that are "perfectly preserved" (Phillips and Van Devender, 1974). Deposited by packrats between 24,000 and 14,000 years B.P., the seam may constitute the largest Pleistocene packrat deposit ever found (Phillips and Van Devender, 1974). Thirty additional indurated (cemented) middens were found both in and around Rampart Cave (Phillips and Van Devender, 1974). Sixty types of plants were identified from within these middens, aiding in paleoecological reconstruction of the Rampart Cave area. Additional plant material from packrat middens yielded dates ranging from 18,890 (*Fraxinus anomala* twigs) to 9,520 years B.P. (*Agave utahensis*) (Van Devender et al., 1977b). These middens were also a rich source of small mammal and reptile remains, including one tortoise species, three lizard species, three snake species, the vampire bat *Desmodus stocki*, four *Neotoma* species, and one species of deer mouse (*Peromyscus* sp.). The remains of *Erethizon dorsatum* (porcupine) and *Marmota flaviventris* were also recovered from Rampart Cave (Van Devender et al., 1977b).

Rampart Cave also contains skeletal remains and dung pellets of *Oreamnos harringtoni* (Mead et al., 1986c). Dung pellets of *O. harringtoni* were dated to approximately 18,430 years B.P. (Mead and Agenbroad, 1992). Eight keratinous horn sheaths were also dated from Rampart Cave. These sheaths yielded ages of ranging from 10,140-28,700 years B.P. (Mead and Agenbroad, 1992). The age of 28,700 years B.P. represents the oldest documented age of an *O. harringtoni* horn sheath (Mead et al., 1986c). *Equus* remains were found in the cave as well, however, they are interpreted as having been brought into the site by *Felis concolor* (mountain lion) due to the steep slope and cliff face below the cave (Hansen, 1978). A number of skeletal remains of *Gymnogyps californianus* are also reported from Rampart Cave (Emslie, 1987). Deposits of material interpreted as bat guano located near the rear of the cave are among the oldest deposits in the cave. The guano has been radiocarbon dated to >35,500 years B.P. (Long and Martin, 1974).

The Muav Caves are three small caves in the Muav Limestone located 1.1 miles (1.7 kilometers) upstream from Rampart Cave. Like Rampart, Muav Caves were formerly located within Lake Mead National Recreation Area until the boundaries of Grand Canyon National Park were expanded in January of 1975 (K. Rohde, personal communication, 2001; Hansen, 1978). Formal excavations have not been undertaken in Muav Caves (Mead and Agenbroad, 1992). Skeletal remains of *Oreamnos harringtoni* are known from Muav Caves (Mead et al., 1986c). Harrington (1936) and Long and Martin (1974) report the presence of a *Nothrotheriops shastensis* dung deposit within Muav Caves. Radiocarbon dating of the deposit yielded dates of 11,140 and 11,290 years B.P. (Long and Martin, 1974). Several additional *N. shastensis* dung boluses were recovered from the caves and radiocarbon dated to between 11,810 years B.P. and 10,650 years B.P. (Mead and Agenbroad, 1992). This is approximately the time range when *O. harringtoni* and 31 other large mammal genera became extinct at the end of the Pleistocene. This extinction is concurrent with the arrival of the Clovis hunters in North America (Hansen, 1978; Mead et al., 1986b).

REDWALL LIMESTONE CAVES

Stanton's Cave is a large solution cavern developed within the Redwall Limestone. The cave is an important archeological site with a number of split-twig figurines having been recovered from the site (Mead and Agenbroad, 1992; Emslie et al., 1987). Several groups of large *Oreamnos harringtoni* dung pellets from Stanton's Cave were found and radiocarbon dated to between 17,300 years B.P. to 10,870 years B.P. (Mead and Agenbroad, 1992). Skeletal remains of *O. harringtoni* are also known from Stanton's Cave (Mead et al., 1986c). Well over 70 bones of *Gymnogyps californianus* have been found in Stanton's Cave, representing at least five individuals (Emslie, 1987). Radiocarbon dating of these condor remains provided an approximate age of 14,260 years B.P. (Emslie, 1987). Dung of a large artiodactyl, perhaps *Ovis canadensis*, was recovered from Stanton's Cave. Radiometric dating of small pellets yielded a date of less than 11,000 years B.P., representing an early Holocene date (Mead and Agenbroad, 1992). Overall, Stanton's Cave deposits have yielded 23 species of mammals and 70 species of birds (Emslie, 1988). Extensive studies of the pollen recovered from Stanton's Cave were undertaken independently by Martin in 1984 and also Robbins, Martin, and Long in 1984 (O'Rourke and Mead, 1985).

Tse'an Bida Cave is a limestone grotto developed in the Redwall Limestone. Inside the rather large (approximately 150 by 300 feet (46 by 91 meters)) lower entrance room are numerous surface skeletal remains of *Oreamnos harringtoni* (Mead, 1986c; Mead and Agenbroad, 1992). Four groups of *O. harringtoni* dung pellets were radiocarbon dated and returned ages ranging from 24,190 years B.P. to 11,850 years B.P. (Mead, 1986b; Mead and Agenbroad, 1992). A skull with hornsheath was also found in the cave and was dated to approximately 12,930 years B.P. (Mead, 1986b; Mead and Agenbroad, 1992). Extensive pollen samples were also extracted from the dung of *O. harringtoni* and *Ovis canadensis* found in Tse'an Bida Cave (Mead et al., 1986c). A comprehensive report on the pollen found throughout Tse'an Bida Cave and Tse'an Kaetan Cave is presented in O'Rourke and Mead (1985). The eolian cave fill at Tse'an Bida contained a thin Holocene pollen record overlying a Late Pleistocene pollen record dating back 24,000 years (O'Rourke and Mead, 1985). The interglacial portions of the pollen record contained an abundance of *Pinus* pollen. On the other hand, the glacial portion of the pollen record showed a much greater abundance of *Artemisia* (sagebrush) and *Picea* (spruce) suggesting cool and dry conditions during the last ice age (O'Rourke and Mead, 1985). The Holocene record is composed mainly of *Juniperus osteosperma* (Utah juniper) and *Ephedra viridis* (mountain joint-fir), both of which are prevalent in the area today (O'Rourke and Mead, 1985). Radiocarbon dates of plant macrofossils in Tse'an Bida yielded dates of 24,000 years B.P., 16,000 years B.P., and 3,000 years B.P. (O'Rourke and Mead, 1985).

Packrat middens in Tse'an Bida Cave contain the remains of numerous animal taxa and plant material dating back to the late Pleistocene and early to middle Holocene. *Neotoma* remains are common within four middens and these remains have been dated to between 13,780 and 6,800 years B.P. (Cole and Mead, 1981). Remains of *Peromyscus* were also identified in a Tse'an Bida midden. One of the middens containing *Peromyscus* remains yielded a date of 8,470 years B.P. (Cole and Mead, 1981). Additional remains reported from the middens of Tse'an Bida include *Thomomys* sp., a *Sceloporus* sp. scale, cf. *Sonorella* (land snail) shell fragment, *Microtus*, and *Coleonyx variegatus* (banded gecko) (Cole and Mead, 1981).

Tse'an Kaetan Cave, in the Redwall Limestone, was first excavated by archeologists who discovered split-twig figures. Subsequent paleontological excavations have been undertaken. *Oreamnos harringtoni* dung pellets, some contained in "matted dung layers", were radiocarbon dated and yielded ages ranging from 30,600 years B.P. to 14,220 years B.P. (Mead and Agenbroad, 1992). Skeletal remains of *O. harringtoni* have also been found in Tse'an Kaetan (Mead et al., 1986c). Pollen from both Tse'an Kaetan Cave and Tse'an Bida Cave is described in detail by O'Rourke and Mead (1985). While the pollen record in Tse'an Bida contained both Holocene and Pleistocene deposits, the pollen from Tse'an Kaetan records only the Late Pleistocene flora of the area. Another important difference between the two caves is that cave fill containing the pollen in Tse'an Bida

FIGURE 13. Fossil condor skull from Steven's Cave, Grand Canyon National Park, Arizona (photo - Steve Emslie)

was primarily eolian in nature while the pollen from Tse'an Kaetan Cave was recovered from dung pellets and matted dung. This is an important difference because pollen is easily separable from eolian fill, while the dung pellets containing pollen are rarely separable from the cave fill and matted dung layers. Thus, the pollen record from Tse'an Kaetan should be interpreted as a dietary component (O'Rourke and Mead, 1985). While similar pollen types were found in both caves, there were significant differences in diversity and composition, most likely due to the dietary nature of the Tse'an Kaetan deposit. *Artemisia* was found in much lower quantities in Tse'an Kaetan, while *Juniperus* abundance was higher than in Tse'an Bida (O'Rourke and Mead, 1985). *Pinus* represented a vast majority (91%) of the pollen recovered in the lower layers of Tse'an Kaetan (O'Rourke and Mead, 1985). Extensive plant macrofossils are also found in Tse'an Kaetan. Radiocarbon dates of this macrofossil material provided approximate dates of 30,600, 24,000, 17,500, and 14,000 years B.P. for the various layers in Tse'an Kaetan (O'Rourke and Mead, 1985). A *Gymnogyps californianus* ulna was found within Tse'an Kaetan and dated to approximately 16,290 years B.P. (Emslie, 1987).

Stevens Cave, a rather extensive cave, also formed within the Redwall Limestone. Cave sediments have been dated by Uranium/Thorium to 700,000 years B.P. (Emslie, 1988). Unlike many of the Grand Canyon caves, Stevens was accessible to mammalian carnivores. This fact is supported by the presence of two associated humeri from either *Canis dirus* (dire wolf) or *C. lupus* (gray wolf). Radiocarbon dated to approximately 10,530 years B.P., these remains represent the first record of wolf in the Grand Canyon (Emslie, 1988). Another exceptional find within Stevens Cave is a nearly complete *Gymnogyps californianus* skull (Figure 13). The skull's beak was still intact and connective tissue was also present and dated to 12,540 years B.P. (Emslie, 1987; 1988). The most common remains from Stevens Cave are those of *Oreamnos harringtoni*. Dung, hair, and a number of bones representing at least four individuals have been found (Emslie, 1988).

Sandblast Cave, in the Redwall Limestone, is made up of a series of three caverns merging together to form a small complex of caves. The caverns may represent a nest or roost for raptors, including *Gymnogyps californianus*, as evidenced by the extensive remains (Emslie, 1988). Literally thousands of bones of fish, lizards, snakes, birds, and rodents are scattered on the floor of the cave (Emslie, 1988). Sixty-four *G. californianus* bones found in the cave, representing at least five individuals, were radiocarbon dated to between 13,110 and 9,580 years B.P. (Emslie, 1986, 1987, 1988). An unconsolidated packrat midden in the cave has also yielded a wealth of paleontological resources. Within the midden were fragments of large mammal (*Equus*, *Bison*, *Camelops*, and *Mammuthus*) limb bones. Skeletal remains of *Oreamnos harringtoni* were also found in the middens (Emslie, 1988). These large mammal bones, together with the small bones littering the floor, probably represent the condor's diet. Dung pellets of *O. harringtoni* were also recovered and radiocarbon dated to >33,100 years B.P. (Mead and Agenbroad, 1992). Driftwood in the cave yielded dates beyond the 40,000 year limit of radiocarbon dating (Emslie, 1988). Additional avian remains recovered from the midden include *Podilymbus podiceps* (pied-billed grebe), *Aechmophorus occidentalis* (western grebe), *Cathartes aura* (turkey vulture), three species of *Anas* (ducks), *Aythya* (duck), *Buteo* (hawk), three species of *Falco* (falcons), *Fulica americana* (American coot), cf. *Porzana carolina* (sora), *Zenaida macroura* (mourning dove), *Aeronautes saxatalis* (white-throated swift), and *Corvus* sp. (crow or raven) (Emslie, 1988).

The Redwall Limestone's Shrine Cave is an important archeological site. The large alcove is the site of more than 33 rock cairns and two split-twig figurines (Emslie et al., 1987). Associated with the archeological resources are much older paleontological resources, which may indicate that the ancient peoples in the canyon used the paleontological resources as their own cultural artifacts. For example, many of the cairns include packrat middens. Some of the split-twig figurines have dung pellets, which may be from *Ovis canadensis*, wrapped inside of them (Emslie et al., 1987). Other middens in the cave contain bone, a skull, hornsheaths, teeth, and dung of either *Oreamnos harringtoni* or *Ovis canadensis*. The middens probably date back to Late Pleistocene, while the archeological resources date back only to approximately 3,500 to 3,900 years B.P. (Emslie et al., 1987). Some skeletal remains of *Gymnogyps californianus* are also reported from Shrine Cave (Emslie, 1987).

Skull Cave is another cave developed in the Redwall Limestone. One large opening leads to three separate passages in Skull Cave. The floor of the cave is littered with the bones of small animals and *Neotoma* and *Peromyscus* feces. Anhydrite from a test pit excavated in the rear of the cave yielded a Uranium series date of approximately 16,000 years B.P. (Emslie, 1988). Extensive mammalian and avian taxa were also recovered from the cave. Mammalian taxa identified from the cave deposits include *Pipistrellus herperus* (western pipistrelle), *Sylvilagus*, *Lepus* sp., *Neotoma*, *Peromyscus*, *Spilogale putoris*, *Oreamnos harringtoni*, *Ovis canadensis*, and a number of unidentified large mammal bones (Emslie, 1988). The presence of *Spilogale putoris* represents a rare occurrence of this mammalian carnivore. The avian taxa include *Gymnogyps californianus* (Emslie, 1987), *Chen caerulescens* (snow goose), four species of *Anas*, *Aythya* sp., cf. *Colinus virginianus* (bobwhite quail), *Phalaropus lobatus* (red-necked phalarope), *Colaptes auratus* (northern flicker), cf. *Junco* sp. (junco), and *Agelaius phoeniceus* (red-winged blackbird) (Emslie, 1988). Some of the *G. californianus* skeletal remains were radiocarbon dated to approximately 12,210 years B.P. (Emslie, 1987).

Skylight Cave is located near Sandblast Cave in the Redwall Limestone. Two openings converge into one passage that continues for nearly 131 feet (40 meters) into the Redwall (Emslie, 1988). A number of avian taxa are represented in Skylight Cave including *Podilymbus podiceps*, cf. *Podiceps nigricollis* (eared grebe), *Gymnogyps californianus* (Emslie, 1987), two species of *Anas*, *Falco spaverius* (American kestrel), *Recurvirostra americana* (American avocet), a member of the Picidae, and an unidentified Passeriformid (Emslie, 1988). Tissue from a

Gymnogyps californianus specimen was radiocarbon dated to approximately 11,345 years B.P. (Emslie, 1987).

Hummingbird Cave is also located near Sandblast Cave. One large passageway of 100 feet (30 meters) leads back to a crawl space. Hundreds of bones from small animals, such as birds and rodents, along with rodent feces (most likely *Peromyscus*) litter the floor (Emslie, 1988). Interestingly, evidence of packrat activity was not observed in Hummingbird Cave. Several bird species, *Anas crecca* (green-winged teal), *Aythya affinis* (lesser scaup), *Circus cyaneus* (northern harrier), two species of *Falco*, *Larus* sp. (gull), and an unidentified Passeriformid have been identified from the remains (Emslie, 1988). In addition, a mummified *Corvus corax* (raven) and a headless *Sphyrapicus varius* (yellow-bellied sapsucker) skeleton were reported from Hummingbird Cave (Emslie, 1988).

Crescendo Cave is a large opening in the Redwall containing over 11 rock cairns. The remains of *Lepus* sp., *Corvus* sp., and *Gymnogyps californianus* have been found. A packrat midden was also reported from the cave (Emslie et al., 1995). Dung layers, probably representing *Oreamnos harringtoni*, were radiocarbon dated to approximately 10,950 years B.P. (Emslie et al., 1995).

Rebound Cave is located 330 feet (100 meters) south of Crescendo Cave, on the same ledge. Packrat middens were noted in the cave. A layer of *Ovis canadensis* or *Oreamnos harringtoni* dung was found and radiocarbon dated to approximately 16,640 years B.P. (Emslie et al., 1995). A partial artiodactyl humerus was also recovered.

Left Eye Cave is located south of both Rebound and Crescendo caves. Within this cave is a layer of *Ovis canadensis* or *Oreamnos harringtoni* dung. A packrat midden was also observed (Emslie et al., 1995).

Right Eye Cave, 330 feet (100 meters) west of Left Eye, is a small cave containing several *Ovis canadensis* and *Oreamnos harringtoni* bone fragments. No dung was found in the cave, but a packrat midden was reported (Emslie et al., 1995).

Five Windows Cave, on the same ledge as Left and Right Eye, 660 feet (200 meters) east of Left Eye, has five openings within 33 feet (10 meters) of each other. Extensive faunal remains have been found in Five Windows. A "loose" *in situ* packrat midden was observed in this cave. A mat of *Oreamnos* or *Ovis* dung was also reported. Several *Gymnogyps californianus* bones were found near one of the middens. Numerous other avian taxa are represented by bones in Five Windows including *Zenida macroura*, *Falco sparverius*, *Catoptrophorus semipalmatus* (willet), *Anas* sp., and an unidentified passerine. The skull of a lizard and femur of a squirrel were recovered from the cave. The presence of a partial feather from *G. californianus* may indicate that Five Windows was a Late Pleistocene nesting site for the condor (Emslie et al., 1995).

A number of other caves in the Redwall have been the subject of more limited research. Skeletal remains of *Gymnogyps californianus* have been recovered from Bridge Cave. These remains yielded radiocarbon dates of approximately 11,140 years B.P. (Emslie, 1987). Additional skeletal remains of *G. californianus* have been found in Midden Cave and were radiocarbon dated to approximately 22,180 years B.P. (Emslie, 1987). *G. californianus* skeletal remains have been reported from Luka Cave, Three Springs Cave, and Tooth Cave (Emslie, 1987). *Oreamnos* or *Ovis* dung is reported from White Cave (Emslie et al., 1995). Radiocarbon dating of *Oreamnos harringtoni* dung pellets and an amalgamated dung layer in Chuar Cave yielded dates of approximately 29,380 years B.P. (Mead and Agenbroad, 1992). Disappearing Cave, a small limestone shelter near the Marble Canyon region, contains a small, stratified section of sediments, plant remains, and *O. harringtoni* dung pellets. The dung pellets from Disappearing Cave were radiocarbon dated to approximately 27,360 years B.P. (Mead and Agenbroad, 1992). Coconino Cavern contains remains of *Nothrotheriops* (Lindsay and Tessman, 1974). A mummified canid, which appears to have wandered into the cave and subsequently died, was found in an unidentified Grand Canyon cave (Carpenter and Mead, 2000). Mats of late Pleistocene *O. harringtoni* dung and masses of late Pleistocene to Holocene packrat middens were also found in cave with the mummified canid (Carpenter and Mead, 2000).

Research into the caves of Grand Canyon National Park has been extensive and multi-faceted.

These cave deposits have yielded approximately 200 animal taxa and more than 200 plant taxa (Spamer, 1993), of which the above is a brief overview. A Microsoft Access database, GCPALEO, created and maintained by E. Spamer of the Academy of Natural Sciences of Philadelphia, provides an index to every fossil that has been cited in the Grand Canyon library. This database includes all fossils found in the park, not just those in caves. Of the more than 17,000 records in the database, nearly 2,400 are from cave localities (Spamer, 1993; GCPALEO records). The arid conditions present in the Grand Canyon create ideal conditions for spectacular fossil preservation in the caves. For example, the soft parts of *Oreamnos harringtoni* such as hair, muscle, and ligament as well as the keratinous hornsheaths and large quantities of dung, are unique to Grand Canyon caves (Mead et al., 1986c). In addition, the aridity aids in the preservation of pollen from the caves (O'Rourke and Mead, 1985). The general inaccessibility of many of the caves in the Grand Canyon to all those except experienced rock climbers (or sure-footed rodents, artiodactyls, and birds) enhance their preservation.

GREAT BASIN NATIONAL PARK

Great Basin National Park (GRBA) is a remnant icefield on the 13,063 foot (3,982 meter) Wheeler Peak in Nevada. The park contains an ancient bristlecone forest and the cavernous network of Lehman Caves. There are more than 30 caves and rock shelters within GRBA, including the quarter-mile long Lehman Cave. Lehman Caves National Monument, named for Absalom Lehman an early rancher and entrepreneur who opened the caves to the public in 1885, was originally designated to protect the Lehman Caves. The monument was later enlarged and redesignated as Great Basin National Park. The caves were formed in the Middle Cambrian Pole Canyon Limestone. Generally massive, pale gray to white, the Pole Canyon underwent low grade metamorphism and is now a low grade marble (Harris et al., 1995). The metamorphism erased much of the Pole Canyon's fossil record, although scattered Paleozoic invertebrates have been found (Kurt Pfaff, personal communication, 1998).

In 1938, S.M. Wheeler initiated an archeological excavation at Lehman Cave. During this excavation, 29 human and 219 animal bones were recovered from within Lehman Cave. The animal bones represent a wide diversity of fauna including remains of *Ovis* sp., *Odocoileus* sp., *Canis* sp., *C. latrans* (coyote), *Vulpes fulva* (red fox), *V. macrotis* (kit fox), *Taxidea taxus* (American badger), *Lepus* sp., *Sylvilagus* sp., *Marmota* cf. *flaviventris*, *Felis rufus* (bobcat), *Neotoma* sp., *N. cinerea*, a grouse and a snake. A variety of small and large unidentified mammal remains were also found during the excavation (Rozaire, 1964).

A second excavation was undertaken during 1963 under the direction of Dr. Charles Rozaire. This project focused on the fluvial deposits within the original entrance area of Lehman Caves. Rozaire's excavations produced additional fauna which were identified by A. Ziegler of the Museum of Vertebrate Zoology, University of California, Berkeley. The remains included: various bats of the genus *Myotis, Citellus* sp. (ground squirrel), and other sciurids, *Thomomys* sp., *Martes americana* (marten), *Ovis canadensis*, *Antilocarpa americana* (pronghorn antelope), *Equus*, *Gopherus* cf. *agassizi* (tortoise), and *Centrocercus urophasianus* (sage grouse). Unidentified amphibian, bird, and rodent remains were also recovered during the excavation. The shell of a desert tortoise was discovered during the excavation and may represent a Native American trade item. The bones were scattered, disarticulated, and exhibited evidence of rodent gnawing. Large mammal remains may have been brought into the cave as the remains of a kill. The animal bones are reported to date back to the Pleistocene (Rozaire, 1964).

Wheeler and Rozaire headed the only excavations of caves from within Great Basin National Park. The natural entrance to Lehman Caves has since been closed by the park and a more accessible visitor entrance was constructed (J. Tuttle, personal communication, 2001). Snake Creek Burial Cave (see section on Caves Near National Park Service Areas in this paper), Danger Cave, Labor-of-Love Cave, Last Supper Cave, Hanging Rock Shelter, Hidden Cave, and Smith Creek Cave are all caves in the vicinity of Great Basin, but outside of the park boundary. Archaeological and/or paleontological studies have been undertaken at these sites (J. Tuttle personal communication, 2001).

GUADALUPE MOUNTAINS NATIONAL PARK

Guadalupe Mountains National Park (GUMO) was established to preserve one of the world's most extensive and significant limestone reefs. The "Permian Reef Complex" is located on the northwestern margin of the Delaware Basin and contains one of the largest fossil reefs in the world (Newell et al., 1972). Additionally, the park preserves one of the most complete Permian marine sequences in the world. Forty miles (64 kilometers) of this reef, known as the Capitan Reef, is exposed in the Guadalupe Mountains. The reef is also exposed in the Apache and Glass mountains, however, most of the reef is present in the subsurface. Hayes (1964) and Hill (1987) provide a excellent overviews on the geology of the Guadalupe Mountains. Girty (1908) published the first description of the Guadalupian fauna.

McKittrick Canyon reveals a cross section of the reef, exposing many fossils and small caves. The fossil fragments are irregular in size and shape, and are poorly sorted, showing little evidence of being transported great distances. Invertebrate fossils are present throughout the exposed reef including algae, fusulinids, sponges, corals, bryozoans, brachiopods, trilobites, ostracods, gastropods, cephalopods, scaphopods, pelecypods, crinoids, echinoids, and conodonts.

Twenty-seven caves have been documented within Guadalupe Mountains National Park. Most of these are administratively closed to the public. Since the 1930s the Guadalupe Mountains have been recognized for their significant Pleistocene/Holocene cave fossils. Of global significance, four of the ten known sloth dung localities in the world occur in Guadalupe Mountains National Park. The sloth dung is documented from Lower Sloth Cave, Upper Sloth Cave, Dust Cave, and Williams Cave (Spaulding and Martin, 1979).

Van Devender and others (1979) established a chronological sequence of Late Pleistocene and Holocene plant communities in the Guadalupe Mountains spanning the last 13,000 years. The chronology is based upon plant macrofossils and pollen collected from four caves in Guadalupe Mountains National Park. The plant communities in the Guadalupe Mountains have gradually changed from relatively mesic woodland and forest associations during pluvioglacial climates in the Late Wisconsin Glacial Epoch to the present xeric Chihuahuan desert scrub (Van Devender et al., 1979).

Burnet Cave, also known as Rocky Arroyo Cave, lies on the eastern slope of the Guadalupe Mountains. Nine feet (3 meters) of unstratified sediments, consisting of wind blown dust and roof spall, cover the floor of the cave. Archeological resources occur in the upper portions of the cave deposits. Charcoal lenses and a few hearths were identified from within the cave sediments. A radiocarbon analysis of one charcoal lens revealed a date of approximately 7,432 years B.P. (Libby, 1954). A Folsom-like spear point was discovered in association with the remains of a bison and muskox in the cave.

A joint expedition into Burnet Cave was undertaken by the University Museum of Philadelphia and the Academy of Natural Sciences of Philadelphia between 1930 and 1933. In 1931, the excavation was visited by Childs Frick and Barnum Brown from the American Museum of Natural History. Sixty-two species were identified including two reptiles, seventeen birds, and forty-three mammals (Schultz and Howard, 1935). The avian remains, including bones from a specimen of *Gymnogyps californianus,* were examined and identified by Alexander Wetmore from the United States National Museum (Wetmore, 1932).

A poorly documented excavation of Burnet Cave was undertaken in 1936 By Edgar Howard. During 1937, Dr. C. Bertrand Schultz (University of Nebraska) and the Academy of Natural Sciences of Philadelphia sent Howard back to excavate Burnet Cave. Sixteen feet (5 meters) of cave sediments were excavated, however, the rock floor of the cave was not reached. More than fifteen thousand specimens of small mammals were recovered (Burnet, 1938).

A number of the vertebrates collected in Burnet Cave represent boreal species extended to their southernmost limits. These taxa include *Marmota flaviventris*, *Neotoma cinerea*, *Microtus longicaudus*, *Lepus townsendi*, and *Vulpes macroura* (Murray, 1957). The *Marmota* specimen has been of particular interest and is considered to be an aberrant member of the fauna (Stearns, 1942; Antevs, 1954). Remains of the extinct *Euceratherium collinum* and *Navahoceros fricki* were also recovered from Burnet Cave and suggest a northern latitude affinity. The fauna includes a number of forest and arid-desert species. Three herptozoans have been reported from Burnet Cave (Gehlbach and Holman, 1974).

Pratt Cave is located on the southwestern portion of McKittrick Canyon. The cave formed within the Lamar Limestone (Bell Canyon Formation). Fossil pollen, molluscs, and vertebrates have been collected from the cave. Although the vertebrate bones are largely disarticulated, they are well preserved. A diverse herpetofauna including eighteen species has been documented from Pratt Cave (Gehlback and Holman, 1974). This assemblage of amphibians and reptiles consist of arid-adapted taxa that span the late Wisconsin/Recent boundary. The Pratt Cave herpetofauna are curated in the vertebrate collections at Michigan State Museum.

During 1962, a test excavation in Pratt Cave yielded six avian bones. The bones were identified by Lyndon Hargrave as the remains of the extinct *Geococcyx conklingi* (Conkling's roadrunner) and a turkey. McKusick (1978) concluded that the Pratt Cave fossil bird specimens were deposited as owl pellets. Howard and Miller (1933) published a list of avifauna collected from caves in the Guadalupe Mountains.

In January 1966, eighteen feathers were collected from test excavations in Pratt Cave. The feathers were analyzed and identified by Norman Messinger (1978). The feather morphologies represent the remains identified as anseriformes (waterfowl), galliformes (gallinaceous bird), ciconiiformes (heron or egret), and strigiformes (owl).

Lundelius (1970, 1979) reported on collections of mammal bones from Pratt Cave. The assemblage of small mammal bones was interpreted either as accumulations of owl pellets or gathered by packrats. An articulated small rodent foot was uncovered with the bone elements held together by dried ligaments. The large mammal bones were interpreted as being transported by carnivores.

Lower Sloth Cave is located on the west side of Guadalupe Canyon. The fauna and flora from the cave spans the transition from Late Wisconsin Stage into the Holocene. Logan (1977) reports on six test trenches that were excavated in Lower Sloth Cave. The remains of two birds and 30 mammal species have been recovered from the cave (Logan and Black, 1979). Plant macrofossils and microvertebrates have also been collected from packrat middens. Three of the species are now extinct or locally extinct including the Pleistocene Black Vulture, Bighorn Sheep, and Shasta Ground Sloth. Sloth dung has been identified in this cave and has yielded a radiocarbon date of 10,750–11,060 years B.P.

Plant macrofossils and pollen profiles from Lower Sloth Cave span the last 13,000 years (Van Devender et al., 1977a). The vegetation indicates an overlap between a Late Pleistocene subalpine forest with grassy meadows. There are a few arid desert species interspersed in the flora. A radiocarbon date of approximately 13,000 years B.P. was obtained from some *Picea* (spruce) needles.

Logan (1977) interpreted the accumulations of vertebrate bones from both natural death assemblages and carnivore transport. The remains of immature birds and bats exhibit little breakage prior to deposition and represent a natural death assemblage of taxa inhabiting the cave. The carnivore-transported assemblages show breakage and evidence of feeding. Small bone accumulations were associated with owl pellets and small carnivore scats (i.e., *Bassariscus, Spilogale, Canis*)

Upper Sloth Cave preserves packrat middens containing plant macrofossils and microvertebrates. Logan (1975) reported on Pleistocene vertebrates from the cave. Sloth dung from the cave yielded a radiocarbon date of approximately 11,760 years B.P. *Picea* needles from a packrat midden yielded a radiocarbon date of about 13,000 years B.P.

Williams Cave (Indian Cave) is located in the southern portion of the Guadalupe Mountains. The cave floor is covered with fine dust and rocks dropped from the cave ceiling. The cave was completely excavated during 1934 and 1935 when seven-foot deep trenches were dug about halfway to the rear of the cave. Ayer (1936) reported the remains of one reptile (snake vertebrae), one bird, and twenty-two mammal species from Williams Cave. The mammal genera include *Cynomys* (prairie dogs), *Citellus* (ground squirell), *Cratogeomys* (pocket gopher), *Perognathus, Neotoma, Erethizon, Lepus, Sylvilagus, Canis, Urocyon, Felis, Lynx, Ursus, Odocoileus, Cervus* (deer), *Antilocarpa, Ovis, Equus,* and *Nothrotheriops*. Additional cave fauna include five locally extinct taxa including the grizzly bear, dire wolf, elk, horse, and ground sloth. Well-preserved sloth dung was also collected and has been curated in the Academy of Natural Sciences in Philadelphia. Remnants of packrat middens are plastered to the cave walls. Radiocarbon dating of cave deposits range between 11,140 and 12,100 years B.P. Ernest Lundelius and the Texas Archeological Society Field School visited Williams Cave in June 1970. The Guadalupe Mountains National Park has copies of the typed field notes from this site visit.

Dust Cave has plant macrofossils and microvertebrate remains that have been preserved in packrat middens. The remains of a black vulture and bighorn sheep have been documented from Dust Cave. Ground sloth dung is preserved in this cave. Redemption Pit is a separate karst feature at Guadalupe Mountains National Park that contains vertebrate bones, but there is little information available about this cave.

HALEAKALA NATIONAL PARK

Haleakala National Park (HALE) was established in 1960 to protect fragile native Ha waiian ecosystems, rare and endangered species, and cultural sites. Haleakala is an ancient shield volcano formed by eruptions starting around 800,000 years ago. The most recent eruption occurred about 1790. Caves and lava tubes are documented in the Kipahulu Valley.

Between 1984 and 1988, the remains of birds have been collected from the lava tubes, sink holes, and sand dunes at the park (Medeiros et al., 1989; James et al., 1987). Bird fossils were collected from Luamanu ("bird pit) and Pukamoa ("chiken-like bird hole") caves at Haleakala. This fossil avifauna increases the endemic terrestrial bird fauna on the island of Maui from 10 to at least 29 species. Many of these new finds represent undescribed bird species. The drop in avian diversity is attributed to the arrival of humans on the island (Olson and James, 1982a & 1982b). The first Polynesian colonizers arrived during the fifth century. The first European naturalists arrived in the late 1700s.

JEWEL CAVE NATIONAL MONUMENT

Jewel Cave National Monument (JECA) was established in 1908 to preserve a network of passages containing calcite crystals. The name Jewel was derived from the extraordinary abundance of the calcite crystals. The "crystal lining" at JECA has been measured up to 10 inches (25 cm) thick in some sections of the cave. A number of other caves exist at the Monument including Secret Cave, Bush's Cave, Cove Cave, and Midden Cave (Schubert et al., 1995; M. Wiles, personal communication, 2001).

Jewel Cave, like Wind Cave 18 miles (29 kilometers) to the east-southeast (see section on Wind Cave National Park in this paper), is formed in the Mississippian Madison Limestone (known locally as the Pahasapa Limestone). The Pahasapa Limestone surrounding Jewel Cave is nearly 400 feet (122 meters) thick. The upper third is cliff-forming and fossiliferous. Common fossils in the Pahasapa include brachiopods, cephalopods and a sponge-like creature which may be bryozoan (M. Wiles, personal communication, 2001). The cave passages are usually located in the upper 200 feet (61 meters) of the formation (M. Wiles, personal communication, 2001).

Two separate excavations were conducted inside Jewel Cave's dry entrance. This historic cave entrance has been enlarged by blasting (circa 1900) to facilitate visitor access. One excavation was conducted in the debris pile or fill cone deposited after the Pennsylvanian paleofill common throughout the cave (M. Wiles, personal communication, 2001). During the excavations, which included the ubiquitous *Neotoma* middens, fragmented skeletal remains were recovered and identified as a snake (*Crotalus*), bats, sciurid and cricetid rodents, *Neotom*a sp., *Microtus* sp., lagomorphs, an unidentified large mammal, and a number of gastropod genera. All of the large mammal bones were fragmented and often displayed rodent gnaw marks. One excavation also uncovered non-rodent coprolites (Schubert et al., 1995). Most of the remains represent extant species suggesting a late Pleistocene or Holocene age. No additional paleontological resources are known from the 125 miles (201 kilometers) of documented cave passages (M. Wiles, personal communication, 2001). Absolute age analysis has not yet been performed at Jewel Cave.

LAKE MEAD NATIONAL RECREATION AREA

Lake Mead National Recreation Area (LAME) was the first national recreation area established by an act of Congress. Lake Mead was formed by the construction of Hoover Dam and consists of the lake and over a million acres (>4,000 square kilometers) of desert and mountains.

There are a number of limestone formations within Lake Mead National Recreation Area including the Cambrian Muav Limestone, the Mississippian Redwall Limestone (Supai Group), the Mississippian-Pennsylvanian Callville Limestone (Tonto Group), and the Bitter Ridge Limestone Member of the Horsespring Formation (K. Rohde, personal communication, 2001). The Redwall is particularly fossiliferous, preserving crinoids, brachiopods, byrozoans and additional marine fauna, along with the rare nautiloid (Harris et al., 1995). Both the Redwall and the Muav limestones are cavernous. Two well-documented caves, Muav Cave and Rampart Cave, were originally within the boundaries of LAME. However, boundary changes in 1975 now place the caves within Grand Canyon National Park (see section on Grand Canyon National Park in this paper).

Currently, Lake Mead has a number of shelters with archeological resources. *Neotoma* middens are common in these shelters. Formal paleontological studies within the shelters or on the middens have not been undertaken. A mammoth site may also be located in the recreation area (K. Rohde, personal communication, 2001).

LAVA BEDS NATIONAL MONUMENT

Lava Beds National Monument (LABE) contains the largest known concentration of lava tube caves in the contiguous United States. The monument is situated on the northern flank of the Medicine Lake volcano. The lava flows in the park are associated with Medicine Lake volcanics (K. Fuhrmann, personal communication, 2001). The landscape of the monument is covered with multiple spatter cones and cinder cone volcanoes, 30 lava flows, and more than 450 lava tube caves and other lava tube features. The oldest lava flow in the monument associated with the Medicine Lake volcano is approximately 450,000 years old. Other geologic features in the park range in age from the approximately two million year old volcanic tuff on Gillem Bluff to the 1,100 year old lava of the Callahan lava flow emanating from Cinder Butte, just outside the monument boundary.

In March 1931, prior to the establishment of Lava Beds National Monument, a dentary fragment with two partial molars of an American mastodon *Mammut americanum* and two *Camelops* teeth were discovered in a lava tube cave located at that time in Modoc National Forest. The collector of the specimens, F.P. Cronemiller, was one of the first individuals to enter the cave later named Fossil Cave.

Collection records from the Museum of Paleontology at the University of California at Berkeley document additional Late Pleistocene specimens that were collected from Fossil Cave by James Moffett during the early 1930s. Moffett, a California Fish & Game employee, turned over an ursid canine and a camelid premolar to William S. Brown, who forwarded all of the Fossil Cave material to the Museum of Paleontology at Berkeley.

Human remains have also been recovered in the park, however, the age of these remains are unknown. Human activity in the region dates back to about 11,000 years ago.

Unlike the more recent bone material discovered within the many lava tubes within the monument, the specimens collected by Cronemiller and Moffett were reportedly embedded within the basaltic lava and appear to be approximately 30,000 to 40,000 years old. The volcanic association of the fossil material raises questions regarding how the specimens survived destruction from the high temperature lava (K. Fuhrmann, personal communication, 2001).

MAMMOTH CAVE NATIONAL PARK

Mammoth Cave National Park (MACA) was established to preserve the largest cave system in the world, consisting of over 350 miles (563 kilometers) of explored passages within the karst topography of Kentucky. Mammoth Cave occurs within the Mississippian limestones of the region and may have begun to develop sometime between 5 and 30 million years ago (A. Palmer, 1995a). Mammoth Cave formed within three limestone formations. The St. Louis Formation is approximately 200 feet (61 meters) thick, although Mammoth Cave passages are found only in the upper half of the formation. Gypsum beds are common at depth in the formation, but ground water solution has removed the near surface deposits (A. Palmer, 1995a). The Saint Genevieve Formation, overlying the St. Louis, ranges between 100-120 feet (30-37 meters) thick, with Mammoth Cave passages throughout the thickness of this formation. Representing a more humid environment than the St. Louis, the Saint Genevieve does not contain gypsum. Thin silty beds represent encroachment of detrital sediments. The Girkin Formation consists of limestone members interspersed with thin silty limestones and shales, which combine to a total thickness of 135-140 feet (41-43 meters). Mammoth Cave passages are found throughout the thickness of the Girkin (A. Palmer, 1995a).

Paleontological remains within the Mammoth Cave System have received relatively little attention in the past. Nevertheless, significant paleontological resources have been documented from caves in the park for nearly 40 years. Jegla and Hall (1962) reported on a desiccated bat guano pile dated to more than 38,000 years B.P. Within the guano deposit were skeletal remains of *Myotis* (bat), *Tadarida* (free-tailed bat), and *Peromyscus*. Ron Wilson, a National Park Service employee, collected paleontological resources from throughout Mammoth Cave during the late 1970s. Wilson (1981; 1985) reported *Tapirus*, *Platygonus*, *Arctodus*, and a mammoth or mastodon from the Proctor section of Mammoth Cave.

In order to more fully document the paleontological resources from within the caves of Mammoth Cave National Park, the Illinois State Museum and the Cave Research Foundation entered into a cooperative research endeavor with MACA to inventory fossil vertebrate remains. The inventory was initiated in 1997 and continued through 2001.

One component of the project focused on historic bat use in the cave, especially around the historic entrance area. Evidence of bat activity was noted early in the study. Large quantities of *Procyon lotor* (raccoon) scat containing a high percentage of bat bones were also documented (Toomey et al., 1998). Additional evidence of bat roosts was also discovered in the more inaccessible areas and passages of the cave. The remains from a number of bat species were found near the Historic Entrance area. The most common bat species was identified as the medium sized species of *Myotis*, either *M. lucifugus* (little brown bat) or *M. sodalis* (Indiana bat) (Toomey et al., 1998). Other species of *Myotis* include *M. griscesens* (gray bat) and *M. leibii*. Less common bat genera found near the Historic Entrance area include *Eptesicus fuscus* (big brown bat), *Pipistrellus subflavus* (eastern pipistrelle), *Lasiurus borealis* (red bat), and *Corynorhinus* sp. (big-eared bat) (Toomey et al., 1998). Bat bones, bat guano, and raccoon scat were radiocarbon dated with ages ranging from 8,700 years B.P. to 100 years B.P. Most of the material yielded dates less than 1,000 years B.P. (Toomey et al., 1998). Portions of the research focusing on bat use in the Historic Entrance area was presented at the 2001 Indiana Bat Symposium (R. Olson, personal communication, 2001).

Another component, a more general vertebrate paleontological inventory, was designed to locate, identify, describe, and map paleontological resources in caves throughout the park in order to assist in paleoenvironmental reconstruction, interpretation, and resource management (Toomey et al., 1998). An additional benefit of the inventory was the development of better models for the different contexts in which paleontological remains have been found within the cave (Toomey et al., 2000). Paleontological resources were identified in four contexts. These include: 1) recent surficial remains (often less than 4,000 years old); 2) relictual deposits representing the cave surface before human utilization of the cave; 3) older surficial deposits (such as bat guano); and, 4) very old (hundreds of thousands to millions of years old) deposits associated with the primary water-lain sediments in the cave (Toomey et al., 2000). This inventory focuses on allochthonous remains, the remains of animals that inhabited/utilized the cave after cave development. Examples of such remains include isolated bones, groups of bones, partial or whole skeletons, partial or whole mummified animals, guano or scat, and traces (scratchings, footprints, trails, and staining)

(Toomey et al., 1998). Plant and invertebrate remains are not actively inventoried, nor are marine invertebrates within the Mississippian limestones of Mammoth Cave. However, such resources are noted when they are encountered near vertebrate remains.

During the first year of the inventory (1998) the data revealed that bat remains were by far the most common vertebrate resource found in the cave. Of the bats, indeterminate medium-sized *Myotis* (*M. lucifugus* or *M. sodalis*) bones were the most common (Toomey et al., 1998). Identifiable specimens of *M. lucifugus* and *M. sodalis* were also very common. A number of other bat species were noted. These species include *M. griscesens*, *M. leibii*, *M. septentrionalis* (northern long-eared bat), *Pipistrellus subflavus*, *Eptesicus fuscus*, *Lasiurus borealis*, *L. cinereus* (hoary bat), *Corynorhinus* sp. (big-eared bat), *Tadarida* sp., and *Desmodus* sp. (vampire bat) (Toomey et al., 1998). In addition to the extensive bat remains found in the caves, other vertebrates were also noted. Bones of *Neotoma* sp., *Peromyscus* sp., *Procyon lotor*, *Gallus gallus* (domestic chicken, apparently left by humans as trash within the last 100 years), *Odocoileus virginianus* (deer), *Sus scrofa* (pig), and various amphibians were all found in Mammoth Cave system (Toomey et al., 1998). Radiocarbon dating have not been performed, however, much of the material appears to be less than 1,000 years old. Although some material may be as old as 1 to 2.5 million years old based on tentative correlations to sediments that have been dated using Aluminum/Beryllium (R. Olson, personal communication, 2001; Toomey et al., 1998). Some specimens appear to be extremely recent, less than five years old.

The remains of *Desmodus* sp., *Cryptobranchus* sp. (hellbender), and some unidentified bat bones were found in the upper level laminated slackwater flood sediments of Backslider's Alley. These remains appear to represent the oldest vertebrate remains found in the cave. The *Desmodus* remains were field identified as belonging to a now extinct species that lived during the Pliocene-Pleistocene, rather than the modern *D. rotundus* (Toomey et al., 1998). A paved trail cut from the Frozen Niagara Entrance to the cave, extending approximately 115 feet (35 meters) into the cave, exposed a rich faunal assemblage. This material has not been fully analyzed, however, vertebrates of a wide taxonomic range have already been identified. Amphibians (both frogs and salamanders), reptiles (turtles, snakes, and lizards), birds, and mammals have all been identified (Colburn et al., 2000). The mammalian remains include two extinct species, *Platygonus* (flat-headed peccary) and *Dasypus bellus* (beautiful armadillo). Large extant taxa were also recovered including *Odocoileus* sp. and *Procyon lotor*. A wide variety of bat taxa were also documented. Rodents found in the deposit include *Geomys* sp., and *Neofiber* sp. (water rat). The *Neofiber* remains are of particular interest because they may represent the modern *Neofiber* species. Modern *Neofiber* is found only in the subtropics of Florida and Southern Georgia, presenting a strong argument for an interglacial age (Colburn et al., 2000). Uranium series dates were obtained from the carbonate crust sealing the top of the deposit and yielded an age of 125,000-126,000 years B.P. (Colburn et al., 2000). These dates may represent the age of the bone-bearing layers, which would make the deposit one of the very few well-dated Sangamonian faunas in the central United States (Colburn et al., 2000). However, none of the other Sangamonian faunas have the wide taxonomic range displayed in the Frozen Niagara deposit (Colburn et al., 2000).

A large number of mummified bats were found preserved near Star Chamber. The quality of preservation ranges from a few bones with tissue attached to complete desiccated bats of the *Myotis* genus (Toomey et al., 1998). The age of this material has not yet been determined. Another interesting discovery was that the *Tadarida* guano deposit described by Jegla and Hall (1962) is much more extensive than previously thought (Toomey et al., 1998; 2000).

NATCHEZ TRACE PARKWAY

Natchez Trace Parkway (NATR) was established commemorating the historic network of closely interconnected trails connecting what is now known as Nashville, Tennessee and Natchez, Mississippi. This 444 mile (714 kilometer) trail or trace was first used by Native Americans and then by early European settlers and traders as a route to the old southwest.

Solution tube caves are present throughout NATR in limestone-dominated formations. Only one cave, Georgetown Cave, is sizeable enough to permit comfortable human entry. Georgetown Cave has been closed to the public since 1969 in an effort to protect this unique resource and its value as an endangered species habitat. Cave Spring is another sink contained within park boundaries located just south of the Mississippi-Alabama State Line. Portions of the ceiling have collapsed somewhat over the past decades, limiting public access. Nevertheless, this interpretive site remains open to the public and walking a short distance into the two caves is still possible. Fossil resources in most park caves are largely unknown, with formal surveys of Georgetown and the other caves being initiated pending the availability of external funding (B. Whitworth, personal communication, 2001).

NATURAL BRIDGES NATIONAL MONUMENT

Natural Bridges National Monument (NABR) was the first National Park Service unit established in Utah. The monument preserves three natural bridges including the second and third largest natural bridges in the world.

The Cedar Mesa Sandstone is a complex unit consisting of three different facies, only two of which, the white sandstone and the red mudstone, are visible within the Monument. The white sandstone facies is made up of quartz rich sandstones, interpreted to be the product of aeolian dune formation due to the facies abundance of high-angle, large-scale cross beds. Sand-sized marine fossil fragments can be found in this unit, but are typically rare (Huntoon et al., 2000). The red mudstone facies is made up of horizontally laminated beds of mudstone ranging in thickness from 1-10 feet (0.3-3 meters) that separate the dune deposits of the white sandstone. Discontinuous and unfossiliferous limestones beds are present within the Cedar Mesa Sandstone. Based on their relative thinness and large geographical extent, the mudstones are interpreted as floodplain deposits that were then covered by subsequent migrating dunes (Huntoon et al., 2000).

A dry cave, named Bare Ladder Shelter, is a flat-floored feature carved into the Permian Cedar Mesa Sandstone at NABR. The shelter preserves the remains of *Oreamnos harringtoni* along with pack rat middens that date to the Rancholabrean. Two metapodials of *O. harringtoni* were recovered on the surface of the shelter floor along with dung pellets. The dung pellets from the lowest layer were radiocarbon dated to more than 39,800 years ago, making it the oldest directly dated find of *O. harringtoni* (Mead et al., 1987; Mead and Agenbroad, 1992). Additional dung pellets have been radiometrically dated with ages ranging from 23,350 to 9,660 years old. The dung pellets were found to contain a wide variety of plant microfossils (Mead et al., 1987). A *Betula occidentalis* twig (water birch) was also found in the shelter and dated to 26,470 years old (Mead et al., 1987). However, this specimen has been considered to be an introduced contaminant (Mead and Agenbroad, 1992). In addition, the shelter contains a large number of cemented packrat middens, apparently from the Late Pleistocene, which contain a wide assortment of plant microfossils (Mead et al., 1987). Not all of the plant microfossils represent the current local flora, presenting evidence for climatic changes outside of the shelter (Mead et al., 1987).

OREGON CAVES NATIONAL MONUMENT

Oregon Caves National Monument (ORCA) contains a series of interconnected chambers that together form a single large cave within the marble of the Jurassic Hayfork Formation. Local mountain building events have substantially influenced cave development. The low-grade metamorphic marble of the Hayfork does not contain an abundance of fossils, however, a few poorly preserved crinoids and foraminifera have been found (J. Roth, personal communication, 2001). Cave sediments, primarily alluvial and fluvial, occur in multiple levels within the cave. These sediments range in age from less than 10,000 years old to strata at least 120,000 years old . Some cave sediments are speculated to be even older, maybe extending back 1.5 million years.

National Park Service Paleontologist Greg McDonald assessed the cave's megafauna in 1995.

Remains of a jaguar and *Ursus americanus* (black bear) were identified. A limb bone, possibly belonging to *Ursus arctos* (grizzly bear) yielded a radiocarbon date greater than 50,000 years old (G. McDonald, personal communication, 2001). Jim Mead initiated a screen washing of cave sediments to inventory fossil material from one locality in the cave. The faunal remains recovered from Mead's locality are quite extensive with salamanders being the dominant fossil. Other remains include snails, slugs, small birds, and a rare anuran. *Elgaria* (western alligator lizard), *Charina* (rubber boa), *Crotalus*, colubrids, bats, *Sorex* spp., *Neurotrichus, Zapus* (jumping mouse), *Peromyscus*, *Reithrodontomys* (harvest mouse), *Neotoma*, *Aplodontia* (mountain beaver), *Thomomys*, sciurids, *Cleithrionomys* (vole), *Microtus*, *Phenacomys/Arborimus* (vole), *Lepus*, *Sylvilagus*, *Ursus*, *Spilogale*, *Cervus*, and *Odocoileus* were specifically identified in the cave deposits. Many of the fossil species are known to live in the area around the cave today. Radiocarbon dates of charcoal from the cave locality date to approximately 1,820 years B.P. (Mead et al., 2000).

Vertebrate trace fossils have also been documented in Oregon Caves. A single 4.5 inch (11 centimeter) bear paw print is preserved in the cave sediments. There are at least 20 distinct claw scratch marks in the sediments, tentatively identified as bear claws (Figure 14). One such trace is exceptionally preserved, showing five claw points pushed into the mud (Figure 15) (S. Knutson, personal communication, 1998).

OZARK NATIONAL SCENIC RIVERWAYS

Ozark National Scenic Riverways (OZAR) preserves 134 miles (216 kilometers) of the Current and Jacks Fork rivers. This unit of the National Park Service was the first national scenic river. The site preserves a wide range of natural, cultural, and recreational resources in southeastern Missouri.

Ozark National Scenic Riverways is home to at least 300-400 recorded caves. The principle cave-forming unit in the park is the Cambrian-Ordovician Emminence Formation, made up primarily of dolomite. Many of the caves in the Emminence are generally small fissure features. Fossils are rare within the Emminence (J. Kroke, personal communication, 2001).

Pleistocene mammal remains have been collected from a number of park caves and overhangs. Oscar "Oz" Hawksley collected many of these fossils between the 1950s and 1980. Much of Hawksley's collection is now curated in the Illinois State Museum's Vertebrate Paleontology Collection. *Ursus americanus* remains were found in a number of caves including Bat, Leather Creek, and Wind. *Arctodus simus* bones have been found in both Round Spring Cavern and Powder Mill Creek Cave. *Panthera onca* (jaguar) bones are known from Bat Cave. *Sangamona* (or *Odocoileus*) specimens have been described from Little Bluff Cave. Remains of *Castor canadensis* (beaver) were collected in Powder Mill Creek Cave.

FIGURE 14. Bear claw marks in cave wall at Oregon Caves National Monument, Oregon.

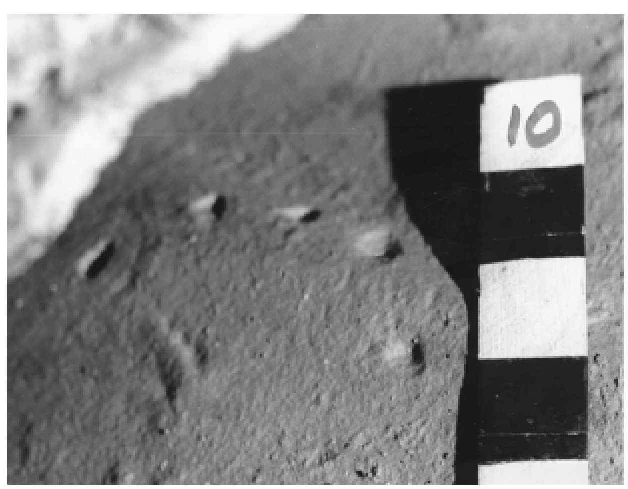


FIGURE 15. Bear claw tips in cave wall at Oregon Caves National Monument, Oregon.

In addition, wolf material was collected from Round Spring Cavern (B. Schubert, personal communication, 2001). Portions of a giant armadillo carapace are also reported from the park's caves (C. Putnam, personal communication, 2001).

RUSSELL CAVE NATIONAL MONUMENT

Russell Cave National Monument (RUCA) is primarily an archaeological site, preserving evidence of occupation by Native Americans for nearly 9,000 years in a cave with nearly seven miles (11 kilometers) of passages. Paleontological resources at the monument extend back to the Mississippian and Pennsylvanian. Entrances to the cave are at the base of the northeast flank of Montague Mountain within the Mississippian Gasper Formation. The Gasper Formation is massive and fossiliferous, with interbedded thin shaley limestone partings above the main entrance to Russell Cave (Jones and Daniel, 1960). The Gasper is mostly a fine-grained lithographic limestone which forms the roof and walls of the cave. Oolitic beds can be found in the cave as well (Jones and Daniel, 1960).

Fossils are common throughout the park, with horn corals and crinoid stems making up the majority of the observed fossil fauna (L. Beane, personal communication, 2001). Crinoids, blastoids, and brachiopods have been found in the roof and walls of Russell Cave. An accession file record for paleontological collections in the Monument indicate horn corals and additional fossils collected from a sinkhole in 1987. Accessions also include *Calamites* bark impressions, horn corals, brachiopods, gastropods, crinoids, and an *Archimedes* specimen. A blastoid, *Pentremites pyriformis*, was discovered along a trail near a shelter over the main entrance. This taxon does not occur in strata below the Gasper Formation (Jones and Daniel, 1960). A basal disk from the crinoid *Agassizocrinus coniens*, a common crinoid in the Gasper, was found in the roof of Russell Cave (Jones and Daniel, 1960). Compound coral, perhaps *Campophylium gasperence*, in association with *Glyptophora punctipora*, have also been observed in the cave.

Remains of an extinct Pleistocene peccary, *Mylohyus* cf. *M. nasutus*, have been found in Russell Cave as well (L. Beane, personal communication, 2001). These remains mark the first known occurrence of *Mylohyus* in Alabama.

Similar fossil assemblages have been noted in Montague Cave, about a mile (1.6 kilometers) southeast of Russell Cave's northern entrance, outside of the park. Ridley Cave, one-half mile (0.8 kilometers) northwest of Russell Cave, but within the park boundaries, may also contain similar fossils. Ridley Cave may be linked to Russell Cave (Jones and Daniel, 1960).

SEQUOIA / KINGS CANYON NATIONAL PARKS

Sequoia and Kings Canyon National Parks (SEKI) are two units of the National Park Service in California that are administered together. Sequoia National Park was established to preserve groves of giant sequoias and Mount Whitney, the highest mountain in the contiguous United States. Kings Canyon National Park consists of two large canyons of the Kings River and the summit peaks of the High Sierra.

There are approximately 200 caves within SEKI boundaries. The vast majority of these caves are formed in metamorphosed limestones (J. Despain, personal communication, 2001). The predominant geology in the park consists of Late Cretaceous granitic batholiths. Due to the intrusion of these batholiths, sedimentary rocks do not exist in their original state and are confined to metamorphosed roof pendants (Harris et al., 1995). These pendants have undergone complex deformation and their stratigraphy is debated. Marble in the pendants has been partially dissolved by groundwater, forming caverns such as Crystal Cave, Clough Cave, Palmer Cave, Paradise Cave, Hurricane Crawl Cave, Lange Cave, and Bear Den Cave (J. Despain, personal communication, 2001).

Most of the fossil remains preserved in the limestones were destroyed during the metamorphism.

However, two heavily deformed fossils, including an ammonite, indicate that the limestones were deposited sometime between the Late Triassic and Early Jurassic (J. Despain, personal communication, 2001). Bear Den Cave is quite dry and holds potential for fossils specimens of relatively good preservation. A brown bear jaw and packrat middens were discovered in Bear Den Cave. Additional material from Bear Den includes extensive deposits of long and short bones, vertebrae, and a skull (Figure 16). Palmer Cave is a large collapsed pit with a debris pile nearly 75 feet (25 meters) high. The cave is rather wet, which quickly degrades any resources that may be found within its confines, however extensive bone material is reported from the cave. Fossilized *Sequoia* has been discovered in a number of the caves. The distribution of the fossil *Sequoia* suggests that that these trees existed in some areas of the park during the past where they are not found today (J. Despain, personal communication, 2001).

FIGURE 16. Large mammal bone in Bear Den Cave at Sequoia / Kings Canyon National Parks, California.

During the 1950s, the remains of a Harlan's ground sloth were discovered in Lange Cave and subsequently excavated. Unfortunately the current location of the specimen is unknown. Small rodent bones, some with "chew" marks on them, and a few long bones were found in Crystal Cave. Inside Hurricane Crawl Cave, a number of small skeletons and bones have been discovered, some contained within the cave's flowstone. Carmoe Crevice discoveries include a few small bones and a skeleton also preserved in flowstone. Small bones have been found in Lilburn Cave. In addition, an apparent deer skeleton was recovered in Pet Cemetery. Ages of the cave passages are not well established. However, passages in Crystal Cave and Soldier's Cave have been dated to 172,000 and 71,000 years old, respectively, using Uranium series dating from speleothems (J. Despain, written communication, 2001).

Cole (1983) produced the first report of late Pleistocene packrat middens from the western side of the Sierra Nevada. Plant remains and dung pellets were collected from seven middens. One midden, King's Canyon No. 8, produced identifiable vertebrate skeletal remains. The following animals were identified from this midden locality: *Hydromantes* sp. (web-toed salamander), *Gerrhonotus* cf. *multicarinatus* (southern alligator lizard), *Sceloporus* cf. *occidentalis* (western fenced lizard), *Thamnophis* sp. (garter snake), *Thomomys* sp., and *Neotoma* cf. *cinerea* (bushy-tailed packrat) (Mead et al., 1985). This assemblage indicates an early or middle Wisconsin record.

TIMPANOGOS CAVE NATIONAL MONUMENT

Timpanogos Cave National Monument (TICA) was established to preserve a colorful lime stone cavern on Mount Timpanogos in the Wasatch Mountains. The cave is known for the presence of both delicate helictites and frost work with an unusual speleogenesis, or origin.

The Monument consists of three separate caves: Hansen, Middle, and Timpanogos. There is a total of 5,600 feet (1,707 meters) of cave passage surveyed in all three caves, with a vertical relief of 189 feet (57 meters). Timpanogos Cave is the longest with 3,000 feet (914 meters) of cave surveyed. The caves have been connected by two man-made tunnels for easier tourist access. All three caves were formed along the American Fork River in the Middle Mississippian Deseret Formation. The Deseret is made up of light to dark grey limestone and dolomite, approximately 426 feet (130 meters) thick. Lenticular cherts have been observed in the formation. Fossil material within the Deseret Formation proper is rather limited, but consists mostly of invertebrates (crinoid stems, horn corals and colonial corals) and coquina. Examples of these have been collected and curated into the monument's museum collection (Rod Horrocks, personal communication, 2001).

Packrat middens and mountain lion food caches are common in the caves of the monument. During 1998, Christian George began excavation of some of the packrat middens with the intent of documenting mammalian remains from the middens. The primary excavation was in the entrance room to Hansen Cave, where packrat middens were found in alcoves along the room's walls. In addition, a small area known as "the Boneyard", located near the natural entrance of Timpanogos Cave, was the site of a limited excavation. The Entrance to Middle Cave may also contain Pleistocene or Holocene deposits, however, difficult access to the site precluded any excavation. Hidden Mine Cave, a prospect excavated in 1920, is a site where miners tunneled into an old packrat midden in a limestone fissure. The skeletal remains recovered from these excavations represented a wide range of exceptionally preserved mammalian taxa. The taxa represented include *Lepus americanus*, *Marmota flaviventris*, *Speromphilus* sp., *Peromyscus* cf. *maniculatus*, *Neotoma* cf. *cinerea*, *Microtus* sp., *Ursus americana*, *Mustela vison* (American mink), *Procyon lotor*, and *Ovis canadensis*. Additional remains of an unknown snake and a small number of postcranial bird bones are known from TICA. All of the mammalian skeletal remains were identified as species extant in the area today except for *Ovis canadensis*. Radiometric dating of the remains has not yet been completed. However, the overwhelming similarity between the midden assemblage and the present-day assemblage of mammals, supports a Holocene age fauna (George, 1999).

VALLEY FORGE NATIONAL HISTORICAL PARK

Valley Forge National Historical Park (VAFO) was established to preserve the site of the Continental Army's 1777-1778 winter encampment. Within the current boundaries of Valley Forge National Historical Park lies an important Pleistocene (Irvingtonian) floral and faunal assemblage from Port Kennedy Bone Cave. The "cave" was actually a fissure fill feature (a paleo-sinkhole) uncovered in 1870 and again in 1896 by quarrymen working the Port Kennedy quarry (Daeschler et al., 1993). The cave deposits were mostly quarried or flooded and later the locality was filled with debris (F. Grady, personal communication, 2001). The quarry was within the northwest dipping Cambrian Ledger Formation, a gray to cream colored limestone (Mercer, 1899). A distinct angular unconformity separates the Ledger from the red sandstones of the Triassic Stockton Formation, part of the Newark Supergroup, that form a "veneer" over the limestones (Daeschler et al., 1993). The Port Kennedy Bone Cave is approximately 40 feet (12 meters) deep and 10-20 feet (3-6 meters) wide (Daeschler et al., 1993; Daeschler, 1996). Much of the fissure fill is unfossiliferous, composed of sediments derived from the Stockton formation. Below this layer is a series of sands and muds forming strata that are "concave-up". Most of the fossils were recovered from this series. Below this fossiliferous series is a layer of black organic-rich clay. Sediments from beneath the black clay are undescribed and unexcavated due to proximity to the water table (Daeschler et al., 1993). Water saturation was indeed an obstacle to the early collection efforts. The collected bones were described as having the consistency of "over-ripe pears" (Mercer, 1899) or "cream cheese" (Daeschler et al., 1993).

Nevertheless, a number of studies and collections were made of the material in the late 1800s, including papers by Edward Drinker Cope in 1871, 1895, 1896, and posthumously in 1899 (Figure 17). Mercer, Wheatley, and Horn (the only study to mention the insects at Port Kennedy) also published on material recovered from Port Kennedy in the late 1800s (Daeschler et al., 1993). Daeschler (1996) reports on the selective mortality of juvenile mammoths from the site. By necessity, modern work on the flora and fauna has focused on the previously collected material, since the fissure, along with the surrounding quarry, was refilled during the 1930s in the interest of public safety (Daeschler et al., 1993). This re-filling has prohibited additional excavations. In fact, the exact location of the sinkhole is unknown. Daeschler and others (1993)

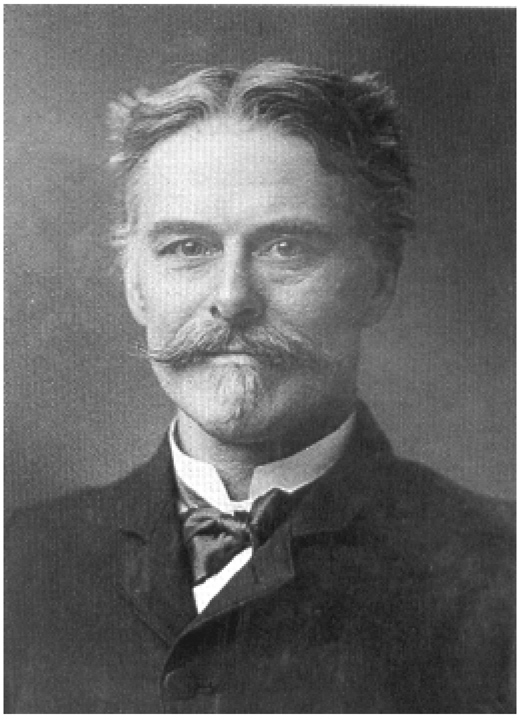


FIGURE 17. Paleontologist Edward Drinker Cope described fossil mammals from Port Kennedy Cave, Valley Forge National Historical Park, Pennsylvania.

believe that they have located the site to within a few hundred meters.

Kurtén and Anderson (1980) present a review of the mammalian fossils collected at Port Kennedy, while Daeschler and others (1993) report on an effort to recurate the Academy of Natural Science's (Philadelphia) extensive collections of Port Kennedy material.

The fossils recovered from Port Kennedy indicate an age of approximately 500,000 years B.P., placing it within the Irvingtonian Land Mammal Age, although there is still some speculation as to the exact age of the deposit (Kurtén and Anderson, 1980; Daeschler et al., 1993). The overall assemblage resembles other assemblages of a similar age including Hanover Fissure No. 1 in Pennsylvania, Cumberland Cave in Maryland, and Hamilton and Trout Caves, both in West Virginia (Daeschler et al. 1993). The mammalian assemblage resembles the Irvingtonian fauna from Cumberland Cave and Conard Fissure, located near Buffalo National River (Kurtén and Anderson, 1980), as well as, Hamilton Cave in West Virginia, and Hanover Quarry Fissure in Pennsylvania (Guilday et al., 1984; Repenning and Grady, 1988). Port Kennedy appears to be slightly older, perhaps closer to 800,000 B.P., due to the presence of *Smilodon gracilis* and a small form of *Ursus americanus* not found in the younger deposits (Kurtén and Anderson, 1980; F. Grady, personal communication, 2001). Specimen quality ranges from remarkable to quite fragmentary. For example, one whole pitch pine cone is described as "blackened but looking as if it had just fallen from a tree" (Figure 18) (Daeschler et al., 1993). A description noted by Kurtén and Anderson (1980), on the other hand, describes one of Cope's *Microtus* (vole) specimens as "a hunk of mud with a tooth impression on it".

After Daeschler's curation of the over 1,200 specimens from Port Kennedy housed at Philadelphia's Academy of Natural Sciences, the current known species list includes nine coleopterid insects, five reptiles, one bird, and 33 mammals (Daeschler et al., 1993). Fourteen plant species were also identified from the collection.

Unfortunately, the current location of the fossil insect collection, representing the only known invertebrates from Port Kennedy, is unknown. Horn's origi-

FIGURE 18. Fossil pine cone from cave deposit at Port Kennedy Cave, Valley Forge National Historical Park, Pennsylvania (photo - Ted Daeschler).

nal paper (in 1876), summarized and reported five different types of ground beetles and three species of dung beetles. Four turtle species and one snake have been collected from Port Kennedy Cave. One turtle species of note, *Emydoidea blandingii* (Blanding's turtle), was unrecognized from Port Kennedy until a re-examination of the turtle specimens in 1993. Additionally, the type specimen of *Clemmys percrassa* was reinterpreted as belonging to the tortoise *Geochelone*, and thus becomes one of the most northeasterly records of the genus in North America (Parris and Daeschler, 1995). The one species of snake from Port Kennedy has been tentatively referred to *Coluber* sp. (racer) but may represent *Masticophis* sp. (whipsnake). The only bird currently identified from the deposit is a turkey from the Meleagrinae (gen. indet.), although Mercer (1899) reports remains of *Gallinago*.

Kurtén and Anderson (1980) describe the extensive mammalian assemblage from Port Kennedy in detail. Daeschler and others (1993) provide updated taxonomy and commentary for the mammals, as well as a summary table of the entire fauna from the deposit. A number of mammalian specimens from the deposit are of particular interest and are mentioned here. Of the six sloth species described by Cope, only *Megalonyx wheatleyi* (Wheatley's ground sloth) is considered valid (Daeschler et al., 1993). Nevertheless, Port Kennedy represents one of the largest single-site samples (remains of 76 individuals were reported by Mercer (1899)) of Wheatley's ground sloth. The first appearances of *Lutra canadensis* (river otter) are in the Irvingtonian faunas of Port Kennedy and also Cumberland Cave (Kurtén and Anderson (1980); Daeschler et al., 1993). *Osmotherium spelaeum* (Port Kennedy skunk) is only known from Port Kennedy. *Martes diluviana* (diluvian fisher) also is only known from the site. The earliest record of *Ursus americanus* is from Port Kennedy. Additionally, a large sample of *Arctodus pristinus* was recovered from the deposit (T. Daeschler, personal communication, 2001). Port Kennedy serves as the type locality of *Smilodon gracilis* (gracile sabretooth). *Ondatra hiatidens* (Cope's muskrat) is another species only known from Port Kennedy. The status of *Neofiber diluvianus* (diluvial water rat) is uncertain, as it is only known from Port Kennedy. Also Port Kennedy preserves the only population sample of large North American Pleistocene tapirs, notably *Tapirus haysii*. *Bison* (bos) remains were reported by Cope (1871), Mercer (1899), and Hay (1923), however, Kurtén and Anderson (1980) describe this identification as "doubtful". Daeschler and others (1993) also do not include *Bison* in their revised taxonomy.

One of the more significant assemblages of a mammalian species preserved at Port Kennedy is the mastodon, *Mammut americanum*, which is known primarily from teeth, although a number of partial tusks are also known (Daeschler, 1996). An interesting quality of the mastodon remains is that nearly 90% of the teeth, representing 14 out of 16 individuals, appear to come from juveniles based on tooth wear, position, and eruption. This selective mortality appears to be the result of carnivore transport and accumulation as a result of hunting the younger, more vulnerable individuals (Daeschler, 1996).

The plant material in the collection was for the most part untouched after having been collected by Mercer in 1894-96 until the 1993 curation by Daeschler. Most common among the plants are nuts of *Fagus grandifolia* (American beech) and *Carya* spp. (hickory). Also present are *Quercus* spp. acorns. and cones from *Pinus rigida* (pitch pine). Additional remains of *Corylus americana* (American hazel), *Crataegus* sp. (hawthorn), and *Parthenocissus quinquefolia* (Virginia creeper) were also recovered.

WILSON'S CREEK NATIONAL BATTLEFIELD

Wilson's Creek National Battlefield (WICR) was established to preserve the site of one of the first major Civil War battles west of the Mississippi River. There are three caves reported within the Mississippian Burlington Limestone of WICR. Archaeological survey reports have been produced for the three caves. Fossilized marine invertebrates have been identified from within the Burlington just outside of the cave entrances. These fossils remain *in situ* and there are currently no collections of these paleontological resources (G. Sullivan, personal communication, 2001).

WIND CAVE NATIONAL PARK

Wind Cave National Park (WICA) was established to preserve a large limestone maze cave with tremendous quantities of boxwork. With approximately 98 miles (158 kilometers) of known passages that have been mapped to date, Wind Cave is the seventh longest cave in the world. The cave has extraordinary examples of a rare speleothem known as boxwork. Boxwork is believed to form when anhydrite hydrated to gypsum, expanding and cracking the surrounding dolomite. Later, this gypsum was replaced by calcite and when the cave formed, the surrounding dolomite bedrock was removed, leaving the boxwork fins in relief (Palmer and Palmer, 2000). Like Jewel Cave, 18 miles (29 kilometers) to the west-northwest (see section on Jewel Cave National Park in this paper), Wind Cave is formed in the upper 200 to 250 feet (61-76 meters) of the Mississippian Madison (Pahasapa) Limestone. The main development of both Wind and Jewel caves likely occurred during the Paleocene and Eocene. However, Feldmann (1995) reports that Pliocene cave development may be more likely. Nevertheless, most other caves developed only within the last few million years, making both Wind and Jewel among the oldest of the world's caves.

Paleozoic invertebrate fossils are fairly abundant in the Madison Limestone in Wind Cave. Molds and casts of brachiopods are quite common within the limestone walls and ceilings of Wind Cave (Figure 22). Bryozoans, corals, sponges, gastropods, and potential worm tubes have also been reported from within the cave. Some of these fossils have been preserved in crystalline form with calcite replacing the original material, giving them a sugary appearance (K. Rohde, personal communication, 1986). Boxwork intersects some fossils in a few locations in the cave.

Pleistocene to Holocene mammalian remains are occasionally found in the sediments of Wind Cave. Bison, *Myotis*, rabbit, *Neotoma cinerea*, *Peromyscus*, and frog bones have been dragged into Wind Cave by woodrats or washed through former entrances. One recently discovered plugged entrance near the Chamber of Lost Souls is located just upstream from the Natural Entrance and was probably open between 5,000-30,000 years ago (Martin, 1984).

A hole in the floor of the Press Room in Wind Cave provides access to a small, round room, now referred to as the "Bone Pit". Skeletal material was scattered throughout the Bone Pit. Preliminary evaluation of the bone identified one woodrat skeleton and the remains of a bird (J. Nepstad, personal communication, 1998). An unidentified femur was found in a small passage adjacent to the Bone Pit, but not collected due to the fragile nature of the bone.

Beaver Creek Shelter is an important Holocene archaeological and paleontological site within Wind Cave National Park. The radiocarbon dates from the shelter range between approximately 1,750 to 9,380 years B.P. Extensive human artifacts at the site support human occupation of the shelter (Alex, 1991). Vertebrate, plant, and gastropod remains have also been recovered from the shelter (Abbott, 1989; Miller, 1989; Benton, 1991, 1999; Martin et al., 1993). A total of 40 species extant in the Black Hills were identified. Except for a few water-dependent species, all major taxonomic groups found in the Black Hills were documented at the site. The presence of *Perognathus* sp. indet., *Dipodomys* sp. indet., *Onychomys* sp. indet., and a member of the family Iguanidae, indicate a period of warming and drying during the Altithermal period. These vertebrate remains were disarticulated and frequently broken. Few of the bones were truly *in situ*, as most were either transported into the cave by humans, fluvial processes, or carried in by carnivores or raptors.

Salamander Cave is a cave near the northern boundary of Wind Cave National Park. The natural trap entrance today captures many small species including *Ambystoma tigrinium* (tiger salamander, the cave's namesake), *Peromyscus* sp., and *Erethizon dorsatum* (porcupine). Within Salamander Cave, the Porcupine Room has an old cemented talus cone where fragments of *Equus* have been found. A second chamber called the Horse Room has yielded fourteen taxa introduced by a currently plugged paleoentrance. These taxa include one rabbit, eight rodents, two carnivores, one horse, and two artiodactyl species (Mead et al., 1996). The most common taxa is *Cynomys* sp. (prairie dog). Six taxa are now extinct and two are currently extralimital. Uranium series dating of the *Equus* fragment and of speleothems in the room give an approximate age of 252,000 years old (Mead et al., 1996). The specimens are currently curated in the Laboratory of Quaternary Paleontology, Quaternary Studies Program, Northern Arizona University.

Graveyard Cave is located in the same area of the park as Salamander Cave. It is a small one-room natural trap littered with a variety of mid to late Holocene vertebrate remains that range from 2,290 to 290 years old (Manganaro, 1994). Cranial elements of 45 species were identified from excavations at this site. Carnivore species accounted for 13% of the remains and suggest the site was a selective trap. Gastropods were found in all levels of the cave's sediment, with a total of 11 species identified (Jass, 1999)

YELLOWSTONE NATIONAL PARK

Yellowstone National Park (YELL) was established as the world's first national park in 1872. The park contains thousands of geothermal features including the famous Old Faithful Geyser. Yellowstone is also renowned for spectacular waterfalls, mountains, meadows, lakes, and wildlife.

Lamar Cave is an important Holocene paleontological locality in the northwestern corner of Yellowstone National Park. The cave is quite shallow, measuring approximately 12 feet (4 meters) wide, 7 feet (2 meters) high, and 20 feet (6 meters) deep. Catastrophic flooding during the deglaciation between 14,000 years ago is probably responsible for the formation of the cave in Eocene volcaniclastic debris-flow deposits. Ten stratigraphic units have been identified in Lamar Cave (Barnosky, 1994). Fossils in the cave include the remains of mammals, birds, reptiles, amphibians, and unidentified fish from the late Holocene (approximately 1,550 years old). Barnosky focused her research on the 36 mammal species found in the cave including insectivores, bats, rabbits, rodents, carnivores, and artiodactyls. Wolf remains were identified in Lamar Cave, providing evidence that wolves have been an integral piece of the Yellowstone ecosystem for more than 1,500 years (Barnosky, 1994). The Lamar cave fossils are curated into the collections at the University of California Museum of Paleontology.

The remains of *Bison bison* are reported from McCartney's Cave within Yellowstone National Park (W. Hamilton, personal communication, 1994).

PALEONTOLOGICAL RESOURCES ASSOCIATED WITH CAVES NEAR NATIONAL PARK SERVICE AREAS

Caves found immediately adjacent to National Park Service units often contain significant paleontological resources. These caves may be indicators for the occurrence of similar paleontological resources within nearby park caves.

Natural Trap Cave is a karst sinkhole feature located on BLM land on the western slope of the Bighorn Mountains just outside of BICA. There is a debris pile at the entrance, similar to the debris pile for Bighorn Cavern, which was excavated and surveyed. The remains of Pleistocene horses, antelope, sheep, mammoth/mastodons, lemmings, American lions, and American cheetahs were collected between 1974 and 1980. The fossil remains range in age from approximately 11,000 to 20,000 years ago. The cave fauna represents the longest and most extensive continuous record of late Pleistocene biota in the Northern Rocky Mountains (Gilbert and Martin, 1984).

Peccary Cave is another cave just outside of Buffalo National River. Peccary remains have been recovered from the cave (C. Bitting, personal communication, 2001).

Cowboy Cave is a large, singe-room grotto located on Bureau of Land Management (BLM) land adjacent to Canyonlands National Park. Extensive archeological resources have been described from Cowboy Cave (Mead and Agenbroad, 1992). Pleistocene dung deposits are reported from the cave. The first radiocarbon dates (ranging from 13,040 to 11,020 years B.P.) for *Mammuthus* remains from the Colorado Plateau were also obtained from Cowboy Cave (Agenbroad and Mead, 1989).

Excavations in Haystack Cave, located on BLM land just outside of Curecanti National Recreation Area, produced the first collection of vertebrate remains from the Rancholabrean in western Colorado. Thirty-one species were identified from anura, squamata, accipitriformes, galliformes, passeriformes, lagomorpha, rodentia, carnivora, artiodactyla, and perissodactyla. A complete list is available in Emslie (1986). Radiometric dating of unidentifiable bone fragments yielded ages of approximately 14,935 and 12,154 years B.P. (Emslie, 1986). While the fauna is very similar to other Rancholabrean sites in surrounding states, remains of *Ursus americanus* are known only from Haystack Cave. Conversely, *U. arctos* is found in Rancholabrean caves in Colorado, Wyoming, and Idaho but are not found in Haystack Cave (Emslie, 1986).

Snake Creek Burial Cave is located just south of Great Basin National Park, on BLM land. Snake Creek, a natural trap sinkhole, has produced a wealth of additional paleontological resources. One test pit produced over 5,000 fish, amphibian, reptile, bird, and mammalian remains (Mead and Mead, 1985). Bell and Mead (1998) collected 395 microtine rodent specimens, referred to *Microtus* sp. and *Lemmiscus curtatus*. One molar morphotype of *Lemmiscus curtatus* found in Snake Creek represents the youngest record of this morphotype, and the only specimens known from the late Rancholabrean (Bell and Mead, 1998). Labor-of-Love Cave is another cave with paleontological resources near Great Basin National Park. A short-faced bear, *Arctodus simus*, and other unpublished fossils were collected and curated into the Los Angeles County Museum (Emslie and Czaplewski, 1985).

There are many caves within the Guadalupe Mountains outside of the national park. Pink Panther Cave has the remains of a large carnivore preserved within flowstone. Hell Below Cave has the partial remains of a bear (F. Grady, personal communication, 2001).

Caves in the area surrounding Mojave National Preserve contain extensive paleontological resources. Mitchell Caverns, located within Mitchell Caverns State Park, has yielded the partially articulated skeleton of the ground sloth *Nothrotheriops* (G. McDonald, personal communication, 2001). Newberry Cave also contains *Nothrotheriops* remains which were radiocarbon dated to approximately 11,600 years B.P. (G. McDonald, personal communication, 2001). Screen washing of fossil-bearing sediments from Kokoweef Cave has yielded over 200,000 skeletal elements. At least 87 species (from 41 families) are represented in Kokoweef Cave (Reynolds et al., 1991a). Charcoal from Kokoweef Cave was radiocarbon dated to approximately 9,830 years B.P., implying a Late Pleistocene/Early Holocene age for the fauna (Reynolds et al., 1991a). Antelope Cave preserves the remains of 34 vertebrate families in an assemblage similar to that of Kokoweef Cave (Reynolds et al., 1991b). Quien Sabe Cave preserves the disarticulated bones of 21 small vertebrate species (Whistler, 1991). Schuiling Cave discoveries include 28 Late Pleistocene vertebrate species of reptiles, birds, and mammals (Downs et al., 1959). Jefferson (1991) presents a summary of Rancholabrean vertebrate cave faunas from the southeastern Mojave Desert region. There are 45 known caves within Mojave National Preserve proper. A recently initiated survey of the caves will attempt to identify caves within the Preserve that may contain paleontological resources (T. Weasma, personal communication, 2001).

Conard Fissure is a limestone fissure-fill feature in the Boone Limestone of the Ozark Mountains. The fissure is approximately a quarter-mile (0.4 kilometer) north of Buffalo National River. There is high potential for similar fissures to exist within the park boundary. The fissure is an important Pleistocene (Irvingtonian) locality, producing a large vertebrate fauna, similar to those described from Cumberland Cave, Maryland and also Port Kennedy Bone Cave in Valley Forge National Historical Area (see section on Valley Forge National Historic Park in this paper). Byron Brown first described the fossil-rich deposit in the early 1900s. Russell Graham revised much of the original work in the 1970s. Smaller mammal bones, identified as *Blarina* sp. and *Peromyscus* sp., are especially abundant in the fauna. The taphonomic interpretation of the small mammal concentrations has been attributed to owls bringing these smaller mammals to the area. *Mylohyus* sp. and *Odocoileus* sp. represent the most common large mammals identified from the site. In addition to the mammalian fossils that have been discovered, the remains of amphibians, reptiles, and birds are also known from Conard Fissure. Many of the remains recovered show evidence of gnawing by rodents or carnivores. There is some speculation as to the age of the deposit. An Irvingtonian age has been suggested by the absence of *Bison* and the presence of animals such as *Felis inexpectata* and *Ondatra annectens* (Brown's muskrat). However, a Kansan or early Illinoian age is also possible. Evidence of a glacial phase is suggested by the presence of boreal species such as *Sciurus hudsonicus, Erethizon dorsatum,* and *Sorex fumeus.* The habitat in the region was most likely a forest with open glades. (Kurtén and Anderson, 1980)

A rather comprehensive review of the extensive Conard Fissure mammalian fauna is given in Kurtén and Anderson (1980). Interesting species of note include *Microsorex pratensis* (meadow shrew) and *Blarina ozarkensis* (Ozark short-tailed shrew), both known only from the Conard Fissure locality. One of the earliest occurrences of the sabretooth cat *Smilodon fatalis* is from Conard Fissure. *Ondatra annectens* was first described from material discovered at Conard. *Mylohyus nasutus*, the long-nosed peccary, is one of the only species of peccary to be described in eastern and central North America during Irvingtonian times.

MANAGEMENT OF PALEONTOLOGICAL RESOURCES ASSOCIATED WITH NATIONAL PARK SERVICE CAVES

In 1975 James Goodbar, then a joint venturer with the Cave Research Foundation (now the senior technical specialist for cave management with the Bureau of Land Management), forced his body into the small vertical entrance of a cave located in Carlsbad Caverns National Park. The cave was known as "Musk Ox" Cave because of some fossil material found at the bottom of the 114 foot (35 meters) entrance drop several years before. The original material had been identified (erroneously) as the remains of a musk ox. This original discovery had fired the imagination of Cave Research Foundation researchers who (with permission of the Park Service) were going to survey the cave and report on any additional paleontological resources. Before entering the cave, Goodbar had joked to his companions that he was going to find "*THE musk ox*".

Entering Musk Ox Cave is difficult and time consuming. Once a rope is rigged, it is necessary to wiggle through an opening that is never more than 11 inches (28 centimeters) wide and that opens directly onto the 114 foot (35 meters) drop. At first it seems that you can not get into the cave and then you find yourself suspended in a narrow fissure dropping into the blackness of the cave below. Once you have rappelled to the bottom of the drop you climb back up some eight feet (2.5 meters) and traverse along the fissure until coming to another vertical drop of about 20 feet (6 meters). At the bottom of this drop you descend a rubble slope and enter a room approximately forty feet (12 meters) in diameter. It is in this now empty room that Goodbar found his "musk ox" laying in a pool of crystal clear water covered with cream colored cave "popcorn" (Figure 4). He had made one of the most amazing fossil discoveries in any cave in the Guadalupe Mountains of New Mexico.

While the fossil was not a true musk ox, it was in fact found to be an almost 85% complete skeleton of a Pleistocene "shrub oxen". The fossil remains of the bush oxen had lain in the cool dark of the cave for at least 17,000 years, unseen and undisturbed.

Goodbar has shown the first light onto the ancient creature that had known only darkness for over 17 millennia. The next day James and his fellow cavers reported the find to the resource management staff at the Park. The quiet of the ages that had enveloped the small underground chamber and its contents was about to be shattered by a scientific team, and the fossil would be forever altered in time and space.

In 1976, the Park hired a cave resources specialist whose first major assignment was to assist paleontologists from Texas Tech University in Lubbock, Texas and the Smithsonian Institution with the removal of the fossil material from the cave. As a new employee of the National Park Service, who had not been asked for input, the cave resources specialist simply made sure that the excavation of the material was conducted safely and that no cave resources were damaged. The difficult and time-consuming project was spread over two years and dozens of trips into and out of the arduous and dangerous cave. Leaving, finally, a room filled with rubble and darkness in the cave and several drawers full of fossil material unopened and filled with darkness in the storage rooms of the Smithsonian. It would be years before serious work would begin on the material removed from Musk Ox Cave and more years until reports began to find their way back to the Park.

In the year 2001, as this is being written, the National Park Service cave and karst management program is written so that caves are managed for a variety of reasons which include:

1) protection of natural processes in cave ecosystems and karst landscapes;
2) scientific studies and research in or about cave and karst resources and systems, to increase the park's scientific knowledge and broaden the understanding of its cave resources and karst processes;
3) detailed cartographic survey of caves and cave systems and a detailed inventory of resources within cave systems;
4) provision for educational and recreational opportunities for a broad spectrum of park visitors to safely visit, study, and enjoy caves at a variety of levels of interest and abilities;
5) establishment of regulations, guidelines, and/or permit stipulations that will ensure maximum conservation of cave resources and karst processes;
6) direction for cave restoration activities that remove unnatural materials or restore otherwise impacted areas;
7) establishment of standard operating procedures in the maintenance and upkeep of developed cave passages;
8) monitoring of natural environmental conditions and visitor use and impact;
9) protection of related cultural and biological resources; and
10) methods for sustainable use of cave resources.

The current guidance for cave resources also now includes a section on aesthetic values, which reads as follows: "The NPS is mandated to preserve the scenery, or the aesthetic qualities, of caves. If a cave contains few or no features of scenic value, or if such resources are present within the cave but they are of the type that cannot, without great effort, be destroyed or removed, then even frequent visitation by cavers may be acceptable."

A cave might be closed when it is difficult to enter without causing irreparable damage to extremely fragile resources, or if it contains an endangered species that could be threatened by visitor use. Some caves contain speleothems that are of unusual quality and/or are extremely delicate and susceptible to breakage, or resources of scientific value that could be seriously disturbed or destroyed by cavers. Examples of such speleothems include selenite needles, gypsum flowers or hair, epsomite or mirabolite formations or crystals, and helictites. Such caves may need more protection than those mentioned above. Also included in the guidance is a section that states "scientific resources may be geological, archeological, ethnographic, biological, or paleontological in nature, or they may be rare speleothems."

Many times over the years between 1976 and 2001 that cave specialist has retained a mental picture of what the shrub ox fossil looked like laying in that pool of crystal clear water deep in a desert cave. He certainly agrees that it is of great importance to support scientific research and to foster understanding, protection, conservation, interpretation and visitor use of caves throughout out the system, but his mind keeps coming back to that silent chamber. Was removal of a one of a kind fossil from an obscure seldom-entered cave the only viable option for advancing scientific knowledge? Would we be more secure in our mandate to keep resources unimpaired for future generations if our decision had been to leave the "shrub oxen" *in situ* for future study? One answer he is sure of is that in over 35 years of entering caves he has seen no more amazing and aesthetically beautiful sights than that fossil deep under the desert.

As we move into the future, we must remember that NPS units are "public parks" managed for everyone and not managed for just one specific group. This is not an easy concept for river runners, climbers, cavers, scientists and other focus groups or individuals to understand. The units administered by the NPS are a shared dream for all Americans, and by extrapolation, for all peoples of the world for all time. The next thousand years and those that follow will likely produce some of the greatest challenges yet faced by NPS cave managers. We must integrate caves and their multiple resources into the collective NPS consciousness as viable components of an ecosystem and not as natural curiosities to be exploited for special interests.

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As the nation's principle conservation agency, the Department of Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the bests interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship can citizen responsibility for the public lands and promoting citizen partcipation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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