Chapter 11. Pleistocene/Holocene Cave Fossils From Grand Canyon National Park

Ice Age (Pleistocene) Flora, Fauna, Environments, And Climate Of The Grand Canyon, Arizona

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Introduction
The Colorado Plateau is a distinct physiographic province in western North America covering an area of roughly 337,000 km² (130,115 mi²) across parts of Arizona, Colorado, New Mexico, and Utah. Elevations range from about 360 m (1,180 ft) in the overall Grand Canyon (GC; which includes the Grand Canyon National Park, GRCA) river corridor to an average at the eastern South Rim of 2,072 m (6,800 ft) to 3,850 m (12,630 ft) on the nearby San Francisco Peaks at Flagstaff, Arizona, with an average elevation of 1,525 m (5,000 ft). The Colorado River of Grand Canyon is located along the southwestern portion of the Colorado Plateau in Arizona and is renowned for its
dramatic display of geomorphic effects created by fluvial incision and its unique dry-preservation of fossils from the Ice Age (late Pleistocene and Holocene [Quaternary]; most recent 2.58 million years). Although there were at least 22 glacial-interglacial cycles during the Ice Age, this discussion is limited to the most recent episode (called the Wisconsinan Glaciation), which includes the transition to the modern climate (latest Pleistocene and Holocene; the most recent 50,000 years of geologic history).

Due to its range in elevations and physiographic position in western North America, the Colorado Plateau (CP; along with its GC river corridor) plays a key role in the continental monsoons much in the same way that the Tibetan Plateau affects the Southeast Asian monsoon climate (Tang and Reiter 1984; Adams and Comrie 1997). In general, precipitation decreases from high elevations to lower elevations. Summer precipitation decreases from the southern Colorado Plateau northward which correlates to the strength of the summer monsoon. These relationships have important consequences for modern and Ice Age biotic distributions in the Grand Canyon and on the surrounding plateaus (Mock 1996; Higgins et al. 1997; Anderson et al. 2000, among others).

Here we review the Ice Age floras and faunas found predominantly within the GC but also on adjacent rims made by the Coconino, Kaibab, Kanab, Uinkaret, Shivwits, and Hualapai plateaus in addition to the Marble Platform at the up-river end of GC. The Grand Canyon includes land administered by the Havasupai, Hualapai, and Navajo Indian tribes along with federal lands managed by National Park Service (Grand Canyon National Park, Lake Mead National Recreation Area), Bureau of Land Management (Grand Canyon-Parashant National Monument), and US Forest Service (Coconino and Kaibab National Forests). The GC and its Colorado River corridor extends nearly 448 km (278 mi) in length and encompasses an area of about 4,921 km² (1,900 mi²).

The preservation potential of Ice Age fossil deposits within the confines of the GC is limited due to active downcutting, steep canyon walls, abundant mass wasting, and periodic catastrophic flooding. Occasionally one can find some perched Ice Age alluvium that has been spared being flushed by subsequent floods down to the Gulf of Mexico. What has been the “gold mine” for Ice Age preservation are the dry caves created in the numerous limestone rock formations coupled with the arid climate. For details about the geology and overall history of the region, see the Geology and Stratigraphy chapter in this report or Beus and Morales (2003).

There are a variety of geochemical analyses used to assess the age of the various deposits found throughout the GC. For the Ice Age fossils of preserved organic remains researchers typically use radiocarbon dating (\(^{14}\)C, radiometric dating). This isotopic dating technique is accurate for only about the most recent 50,000 years. Over the past couple of decades the technique has been refined and now researchers refer to ages in “calibrated” (or corrected) years before present (cal yr BP). “Before present” is expressed as pre-1950 (pre-atomic bomb) and can be thought of in terms of “years ago”. In the 1970s and 1980s a researcher would need enough organic remains to fill an old 35-mm film can in order to obtain an accurate radiocarbon age. Now, with a technique called accelerator mass spectrometry (AMS), a researcher can use a single seed or piece of wood the size of a pin head. In the review below of fossil localities, the established age range will be presented. The interested
reader who wants to know more details about the chronology will need to go to the original publications provided in the literature cited.

Preservation Scenarios (Taphonomy)

River Corridor Sediments

Much has been written about the Colorado River and its evolution in the GC region (e.g., chapters in Young and Spamer 2001; Beus and Morales 2003). Tobin et al. (in press) provide a detailed overview of the karst system model as one of the primary drivers of canyon development and stream piracy. Critical for the preservation of the fossil record is a preserved depositional environment. The fairly narrow river corridor offers few places where fluvial and alluvial sediments can persist for a long period of time. Periodic floods have occurred along the river corridor, especially related to the series of lava dams that were positioned in the west region of the GC (Hamblin 1994; Fenton et al. 2002). Damming with sediment infilling (along with outburst-flood deposits) within the GC has permitted select side canyons to preserve some of the perched alluvial deposits (although some of these observed units might be related to spring-fed deposition and not flood debris; see Kaufman et al. 2002 and references within). These rare sedimentary deposits hold a record of select Grand Canyon past environments.

Dry Caves

Cave morphology throughout the GC can be separated into two distinct groups: 1) caves formed under confined hydrogeologic conditions (i.e., phreatic zone, saturated, below water table) and 2) those formed under unconfined conditions (i.e., vadose, unsaturated zone; Hill and Polyak 2010). Those formed under confined conditions are typically older, dry today, and removed from current hydrologic processes and are typically assumed to have formed either during or prior to river corridor incision. Unconfined caves are being formed currently, are a part of the karst groundwater system of the region and are actively recharged from precipitation on the surrounding plateaus. These differing conditions have resulted in a dichotomy of cave morphology in GC (Huntoon 2000).

Some of the oldest and most impressive cave systems in the area are formed in the upper members of the Redwall Limestone (see overview in Tobin et al. in press). Dating of mammillary cave formations in some of these caves places their formation prior to 1.6 to 3.7 million years ago (Polyak et al. 2008). These caves form along regional fracture patterns, resulting in two-dimensional maze caves with minimal vertical development, except in rare cases. These “maze caves” formed under phreatic conditions (Hill 2010) and follow regional hydrologic gradients, ultimately emerging in the canyon. As the canyon incised, the water table dropped, resulting in the dewatering of these cave systems and exposing cave entrances along canyon walls. There are competing hypotheses on their formation with observations supporting both: epigenic processes (Huntoon 2000) versus hypogenic processes (Hill and Polyak 2010).

Due to the dry nature of these “confined” caves, they often provide the best environment for preservation of paleontological resources from the Pleistocene to recent times. The nature of the known entrances to these caves also plays a major role in what species are most likely to be preserved within them. Since these caves were exposed to the surface environment due to canyon incision, the entrances are typically in cliff faces with hundreds of feet of cliff above and below. This
results in a limited variety of species that can actively use them. These species typically include birds, bats, packrats, ringtails, and an extinct mountain goat. When these dry caves have easier access, evidence of a wider array of species can be found that utilized them, including ground sloths, carnivores of many types, tortoises, and other forms of Pleistocene fauna.

Ongoing cave development is evident throughout the region as well. While these “unconfined” caves are more sporadically distributed throughout the park, many large springs are tied to them. The speleogenesis of these caves is much simpler than the confined systems, following the typical model of epigenic karst development. As with caves at the top of the Redwall Limestone, these caves follow regional structural patterns. Water is sourced directly from precipitation that recharges the aquifer via sinkholes on the surrounding plateaus. These regional aquifers appear to have a distributary pattern (Jones et al. 2018), with individual sinkholes tied to multiple springs. Springs on either side of the Colorado River have distinct flow patterns (Tobin et al. 2018), resulting in vastly different spring morphologies, with only aquifers on the north side of the Colorado River having significant cave development. Due to the increased moisture in these caves, they typically have minimal paleontological resources, with the majority that have been noted tied to packrat (typically nearer the drier entrance) and bat use.

What makes the greater Grand Canyon region unique in the Southwest is the abundance of dry caves. The development of these confined caves helps keep the cave and its contents dry, but having the climate and environment outside arid is equally as critical for preservation of Pleistocene-age fossils. A case in point: a horizontal crevice a mere 20 cm (8 in) in from the dripline can preserve packrat middens (see below) for over 30,000 years.

**Packrat Middens**

Packrats (trade rats, woodrats) are a genus of rodent (Rodentia, Cricetidae, *Neotoma*) with about 20 species with distributions from Alaska to southern Mexico (Vaughan 1990). There are more species of packrats whose distributions include the greater Grand Canyon area than any other region for the genus. They all have the habit of making a nest and den along with the construction of debris piles over the living areas (Dial and Czaplewski 1990; Finley 1990). Materials for these debris piles include a wide diversity of plant remains (such as leaves, twigs, flowers, thorns, bark, and seeds), dung, bones, and rocks—typically all gathered from within 100 m (330 ft) of the nest (Spaulding et al. 1990). Faunal remains recovered from the debris piles are not all necessarily of local origin (especially when sourced from carnivore dung, regurgitated pellets, and raptor and vulturid nests; Figure 11-1) (Mead 2005). These nests and dens can be created in caves, crevices, overhanging rock ledges, and rockshelters. As long as the middens are protected from direct precipitation, the contents are preserved.

As the packrat uses the den and nest, it cleans the passageways and reassembles the pile of debris on top. In so doing, what looks like a mine tailing dump develops along the edge of the constructed mound. Over time this mound, containing all of the contents collected by the packrat along with its dung is incorporated into a mixed heap of debris and then is scent-marked with its urine. Repeated urination on the debris pile ultimately cements all the material into a rock-hard mass (concentrated urine is called “amberat”); the cemented debris pile is called a “midden” (Figure 11-2).
Figure 11-1. Steve Emslie (right) and Larry Coats (left) excavating a condor (*Gymnogyps*) nest and skeletal remains reclaimed by a packrat and made into a midden, Sandblast Cave, 1984 (EMILEE MEAD).

Some of the earliest paleoecological studies of the American Southwest using packrat middens began in the GC (Phillips and Van Devender 1974; Van Devender and Mead 1976). The entire GC has not been assessed for packrat middens and their paleoecological data; rather, research has been limited to select regions primarily in the eastern half. Major study areas are typically along the river corridor and in side canyons such as Stanton’s Cave (Dryer 1994), Little Nankoweap Canyon (Mead et al. 2003), Chuar (Cole 1982, 1990), Hance Canyon and Horseshoe Mesa (Cole 1982, 1990), and Rampart Cave, Vulture Cave, and surrounding canyons (Phillips and Van Devender 1974; Mead and Phillips 1981; Phillips 1984; Spaulding 1990).
These preserved middens are valuable for a number of reasons. Each can be accurately radiocarbon dated. They contain abundant macrobotanical remains typically from within the home range of less than 100 m (330 ft) (Spaulding et al. 1990). Multiple species of macrobotanical remains can be independently radiocarbon dated to produce accurate coeval habitat reconstructions. Microfaunal fossils found associated with botanical remains often include the delicate skeletal remains of the local herpetofauna, species often not found in typical alluvial localities due to the abrasive nature of deposition. Interestingly, radiocarbon-dated packrat middens were used to determine the rates of cliff retreat in the eastern GRCA (Cole and Mayer 1982).

**Taxonomic Groups**

Appendix 11-A presents a list of known biotic remains recovered from Pleistocene deposits in the GC region. The list presents taxa by primary publication resource and not by locality (which can be determined from the primary reference).

**Plants**

Due to the numerous dry cave and rockshelter localities coupled with the overall arid environment, Pleistocene-age plant remains are plentiful within each packrat midden unit. Packrats are basically browsers, over-selecting the woody and herbaceous plants but typically underrepresenting the graze species such as the grasses. Although equally as well-preserved as the macrobotanical fossil, pollen remains from the region have been less frequently utilized for paleoenvironmental reconstructions.
Martin et al. (1961) recovered pollen from Shasta ground sloth dung in Rampart Cave. Pollen frequencies recovered from sediments were compared to pollen counts from artiodactyl dung pellets and macrobotanical remains from the same sediments from test pits in Bida and Kaetan caves (see below; O’Rourke and Mead 1985). Pollen and microhistological remains from dung were also compared to fossils from test pits in Stanton’s Cave (Robbins et al. 1984; see Hansen 1974 about technique). Pollen assemblages and associated plant macrofossils from packrat middens do reflect similar vegetation signals but this still needs to be further assessed for future paleoecological reconstructions (Anderson and Van Devender 1991). Ideally one would sample the macrobotanical remains and pollen from packrat middens and also assess the pollen and microhistological remains from dung also in the midden, hopefully selecting not only packrat pellets but also dung from potential grazers.

**Invertebrates**

The recovery and study of Ice Age and Holocene-age mollusks from the GC is still in its infancy. The extant taxa and their distributions are well studied from a few localities, primarily from the work of Pilsbry and Ferriss (1911). Spamer and Bogan (1993) provided a critical overview of the extant taxa. Spamer (1993) and Spamer and Bogan (1993) synthesized the known late Pleistocene malacofaunas (molluscan faunas) and emphasized that much is yet to be understood about the mollusks of the region dating to the last glacial and early Holocene. Kaufman et al. (2002) provide a few more records but still illustrate that the Pleistocene molluscan faunas are not adequately studied. Mollusks have also been incorporated into packrat middens (Cole and Mead 1981). Ostracodes are equally as poorly understood in the GC region (Kaufman et al. 2002). The record of Pleistocene arthropods is restricted to those fossils recovered from dry-preserved packrat midden and cave sediment localities (Elias et al. 1992), and again, the group as a whole for the Ice Age is poorly understood. The single discussion about nematodes comes from a study of dry-preserved sloth dung from Rampart Cave (Schmidt et al. 1992).

**Vertebrates**

The recovery and study of vertebrates from the GC is much more voluminous and well understood than the invertebrates. Appendix 11-A provides an extensive list of the fossils and relevant citations. The first study of the Pleistocene vertebrates in the GC occurred at Rampart Cave (see below) following the discovery of Shasta ground sloth dung (Evans 1936; Laudermilk and Munz 1938; Hansen 1978). Vertebrate remains include skeletal elements, dung, hair, dermal scales, and occasionally entire mummified animals (Figure 11-3). These fossils are recovered from cave sediments, dung mats (both bat and artiodactyl), packrat middens, owl pellets, raptor nests, and ringtail refuse areas (e.g., Mead and Van Devender 1981; Mead 2005).

A number of studies have been made of the Pleistocene vertebrate remains but there is only one comprehensive, albeit outdated, overview (Mead 1981; see review in Kenworthy et al. 2004). The Pleistocene record of amphibians (anurans and salamanders) is non-existent for the GC. The record of turtles is exceedingly rare and occurs only from cave and midden deposits in the far western river corridor (Rampart and Vulture caves; see below). Lizards and snakes are abundant in the record due to the presence of their remains in dry cave deposits and packrat middens from throughout the GC.
Some of the first or only fossil records of select squamate species come from packrat middens. Birds are fairly well represented due to the in-depth records from Rampart and Stanton’s caves and localities in the Sandblast Cave area (see below; Emslie 1988), but there is a bias toward the river corridor avifauna.

![Image](image.jpg)

*Figure 11-3. A mummified myotid bat at its last perch among the gypsum crystals in Double Bopper Cave (NPS/SHAWN THOMAS).*

Mammals are equally as well represented as the birds. Entrances to a number of the cave localities is inaccessible to most mammals due to their locations high on cliff faces (Figure 11-4). Only the best cliff climbers (mountain goats, packrats, ringtails) and fliers (bats) gain entrance to some of these caves. With all the caves in the GC, studies of extant and ancient bats and their guano (dung) deposits are abundant (e.g., Wurster et al. 2008; Pape 2014), with a number of mummified remains beginning to be studied in detail (e.g., Mead and Mikesic 2001; see Double Bopper Cave below). A number of medium to large mammals (some extinct) are reported from various caves throughout the GC region, both within the river corridor and above the Tonto Platform mid-canyon, including Shasta ground sloth (*Nothrotheriops shastensis*), camel (*Camelops* sp.), Harrington’s mountain goat (*Oreamnos harringtoni*), bighorn (*Ovis canadensis*), bison (*Bison* sp.), and horse (*Equus* sp.) (Mead 1981).
Select Localities
Not all caves and packrat midden localities will be described here, only those with a more complex, unusual, and/or diverse fossil assemblage story. The descriptions below are arranged based on their approximate down-canyon/river location, beginning up-river.

Stanton’s Cave and Skull Cave
Stanton’s Cave (named after Robert Brewster Stanton) is a large Redwall Limestone (Mississippian) cavern along the Marble Canyon river corridor. Nearby is Vasey’s Paradise (named after George Vasey, a friend of John Wesley Powell), a gushet spring flowing into the river (Springer et al. 2008) that appears to show how Stanton’s Cave was formed in the distant past. The cave has a long history of use in part due to easy access from the river and from the canyon rim country above via nearby South Canyon. Euler (1984) provides a synthesis of the historic and prehistoric use of the cave. Much of the surface deposit is composed of Holocene-age sediments containing bighorn (*Ovis canadensis*) dung and archaeological artifacts. Excavations in 1969–1970 produced a wealth of archaeological and paleontological information (see chapters in Euler 1984). Dryer (1994) produced a research
project on the packrat middens recovered from the back room of the cave—an area not thoroughly studied previously. The dry environment within the cave provided a wealth of information about the extinct *Oreamnos harringtoni* with the preservation of horn sheaths and dung (Mead et al. 1986; Mead and Lawler 1994). Today, a large steel lattice keeps human visitors from entering the cave but bats and other animals can still utilize the cave.

Packrat middens from the back of the cavern produced $^{14}$C ages ranging from about 11,000 to 35,000 years ago (Dryer 1994). Radiocarbon dates on dung, wood, and a bone of an extinct bird (*Teratornis*) produced ages ranging from as young as 1,500 to as old as about 17,000 (uncorrected) yr B.P.; drift wood at the base of the sediments dated to > 35,000 years old (Robbins et al. 1984).

Skull Cave is a rather small cavern that divides into three separate passages (Emslie 1988). Analysis of three test pits indicated that for the most part the cave was used by packrats and birds, producing an impressive avifauna (Emslie 1988). Only a few radiometric ages provide a preliminary chronology via a uranium series date on anhydrite from test pit sediments and AMS ages obtained from packrat pellets. All ages are less than 20,000 yr B.P.

**Sandblast Cave and Nearby Caves**

A series of cliff-entrance caves can be found in the exposed Redwall Limestone in the Marble Canyon river corridor. Probably the most significant locality is Sandblast Cave (Figure 11-5) which is a grouping of crevices and tunnels (Emslie 1988). Excavations produced important data about the condor (*Gymnogyps californianus*, including a preserved nest; Figure 11-1) in addition to specimens of the extinct mountain goat, bison, camel, and horse, along with the only reported mammoth remains from the GC; these large mammal remains are thought to be remnants of food items brought in by condors (Emslie 1987, 1988; Mead et al. 2003). Other caves with fossils in the corridor stretch include Skylight (Figure 11-4) and Hummingbird caves, among others (Emslie 1987). Radiocarbon ages on *Gymnogyps* skeletal remains range from about 10,000 to 13,000 (uncorrected) yr B.P. $^{14}$C ages on packrat middens and *Oreamnos* dung are all older than 30,000 and wood dating in excess of 40,000 yr B.P. (Emslie 1987, Mead et al. 2003).
Little Nankoweap

The Little Nankoweap drainage is known to have countless caves, many containing important archaeological and paleontological remains (Emslie et al. 1987; Mead and Lawler 1994; Emslie et al. 1995). Crescendo (CC:5:1), Rebound (CC:5:5), Left and Right Eye, Five-Window (CC:5:2), Shrine (CC:5:3), and Stevens (CC:5:4; Figure 11-6) caves have been the most intensely studied and described, but many chambers and passageways in these caves still contain numerous areas and deposits that remain to be fully analyzed. Besides data on condors (Emslie 1987, 1988), a series of packrat middens produced copious plant macrofossils (Coats et al. 2008) and faunal remains (Carpenter and Mead 2000; Mead et al. 2003). The entrances to most of these caves are on the sheer cliff face of the Redwall Limestone well out of the main river corridor. Some of the flora and fauna (e.g., extinct camel and the extinct shrubox *Euceratherium collinum*) recovered from these cave deposits likely represent inhabitants of the flat plateau surface immediately above (Figure 11-7),

Figure 11-5. Close-up of the entrance to Sandblast Cave showing the series of openings, 1984 (EMILEE MEAD).
which also provide access to the higher plateaus of the North Rim, and not the narrow, steep river corridor and side-canyons. A number of the caves have multiple packrat middens and *Oreamnos* dung remains dating from about 11,000 to 46,000 yr B.P. (Mead et al. 2003).

*Figure 11-6.* Stevens Cave entrance located high on the cliff face of the Redwall Limestone, 1984 (EMILEE MEAD).
Figure 11-7. An expansive flat region exists above the Redwall Limestone caves in the Little Nankoweap Canyon region. With access from the higher North Rim plateau region above, large artiodactyls such as camels (*Camelops*), shrub ox (*Euceratherium*), and bison (*Bison*), not cliff-climbers, were able to easily enter into portions of the eastern Grand Canyon (JIM MEAD).

**Hance Canyon and Horseshoe Mesa**

A series of packrat middens from Bida Cave were described by Cole (1981, 1985). Faunal remains from the middens were reported in Cole and Mead (1981). Surface remains and a test pit produced a wealth of information about the skeleton, diet, and habitat of *Oreamnos harringtoni* (Mead 1983; O’Rourke and Mead 1985; Mead et al. 1986; Mead, Martin et al. 1986; Mead and Lawler 1994). The cave is extensive, with the lower entrance a large, gaping cavern. At the point where the main cavern turns and narrows into a tunnel and all outside light ceases, bedding depressions are littered with *O. harringtoni* dung (Mead 1983). The cave system goes through a series of small tubes and large rooms, many with additional fossil and subfossil remains that have yet to be fully documented and studied. Ultimately the cave emerges at the top of the Redwall Limestone as a small entrance providing rare access through the cliff to the Inner Gorge region.

Multiple packrat middens have been dated from Bida Cave ranging from 8,000 to about 13,000 (uncorrected) yr B.P. (Cole 1981). *Oreamnos* dung and keratinous horn sheaths range in $^{14}$C age from 12,000 to about 25,000 (uncorrected) yr B.P. (Mead 1983; Mead et al. 1986).

The caves and dry crevices of Horseshoe Mesa up Hance and Cottonwood canyons have been studied speleologically and to a certain extent archaeologically (see Farmer and deSaussure 1955), but are
poorly known paleontologically. Ancient packrat middens were recovered from many areas in these two canyons and a few across the river (Cole 1985). Cole (1981, 1990) reviews all the radiocarbon ages from multiple packrat midden dating from about 10,000 to 35,000 (uncorrected) years old.

**Cremation Creek Caves**

The first realization that many caves preserve organic remains for a long period of time came with the report of split-twig figure artifacts at sites on Cremation Creek (Farmer and deSaussure 1955). The greater Cremation Creek provides a number of caves that were explored in the early 1950s and found to contain Ice Age fossils. Marmot (*Marmota*) remains (not found in the region today at these elevations) were recovered in Tse-an Olje, Cylinder, Tse-an Kaetan, and Tooth caves (Lange 1956; among other caves across the river). Caves being explored in the 1950s were to be kept secret so the names applied by Lange (1956) and deSaussure (1956) were given in the Navajo (Dinéh) language; tsé’áán refers to “rock cave”.

Only Kaetan Cave (“prayer stick cave”; Figure 11-8) in this area is fairly well studied; it is a small cavern with abundant archaeological material in the entrance chamber (Schwartz et al. 1958). Although the cave has a dry entrance chamber, it becomes wet further in with pools. Because of the exploration in 1955 for split-twig figures, Schwartz et al. (1958) also provided the earliest Ice Age palynological analysis in the GC. This then pointed the way for further work in the cave in the late 1970s (Mead 1983; O’Rourke and Mead 1985). An owl roost deposit in the cave was sampled but never studied and remains to be examined. As with Bida Cave, *Oreamnos harringtoni* remains were abundant (Mead and Lawler 1994). Packrat middens with plant and micromammal remains are $^{14}$C 15,000 to 19,000 (uncorrected) yr B.P. A stratified test pit produced uncorrected ages from 14,000 to 30,000 yr B.P. An owl roost deposit may date back to 21,000 yr B.P. (Mead 1983).
Double Bopper Cave
Double Bopper Cave is the longest known cave in GRCA. This cave developed in Redwall Limestone, and is located in a remote part of the north rim (Figure 11-9). Difficult to access and largely hidden from view, the cave was only discovered in 2008. Annual expeditions have mapped over 64 km (40 mi) of passage, making it the longest known cave in Arizona and among the 50 longest caves in the world. The cave is still being actively mapped, so the length will continue to increase with future exploration. Double Bopper Cave is a maze cave characterized by rectilinear, joint-controlled passage development (see Tobin et al. in press). Parallel primary passages are large and relatively easy to travel through. Between these primary corridors, smaller passages connect the parallels, sometimes with dense and complicated cave development. The cave is predominantly horizontal, though there is multi-level development in a few isolated areas with vertical passages connecting the levels. The massive extent of the cave and diversity of passage sizes provides a considerable amount of habitat for subterranean wildlife.

Figure 11-8. Entrance to Kaetan Cave, 1980 (JIM MEAD).
One of the most unique features of Double Bopper Cave is the abundance of mummified bats, which are typically rare or altogether absent from other GRCA caves. Bats still actively use the cave with flyways indicated by fresh guano deposits. However, live bats are rarely seen in the cave aside from bats exiting the main entrance at dusk and occasional solitary individuals in torpor. Mummified bats occur throughout the cave, especially along the larger parallel passages. Mummies are typically found clinging to walls and secondary gypsum formations but are also found scattered on the ground. The stable microclimate conditions in the cave, with low relative humidity (typically 35–45%), have likely persisted for thousands of years, making for excellent preservation of specimens. Most mummified bats can be identified to species, possessing intact skin and fur, and many mummy specimens “roosting” on walls cannot immediately be distinguished from live bats without closer examination (Figure 11-3).

Though a complete census has not been conducted, estimates from survey teams suggest the cave contains many hundreds to thousands of bat mummies. At least eight bat species have been identified in the cave. Townsend’s big-eared bat (*Corynorhinus townsendii*), a cave-obligate species, is the most common. Less abundant but still commonly observed are pallid bats (*Antrozous pallidus*), big
brown bats (*Eptesicus fuscus*), and myotid species (*Myotis* spp.). Canyon bats (*Parastrellus hesperus*) and free-tailed bats (*Tadarida brasiliensis* and possibly *Nyctinomops femorosaccus*) are also present. The rarest species, consisting of only a few specimens, include hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*), which is unusual in that these species are typically considered tree-dwelling bats. A nearby cave, Leandras Cave, also contains abundant bat mummies but with a suspected higher proportion of hoary bats and silver-haired bats (future inventory work is being planned to answer this question). Radiocarbon dating of a subset of bat mummy tissues collected from Double Bopper Cave yielded ages ranging from 3,500 to 33,650 yr B.P., demonstrating long-term use of the cave by bats.

Double Bopper Cave also contains mummified remains of other mammals. Packrats (*Neotoma* spp.) are far outnumbered by bats but still common. Several ringtail (*Bassariscus astutus*) specimens have been found deep in the cave in excellent states of preservation (Figure 11-10) but have not been radiocarbon dated yet. Other skeletonized specimens have yet to be fully assessed, including one gray fox (*Urocyon cinereoargenteus*; Figure 11-11). Inventory and carbon dating continue for paleontological resources in Double Bopper Cave.

![Figure 11-10. A mummified ringtail (*Bassariscus astutus*) from Double Bopper Cave. With the carcass still with all its hair and it only being slightly modified in color, the age of this individual is likely fairly recent. Other carcasses of this taxon in the cave will be radiocarbon dated (NPS/SHAWN THOMAS).](image)
Rampart, Muav, and Vulture Caves
Rampart, Muav, and Vulture caves are located in the far western end of the GC not far from where the river exits the Colorado Plateau and heads across the Basin and Range Province. This series of caves and packrat midden studies are about 305 km (190 mi) west of the other well-known fossil localities mentioned above. Only a few packrat midden localities have been found in between (Van Devender and Mead 1976; Cole 1985).

The entrance to Rampart Cave is a fair distance up a long, steep talus slope from the Colorado River. Today there is a short inclined climb into the cave, but there may have been more of a subtle ramp into the cave during the Pleistocene based on the occurrence of Shasta ground sloth and tortoise remains in the deposit.

The cave was the first location studied in the GC for Pleistocene biotic remains. In 1936 the CCC (Civilian Conservation Corp) produced a few test pits (Figure 11-12). Laudermilk and Munz (1938) described the plant remains from the dry-preserved dung. Subsequent excavation in the cave was made by Remington Kellogg of the National Museum of Natural History in 1942. Preliminary description of the faunal remains was published by Wilson (1942). Martin et al. (1961) provided the
first detailed paleoenvironmental and chronological study of cave contents with the analysis of dung from the 1956 Shutler Profile. A detailed analysis of radiocarbon-dated sloth dung was produced by Long and Martin (1974; Long et al. 1974). Fortunately, the Kellogg test trench was excavated to the limestone cave floor, because in 1976–1977 the bulk (~70%) of the deposit was destroyed by a smoldering fire set by an unauthorized visitor. The test trench produced a fire break saving some of this non-renewable fossil deposit. An exhaustive history of the various field studies in the cave (including field notes, early photographs, and the relocation of field maps) and an assessment of the remaining, unburned deposit was presented in Carpenter (2004). The entrance today requires permission and a key to open the steel gate. Studies of packrat middens from Rampart Cave and a multitude of isolated limestone crevice localities in a number of nearby canyons were published by Phillips (Phillips and Van Devender 1974; Mead and Phillips 1981; Phillips 1984). Sloth dung from the 1.5 m (5 ft) deep deposit produced ages from as young at 11,000 (uncorrected) years old, back to greater than 40,000 (Long and Martin 1974).

Muav Caves is a series of small tubes just above the pre-dam river level and now just above the high-stand of Lake Mead. The caves are best known for the remains of Shasta ground sloth (Long and Martin 1974; Long et al. 1974). Although some test pits were made in the cave entrance long ago, very little is understood about the contents of the deposits. In some crevices below these caves are a series of packrat middens and ringtail refuse den deposits in the Whipple Cliffs, but these remains have not been published at this time (Mead et al. in progress).

Vulture Cave is primarily a low crawlway along short passageways, but all areas are heavily congested with a multitude of packrat middens, floor deposits, and ringtail den debris (Mead and Phillips 1981; Mead and Van Devender 1981). Besides remains of Gymnogyps californianus, Cathartes aura (turkey vulture), and Camelops sp. the deposits provided a wealth of information about the Ice Age desert and woodland herpetofauna (Mead and Phillips 1981). Packrat midden contents ranged in age from 1,100 to 33,000 (uncorrected) yr B.P. (Mead and Phillips 1981). Important herpetological data came from a ringtail den $^{14}$C dated to 2,000 yr B.P. (Mead and Van Devender 1981).
Figure 11-12. Rampart Cave in the 1930s. A. Photograph by the CCC (Civilian Conservation Corp) of the Shasta sloth (*Nothrotheriops shastensis*) dung deposit prior to excavation in the 1930s and the fire in 1975–1976. B. Photograph of the CCC excavating a Shasta sloth skeleton from the dung deposit in the 1930s.
Environments and Climate Discussion

When one thinks of the GC, it is often visualized as an uncomplicated, sinuous, deep gorge east to west, with high elevations with forests at the rims, and low elevations with hot desert habitats along the roaring river at its spine down below. Conceptually this viewpoint may be good, but the real understanding is that the modern canyon is truly complex in all aspects, and this was equally true during the Pleistocene. The eastern region is distinctly different from the western end—climatically, ecologically, and geologically. The differences are in the details. To understand the record of the Pleistocene (Ice Age), preservation is at the core to the recovery of the details. Any cave or shelter with the occurrence of split-twig figures (e.g., Farmer and deSaussure 1955; Emslie et al. 1995) illustrates that preservation of these Archaic cultural remains in the chamber is ideal enough that Ice Age remains are more than likely also present and the cavern should be assessed for them as well. Split-twig figures are part of the Archaic culture that occurred throughout the GC region and elsewhere on the Colorado Plateau, all since the Ice Age and within the Holocene. Overviews of this cultural period as it relates to the GC region can be found in Geib (1995), Huckell (1986), and Janetski et al. 2012.

The CP is a distinct physiographic province, straddling the present transition between summer-wet climatic regimes to the south and summer-dry climatic regimes to the north. With the tremendous topographic diversity of the region, there are extremes in available habitats and plant communities today; and these attributes were certainly expressed with the Ice Age climate regimes. Anderson et al. (2000) provides a detailed synthesis of many southern CP late Ice Age localities for paleoclimatic and paleobotanic reconstructions.

The data about world-wide changes in temperature are derived from deep sea core samples. A multitude of fossil forms have been used to create a world-wide record of climate and temperature changes. Different phases are grouped into like clusters termed marine isotope stages (MIS) or oxygen isotope stages (OIS) (see Cronin 2010; Bradley 2015, 3rd edition). For the GC region, the preserved dataset permits one to examine MIS 1 (14,059 cal. yr BP to present), MIS 2 (27,500–14,060 cal yr BP, and MIS 3 (59,000–27,501 cal yr BP). Clearly much of the Pleistocene (~2.59 million to 11,000 years ago) is not understood. More is known for other regions on the CP, but these deposits are not to be recovered in the GC.

Some of the best high elevation paleoecological data comes from stratified sediment cores taken from lakes that are not found within the limestone region of the GC, but elsewhere on the southern CP (Potato Lake, Anderson 1993; Walker Lake, see Anderson et al. 2000, for detailed discussion of dataset; Hay Lake, Jacobs 1985).

Data about MIS 2 and MIS 3 plant communities above about 2,800 m (9,190 ft) elevation are presently not fully understood. Lake-core pollen records at about 2,700 m (8,860 ft) suggest that during MIS 3 high-elevation pine species (perhaps bristlecone and or limber) mixed with Engelmann spruce and subalpine fir created an open forest, possibly with sagebrush growing in open areas. Calculated average summer temperatures were about 3–4°C cooler during MIS 3 than at present (Anderson et al. 2000).
The knowledge of plant communities between 1,600–2,100 m (5,250–6,890 ft) elevation is minimal due to the lack of fossil data. One thing is consistent with the preserved macrobotanical record, there is a lack of ponderosa pine from MIS 3–2. Below 1,500 m (4,940 ft) elevation to about 450 m (1,380 ft) a juniper-desertscrub open woodland persisted, including sagebrush, prickly pear cactus, agave, and, lower down, saltbush. Looking down into the GC during the Ice Age, one would be overwhelmed with this open woodland desertscrub community growing clear to the river’s edge. Side canyons would have stands of Douglas fir and white fir in the wetter habitats. A mixed-conifer forest (montane conifers) with limber pine, white fir, and Douglas fir occupied the upper slopes, buttes, and rim county.

The transition from MIS 2 to MIS 1 (~14,000 cal yr BP) occurred with a major reorganization of the plant communities from rim to river. Many species of mixed-conifer forest retreated upslope to attain their near-current elevation distributions. Ponderosa pine quickly became established across middle elevations, as they are today. At lower elevations desertscrub communities replaced the juniper woodlands. All species did not move in concert to these climate-induced changes; instead, what is observed is a mosaic change. Figure 11-13 shows diagrammatically the inferred elevational distribution of plant communities in and adjacent to the GC during the most recent approximately 50,000 years. The data seem to imply that during the last glacial, the southern position of the jet stream, a cooler tropical ocean, and a heavy spring snowpack over the CP and adjacent Colorado Rocky Mountains probably conspired to suppress the monsoonal flow pattern (Anderson et al. 2000). During this time the seasonality of precipitation appears to have been dampened to predominate during the winter storms. The change to a summer precipitation maximum at the beginning of MIS 1 may be recorded by the sudden appearance and rapid migration of ponderosa pine across the southern CP. Data suggest that the mean depression of late glacial temperatures was at least 5° C (~9° F) colder than today (Anderson et al. 2000).

The vertebrate species were likewise responding not only to the temperature and precipitation changes (i.e., they are affected directly by these parameters) as discussed above but also to the modifications to the local plant community changes (i.e., their food source and/or their habitat requirements). Some species were not directly affected by these parameters and have not changed their distribution within the greater GC region, such as the bighorn, possibly the bison, and Gila monster (*Heloderma suspectum*). Other species appear to have moved up in elevation but stayed within the overall region (some species of voles), or moved out of the GC region to other areas of the continent (*Gymnogyps californianus*), or died out completely (extinction occurred), such as *Oreamnos harringtoni, Euceratherium collinum, Nothrotheriops shastensis, Camelops* sp., and likely some carnivores.

The trends in climate and climate-induced biotic changes over the most recent 50,000 years are based on the data discussed above. It must be remembered that these statements are based on an incomplete fossil record, both through time and for the length of the GC. Packrat midden and dry-preserved cave data have at least a 360 km (190 mi) gap beginning in the eastern GC and going throughout much of the western GC. Most of the above data is really the eastern GC. Data are sparse to almost non-existent for the Hualapai Plateau on the southwest end of the GC. The topographic structure of the
northwestern GC (Shiwwits and Uinkaret plateaus) is completely different than the eastern GC so it should be expected that biotic communities and climate responses would have been different over the past 50,000 years. Much still needs to be recovered and assessed to understand the details surrounding this rapid and critical change in climate along with plant community distributional changes for the greater GC.

Figure 11-13. Inferred elevational distribution of plant communities within and adjacent to the Grand Canyon during the most recent 50,000 years. Cross-section is a line oriented from the San Francisco Peaks north through the Grand Canyon to the North Rim region (Anderson et al. 2000: Figure 8).

Acknowledgments
We thank Kim Besom and Colleen Hyde, Collections, GRCA for assisting us with identifying specimens in the collections that have not been fully published upon, and Janet Gillette, Museum of Northern Arizona, for assistance with Stanton’s Cave material. We also recognize the contributions, comments, and reviews offered by Diana Boudreau, Robyn Henderek, Anne Miller, Gary Morgan, and Klara Widrig.

Literature Cited


24

Grand

Science

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Prehistory

Hydrology

183

4(3):302

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Arizona

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Cenozoic extinctions

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Shasta

sloth

The Bodily, sloth

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Lucas

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the Archaic

Boulder, Colorado.

Memoir 183.

Dietary of the chuckwalla, Sauromalus obesus, determined by dung analysis.

Herpetologica 30:120–123.


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Appendix 11-A. Grand Canyon Ice Age Taxa

The following tables list plants and animals reported from various Ice Age localities in the greater Grand Canyon (GC), Arizona. Almost all reports are of localities within Grand Canyon National Park (GRCA) itself, although a few localities are just outside of the park (e.g., some mollusks from Kaufman et al. 1992). The tables are set up taxonomically and refer to the publication(s) that discuss each taxon. The publications are included in “Literature Cited”. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

Plants

Ice Age plant taxa reported from the Grand Canyon are listed in Appendix Table 11-A-1.

Appendix Table 11-A-1. Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

<table>
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<td>Pteridaceae</td>
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<td>Adiantum sp</td>
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</tr>
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<td></td>
<td>Ephedraceae</td>
<td>Ephedra nevadensis/viridis</td>
<td>Cole 1985</td>
</tr>
<tr>
<td></td>
<td>Ephedraceae</td>
<td>Ephedra torreyana</td>
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<td></td>
<td>Ephedraceae</td>
<td>Ephedra viridis</td>
<td>Cole and Mead 1981</td>
</tr>
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</table>
Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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<tr>
<td>Pinaceae</td>
<td>Pinus edulis var. fallax</td>
<td></td>
<td>Cole et al. 2013</td>
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</table>

¹ *Juniperus californicus* var. *osteosperma* = *Juniperus osteosperma*
Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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**Appendix Table 11-A-1 (continued).** Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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**Appendix Table 11-A-1 (continued).** Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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² Aplopappus = Haplopappus
Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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**Appendix Table 11-A-1 (continued).** Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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3 *Platypuntia* of Coats 1997 accepted as *Opuntia (Platyopuntia)*

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Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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### Appendix Table 11-A-1 (continued)

Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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Appendix Table 11-A-1 (continued). Ice Age plant taxa reported from the Grand Canyon. Those records that are pollen-only are reported as such; otherwise, records may be macrofossil-only or mixed macrofossil and palynomorph.

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**Invertebrates**

Ice Age invertebrate taxa reported from the Grand Canyon are listed in Appendix Table 11-A-2.

**Appendix Table 11-A-2.** Ice Age invertebrate taxa reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

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4 *Catinella cf. C. avara = Catinella cf. C. vermet*

5 *Cochlicopa lubrica = Cionella lubrica*

6 Subspecies of *Oreohelix yavapai*, such as *O. y. fortis* Cockerell 1927, are now generally rolled into *Oreohelix yavapai*
Appendix Table 11-A-2 (continued). Ice Age invertebrate taxa reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

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Appendix Table 11-A-2 (continued). Ice Age invertebrate taxa reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

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Appendix Table 11-A-2 (continued). Ice Age invertebrate taxa reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

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Vertebrates
Ice Age vertebrate taxa reported from the Grand Canyon are listed in Appendix Table 11-A-3.

Appendix Table 11-A-3. Ice Age vertebrate taxa reported from the Grand Canyon.

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7 *Sauromalus obesus* = *Sauromalus ater*
### Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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8 *Lampropeltis getulus = Lampropeltis getula*
Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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### Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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\(^9\) Catoptrophorus semipalmatus = Tringa semipalmata
## Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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10 *Pica pica hudsonica* = *Pica hudsonia*
Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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\(^1\) Nothrotherium shastense = Nothrotheriops shastensis
Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

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<td>Lindsay and Tessman 1974, Emslie et al. 1995</td>
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<td>Mead et al. 2003</td>
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<tr>
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<td>Neotoma devia or N. lepida</td>
<td>Hunt et al. 2018</td>
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<tr>
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<td>Neotoma lepida</td>
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<td>Neotoma stephensi</td>
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<td>Cole and Mead 1981</td>
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<td>Rodentia</td>
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<td>Neotoma cf. N. lepida</td>
<td>Cole and Mead 1981</td>
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<td>Neotoma cf. N. mexicana</td>
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<td>Rodentia</td>
<td>Rodentia</td>
<td>Ondatra zibethicus (Holocene general)</td>
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<td>Emslie 1988</td>
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<td>Rodentia</td>
<td>Rodentia</td>
<td>Peromyscus spp.</td>
<td>Mead 1981, Mead and Van Devender 1981</td>
</tr>
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<td>Rodentia</td>
<td>Rodentia</td>
<td>cf. Reithrodontomys</td>
<td>Cole and Mead 1981</td>
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<tr>
<td>Rodentia</td>
<td>Rodentia</td>
<td>Sciurus sp. (Holocene?)</td>
<td>Olsen and Olsen 1984</td>
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<tr>
<td>Rodentia</td>
<td>Rodentia</td>
<td>cf. Sciurus sp.</td>
<td>Emslie 1988</td>
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<td>Rodentia</td>
<td>Rodentia</td>
<td>Spermophilus sp.</td>
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<td>Hunt et al. 2018</td>
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<td>Thomomys sp.</td>
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<tr>
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<td>Rodentia</td>
<td>Rodentia undetermined</td>
<td>Hevly 1984</td>
</tr>
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<td>Lepus californicus</td>
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<td>Mead 1981, Olsen and Olsen 1984</td>
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<tr>
<td>Lagomorpha</td>
<td>Lepus near L. californicus</td>
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<td>Wilson 1942</td>
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Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

<table>
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<th>Class</th>
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<td><em>Sylvilagus</em> cf. <em>S. audubonii</em></td>
<td>Olsen and Olsen 1984</td>
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<tr>
<td>Lagomorpha</td>
<td>Lagomorpha undetermined</td>
<td>Hevly 1984</td>
<td></td>
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<td>Ray et al. 1988, Carpenter 2003, Hunt et al. 2018</td>
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<td><em>Euderma</em> maculatum</td>
<td>Mead and Mikesic 2005</td>
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<tr>
<td>Chiroptera</td>
<td><em>Eumops</em> sp.</td>
<td>Carpenter 2003, Hunt et al. 2018</td>
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<tr>
<td>Chiroptera</td>
<td><em>Lasiusurus</em> cinereus</td>
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<td>Chiroptera</td>
<td><em>Lasionycteris</em> noctivagens</td>
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<tr>
<td>Chiroptera</td>
<td><em>Myotis</em> sp. (possibly Holocene)</td>
<td>Olsen and Olsen 1984</td>
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<tr>
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<td>Emslie 1988</td>
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<td>Chiroptera</td>
<td>[Parastrellus]</td>
<td></td>
<td></td>
</tr>
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<td>Chiroptera</td>
<td><em>Plecotus</em> townsendi</td>
<td>Emslie 1988</td>
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<tr>
<td>Chiroptera</td>
<td>[Corynorhinus]</td>
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<td><em>Bassariscus</em> sp.</td>
<td>Lindsay and Tessman 1974</td>
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<tr>
<td>Carnivora</td>
<td><em>Canis</em> latrans (Holocene general)</td>
<td>Mead 1981, Olsen and Olsen 1984</td>
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<tr>
<td>Carnivora</td>
<td><em>Canis</em> sp. (wolf)</td>
<td>Emslie 1988</td>
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<td><em>Lynx rufus</em></td>
<td>Mead 1981</td>
<td></td>
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<tr>
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<td><em>Lynx</em> sp.</td>
<td>Wilson 1942, Hunt et al. 2018</td>
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</tr>
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<td><em>Mustela</em> sp.</td>
<td>Lindsay and Tessman 1974, Hunt et al. 2018</td>
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<tr>
<td>Carnivora</td>
<td><em>Puma concolor</em></td>
<td>Mead 1981, Mead et al. 2003, Hunt et al. 2018</td>
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</tr>
<tr>
<td>Carnivora</td>
<td><em>Puma concolor?</em></td>
<td>Wilson 1942</td>
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</table>

12 *Felis concolor* = *Puma concolor*
Appendix Table 11-A-3 (continued). Ice Age vertebrate taxa reported from the Grand Canyon.

<table>
<thead>
<tr>
<th>Class</th>
<th>Order</th>
<th>Taxa Observed</th>
<th>Sources</th>
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<tbody>
<tr>
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<td>Carnivora</td>
<td>Spilogale putorius</td>
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<td>Spilogale gracilis or S. putorius</td>
<td>Hunt et al. 2018</td>
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<tr>
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<td>Carnivora</td>
<td>Spilogale sp.</td>
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<tr>
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<td>Carnivora</td>
<td>Urocyon cinereoargenteus</td>
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<td>Carnivora</td>
<td>Vulpes vulpes</td>
<td>Carpenter 2002</td>
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<td>Carnivora</td>
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<td>Carpenter and Mead 2000</td>
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<td>Emslie 1987, Emslie 1988</td>
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<td>Equus sp. (E. conversidens?)</td>
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<td>Artiodactyla</td>
<td>Antilocapra americana</td>
<td>Mead 1981, Mead and Phillips 1981</td>
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<td>Artiodactyla</td>
<td>Camelops hesternus</td>
<td>Mead et al. 2003</td>
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<td>Artiodactyla</td>
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<td>Euceratherium collinum</td>
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<td>Mead et al. 2003</td>
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<td>Artiodactyla</td>
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<td></td>
<td>Artiodactyla</td>
<td>Oreamnos harringtoni</td>
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### Ichnofossils and Reproductive Traces

Ice Age ichnofossils and reproductive traces reported from the Grand Canyon can be seen in Appendix Table 11-A-4.

**Appendix Table 11-A-4.** Ice Age ichnofossils and reproductive traces reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

<table>
<thead>
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<tr>
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<td>Dipteran pupal case</td>
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<td>“Helminth” eggs</td>
<td>Schmidt et al. 1992</td>
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<tr>
<td></td>
<td>Nematode eggs</td>
<td>Laudermilk and Munz 1938</td>
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<td></td>
<td>Artiodactyl dung</td>
<td>Mead and Swift 2012, Hunt et al. 2018</td>
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<td></td>
<td><em>Bassariscus astutus</em> dung</td>
<td>Mead and Swift 2012, Hunt et al. 2018</td>
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<tr>
<td></td>
<td>Bat guano</td>
<td>see text</td>
</tr>
<tr>
<td></td>
<td><em>Bison</em> sp. dung</td>
<td>Mead and Swift 2012</td>
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<td></td>
<td><em>Equus</em> sp. dung</td>
<td>Mead and Swift 2012</td>
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<td></td>
<td><em>Erethizon dorsatum</em> dung</td>
<td>Mead and Swift 2012</td>
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<td>Large felid dung</td>
<td>Mead and Swift 2012, Hunt et al. 2018</td>
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<td></td>
<td><em>Neotoma</em> spp. dung</td>
<td>abundant in <em>Neotoma</em> middens; see text</td>
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<td><em>Nothrotheriops shastensis</em> dung</td>
<td>see text</td>
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<td></td>
<td><em>Oreamnos harringtoni</em> dung</td>
<td>see text</td>
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<td></td>
<td><em>Ovis canadensis</em> dung</td>
<td>Robbins et al. 1984, O’Rourke and Mead 1985, Mead and Swift 2012, Hunt et al. 2018</td>
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<td><em>Peromyscus</em> sp. dung</td>
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<td>Rabbit dung</td>
<td>Hevly 1984</td>
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<td>Rodent dung</td>
<td>Hevly 1984, Mead and Swift 2012, Hunt et al. 2018</td>
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<td></td>
<td><em>Sauromalus</em> dung (age not stated)</td>
<td>Mead and Swift 2012</td>
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<td>cf. <em>Sylvilagus</em> sp. dung</td>
<td>Mead and Swift 2012, Hunt et al. 2018</td>
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<td></td>
<td>Bird regurgitation pellets</td>
<td>Emslie et al. 1995, Mead and Swift 2012</td>
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<td><em>Bassariscus astutus</em> middens (late Holocene)</td>
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<td><em>Neotoma</em> spp. middens</td>
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<td></td>
<td><em>Gymnogyps californianus</em> eggshells</td>
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<td><em>Gymnogyps</em> nest</td>
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Other Fossils
Other fossil Ice Age taxa reported from the Grand Canyon are listed in Appendix Table 11-A-5.

Appendix Table 11-A-5. Other Ice Age fossil taxa reported from the Grand Canyon. Taxa followed by an asterisk (*) were named from specimens found within GRCA.

<table>
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<td>Coccidia</td>
<td>Archaeococcidia antiquus*</td>
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<td>Coccidia</td>
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<td>–</td>
<td>Fungal spores</td>
<td>Robbins et al. 1984, Schmidt et al. 1992</td>
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