PLEISTOCENE VERTEBRATES FROM CARLSBAD CAVERNS NATIONAL PARK, NEW MEXICO

SCOTT KOTTKAMP[1*], VINCENT L. SANTUCCI[2], JUSTIN S. TWEET[3], RODNEY D. HORROCKS[1] and GARY S. MORGAN[4]

[1]Carlsbad Caverns National Park, 3225 National Parks Highway, Carlsbad, NM 88220, skottkamp92@gmail.com; Rod_Horrocks@nps.gov;
[2]National Park Service, Geologic Resources Division, 1849 C Street, NW, R2644, Washington, DC 20240, Vincent_Santucci@nps.gov;
[3]National Park Service, 9149 79th Street S., Cottage Grove, MN, 55016, Justin_Tweet@nps.gov;
[4]New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, NM 87104, gary.morgan1@state.nm.us

Abstract—Carlsbad Caverns National Park (CAVE) is located in southeastern New Mexico, southwest of Carlsbad, Eddy County. Situated in the Chihuahuan Desert, the park includes more than 120 caverns of all sizes, formed by millions of years of limestone dissolution. Best known to visitors for its cave systems with expansive rooms adorned with spectacular speleothems, the park also preserves many important paleontological resources. Some of these are invertebrate fossils associated with the Permian age reef complex that forms the bedrock, but the caves also preserve Pleistocene age fossil deposits dominated by vertebrate remains. During the Fall and Winter of 2019 into 2020, a paleontological resources inventory was conducted at the park. This inventory was primarily a synthesis of published articles, unpublished reports, park records, and museum collections, but it included fieldwork as well. This research resulted in the most complete list, to date, of park fossil fauna and fossil localities, including many taxa not known from publicly available sources. In total, 95 vertebrate taxa have been confirmed from Pleistocene cave deposits at CAVE. This inventory will provide a baseline source of data critical to future research, resource monitoring, and management decisions involving paleontological resources in the park. The Pleistocene fossil record of CAVE documents species extinctions and extirpations associated with a drying climate, making it especially relevant to conservation paleobiology efforts in regions facing desertification.

INTRODUCTION

Carlsbad Caverns National Park (NPS acronym is CAVE) protects 18,926 hectares of land containing extensive cavern systems with large rooms developed in the Permian age bedrock of the Guadalupe Mountains (Fig. 1). The Permian Capitan reef complex preserved here, and in analogous units in the nearby Guadalupe Mountains National Park, is important both geologically and paleontologically (Hayes, 1957, 1964; Hayes and Koogle, 1958; Hill, 1987; Kottkamp et al., 2020). The cave systems developed within the last 12 Ma and opened to the surface sometime during the Pleistocene, likely within the last million years (Lundberg and McFarlane, 2006). These caves made for ideal shelters, dens, and natural traps, and thus preserve a snapshot of the terrestrial Pleistocene fauna of the region (Harris, 1985, 2005, 2020; Morgan and Lucas, 2006; Morgan and Harris, 2015).

The exact nature of the fossil deposits varies. Several localities, including the Bat Cave of Carlsbad Cavern and the guano mining trenches of Slaughter Canyon Cave, have massive assemblages of colonial bat skeletons preserved *in situ* in guano deposits (Baker, 1963; Morgan, 2002, 2003a, 2003b). These animals roosted seasonally in the cave and died there, though in some cases the bones may have been transported small distances and into pits by water dripping or flowing into the caves (Baker, 1963). Other caves, such as Muskox Cave, acted as natural traps where animals were lured into steep vertical drops by the presence of water, shelter, or prey (Logan, unpubl. report to NPS, 1979; Logan, 1981). Gradual sedimentation into these natural traps buried and preserved the remains in large debris piles. Caves with more gradual entrances served as dens and shelters for animals (modern animals still use the caves for these purposes), preserving both the remains of cave inhabitants and those of prey dragged back to the den. More rarely, depending on the climate of the cave room in question, remains were mummified through desiccation or encased in secondary calcite deposits.

The fossil taxa found in CAVE include not only extinct species, but also species that have been locally extirpated from southeastern New Mexico. These include more boreal and/or water dependent species that cannot survive in the modern Chihuahuan Desert. The faunal turnover from the Pleistocene taxa preserved at CAVE, to more xeric-adapted taxa dating to the early Holocene and extant in the park today, provides a

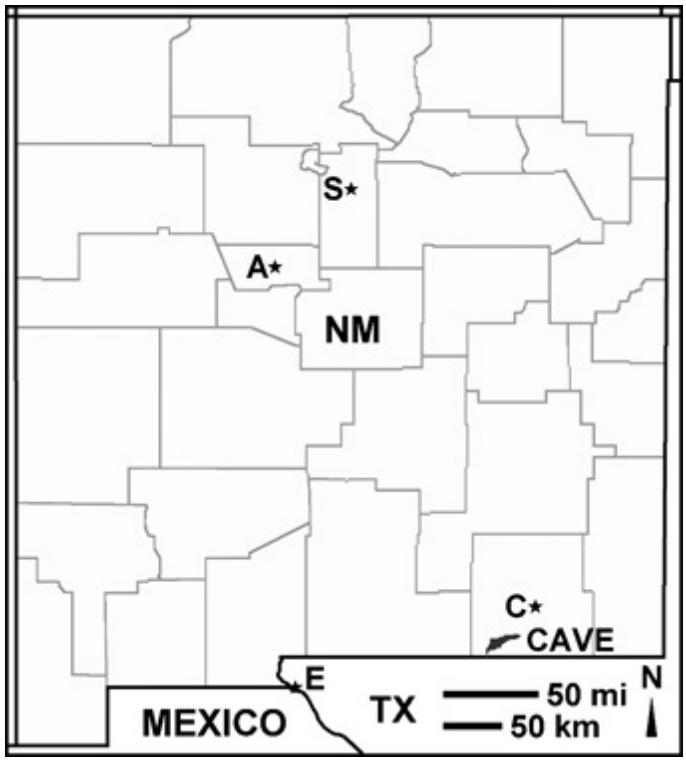


FIGURE 1. Map of New Mexico, displaying the location of CAVE within the state. Letters represent cities: C = Carlsbad, A = Albuquerque, S = Santa Fe, E = El Paso (NPS Photo)

detailed view of both the Pleistocene paleoecology of the park and a major period of ecological adjustment to climate change at the beginning of the Holocene. Given the present threat that climate change poses to the Chihuahuan Desert locally, and the biosphere globally, data compiled from the CAVE Quaternary fossil record is keenly relevant to conservation paleobiology efforts.

NATURE OF FOSSILIFEROUS LOCALITIES

The Pleistocene vertebrate fossils of CAVE are not preserved in the bedrock, which is exclusively of Permian age. Pleistocene fossils are primarily preserved in the rooms of cave systems, sometimes sitting exposed on the surface of the cave floor, but more often shallowly buried in loose sediment, talus, or bat guano and sometimes encased in flowstone (Santucci et al., 2001; Graham, 2007). In many caves, Pleistocene and Holocene remains are both present, sometimes in the same deposits. Many localities have not had their contents radiometrically dated; therefore, a number of specimens of uncertain age will be included in this report. There are also mummified mammal remains in several locations in Carlsbad Cavern. Most of these mummies are bats, but three examples of *Bassariscus astutus* (ringtail) mummies have also been reported (Baker, 1963; Jablonsky, unpubl. report to NPS, 1999; R. Horrocks, personal observation, 2020). A small number of specimens have been recovered from alluvium and gravel deposits found outside of caves, most frequently at springs. None of these specimens have been dated and they may not be of Pleistocene age.

METHODS

The bulk of this study was completed through a synthesis of literature and archival records that report on fossiliferous localities in CAVE (Kottkamp et al., 2020). This included both published studies and internal park reports. This synthesis was augmented by field observation of fossils in Carlsbad Cavern and Slaughter Canyon Cave, as well as an inventory and reorganization of the vertebrate fossils housed in the park museum collections. Fossils were not collected during field observation. Specimens were updated to current taxonomic identifications via cross referencing with online databases (e.g. Paleobiology Database) and collaboration with coauthor Gary Morgan, Curator of Paleontology at the New Mexico Museum of Natural History and Science, who has done extensive work on the Pleistocene vertebrates of New Mexico (Morgan, 2003a, 2004; Morgan and Lucas, 2006; Morgan and Harris, 2015; Paleobiology Database Contributors, 2020).

There are very few radiocarbon or other radiometric dates from fossil sites in CAVE. Because sites have not been dated, and most Pleistocene material at CAVE is not significantly altered diagenetically, we are not certain in many cases if fossils are Holocene or Pleistocene in age. This is particularly true for extant species that also have a Pleistocene record. Extinct species (e.g., †*Nothrotheriops shastensis*) are obviously Pleistocene. Where dates are available, we have included them.

Vertebrate fossils from sensitive caves (identified here only by number, e.g., C-10) were often left in place and not collected by CAVE staff, surveyors, or visiting researchers. In some of these caves, photos were taken of the fossil specimens, and the photos are preserved in CAVE reports and files. If photos are available, we attempted to make the most accurate identification possible of the fossils left behind in the cave. In other caves, there are no specimens or photographs, and the only fossil identifications available were made by surveyors or CAVE staff, most of whom were not trained in vertebrate osteology. Therefore, identifications from unpublished CAVE reports by non-paleontologists are considered tentative and subject to change based on additional information. In most cases, those identifications are very general (e.g., "bat" or "medium-sized carnivore"). We consider it important to include these tentative identifications in our paper to provide basic information for future paleontologists who might be interested in conducting further research in a particular cave or for CAVE staff who are evaluating paleontological resources (e.g., Kottkamp et al., 2020).

The higher taxonomic categories of mammals (orders and families) and the phylogenetic order in which they are listed in Table 1 and discussed in the accounts of the individual cave faunas follow Wilson and Reeder (2005). Within mammalian families in Table 1, the genera are listed in alphabetical order, and within genera the species are also alphabetical.

Where possible, unpublished discoveries and identifications are cited in the form of "(Unpubl. report to NPS, year)" if the report was written by someone outside the NPS and "(Unpubl. NPS Report, year)" if written by NPS staff, with individual names mentioned in the surrounding text. Where confidentiality or missing information precludes mentioning specific names or years, the citation "(Unpubl. NPS Report, 2019)" is given without names.

FOSSIL VERTEBRATE INVENTORY

Fossil taxa are organized by the caves or karst feature in which they were found, with subdivision by higher taxonomic groups. Extinct taxa are marked with a dagger (†) prior to their scientific names. Table 1 summarizes this information, but is arranged taxonomically. Caves that are not being disclosed to the public are identified by their site designations, e.g. C-32. Karst features, which have no names associated with them, are identified by their site designations, e.g. KF-39.

C-01 - Carlsbad Cavern

Carlsbad Cavern is the namesake of Carlsbad Caverns National Park, and was the primary natural feature that led to the designation of CAVE as a unit of the NPS in 1923 (Kottkamp et al., 2020). The extensive cavern system was likely formed by dissolution of the source rock by sulfuric acid, with secondary speleogenesis through a more typical sculpting via carbonic acid (Hill, 1987). The unusual manner of speleogenesis led to a prevalence of large, well-decorated rooms throughout the cave. The natural entrance to the cave is situated adjacent to the visitor center, and a large portion of the cavern is open to the public.

The switchbacks and gentle slopes that allow easy descent into the cave are the product of human engineering in the mid-20th century, but the interior of the cave was accessible by nonvolant animals even prior to the development of the trails. Several specimens of nonvolant animals found deep within Carlsbad Cavern suggest it may have had other, now collapsed, entrances in the past. However, bats and bat guano are the most common vertebrate fossils found within Carlsbad Cavern. These bat remains include the remnants of several long-lasting bat colonies, including an extant *Tadarida brasiliensis mexicana* (Mexican free-tailed bat) colony. Several bat skeletons are encased and preserved *in situ* within flowstone (Fig. 2).

The first documented collection of a vertebrate fossil from Carlsbad Cavern was a †*Nothrotheriops shastensis* (Shasta ground sloth) partial skeleton discovered in the 1940s (Hill and Gillette, 1987; McDonald and Morgan, 2011). Collection of fossils during the 1950s was opportunistic and sporadic, coinciding with the construction of park trails within Carlsbad Cavern. However, it seems the majority of this material was presumed to be recent, went unanalyzed, and was discarded (Black, 1953; Kottkamp et al., 2020). Ela Hammond collected a set of large felid podials from the entrance to Carlsbad Cavern in 1957. This felid has been variously identified as different species by park staff in the past, and is identified in this paper as †*Panthera atrox* (American lion). James Baker inventoried and published a paper on the bat fossil assemblage of Carlsbad

Cavern in 1963. Carol Hill (Cave Research Foundation) and David Gillette (New Mexico Museum of Natural History) revealed the †*Nothrotheriops* specimen to be about 110,000 years old based on a U-series date, greatly expanding the known upper age limit of Quaternary fossils at CAVE (Hill and Gillette, 1985, 1987a). Patricia Jablonsky (Denver Museum of Nature and Science) conducted a major inventory of Carlsbad Cavern's chiropteran taxa and fossil resources in the 1990s. This study identified several more bat species, and radiocarbon dating found one fossil bat colony to be up to 50,000 years old (Jablonsky, unpubl. reports to NPS, 1993, 1996, 2001, 2004).

Reptilia

Phrynosomatidae: Isolated bones and scales of *Phrynosoma* (horned lizard) were found while excavating the natural entrance debris pile (Black, 1953). These specimens are not in the CAVE collection. All paleontological resources from the debris pile (except possibly for a †*Panthera atrox* specimen discussed below) are thought to have been discarded.

Mammalia

Pilosa (=Edentata = Xenarthra, in part)

†**Nothrotheriidae:** A juvenile †*Nothrotheriops shastensis* specimen was collected from the cave in the 1940s (Bretz, 1949; Hill and Gillette, 1987a; Santucci et al., 2001; McDonald and Jefferson, 2008; McDonald and Morgan, 2011). This specimen is curated in the CAVE collection. Hill and Gillette (1987a; unpubl, 1987b) dated this specimen to 111,900 (+13,300, -11,700) years old using uranium-series dating. Based on the taphonomic condition of the bones, the authors hypothesized that the animal must have died near where it was found. This is in contrast to older hypotheses that the carcass was washed in (Bretz, 1949; Gale, 1957).

Chiroptera

Molossidae: Free-tailed bats, in particular *Tadarida brasiliensis mexicana*, constitute the most abundant vertebrate fossil specimens in Carlsbad Cavern (Baker, 1963). The cave is currently home to a large colony of this species in the Bat Cave section, and fossil evidence suggests several prior colonies of the species inhabited the Big Room and Lower Cave (Santucci et al., 2001; Jablonsky, unpubl. report to NPS, 1999). While specimens from Bat Cave are exclusively Holocene in age, a locality in Lower Cave, and another in the Big Room, have guano radiocarbon-dated to around 50,000 years old and 35,000 years old, respectively (Jablonsky, unpubl. reports to NPS, 1999, 2001). The larger Pleistocene-aged †*Tadarida constantinei* (Constantine's free-tailed bat) has also been found in small numbers in Carlsbad Cavern according to Baker (1963), but we were not able to verify this identification.

Vespertilionidae: These bats are less abundant in the fossil assemblage of Carlsbad Cavern than their molossid counterparts, but still more abundant than any other vertebrates. Fossil species recovered or observed from the cave include: *Corynorhinus townsendii* (Townsend's big-eared bat); *Eptesicus fuscus* (big brown bat) and its Pleistocene subspecies †*Eptesicus fuscus grandis*; *Lasiurus blossevillii* (western red bat); *Lasiurus* (= *Aeorestes* according to Baird et al., 2017) *cinereus* (hoary bat); *Myotis ciliolabrum* (western small-footed bat); *Myotis velifer* (cave myotis); *Myotis volans* (long-legged myotis); *Myotis yumanensis* (Yuma myotis); and *Myotis* sp. (Baker, 1963; Jablonsky, unpubl. reports to NPS, 1996, 1999, 2001). These specimens are likely of mixed Pleistocene and Holocene age based on a combination of Baker's (1963) identifications and Jablonsky's radiometric dating (unpubl. reports to NPS,



FIGURE 2. A bat encased in flowstone within Carlsbad Cavern (NPS Photo).

1999, 2001).

Carnivora

Felidae: Santucci et al. (2001) reported *Puma concolor* (mountain lion) from a room deep in Carlsbad Cavern. Park staff hypothesize that the specimen's presence so deep in the cave indicates that another, now closed, natural entrance to the cavern once existed (Santucci et al., 2001; unpubl. NPS Report, 2020).

The CAVE paleontology collection also contains a specimen from Carlsbad Cavern that has previously been identified as either the American lion †*Panthera atrox* or the jaguar *Panthera onca* (Pate, 1999; Santucci et al., 2001; unpubl. NPS Reports). This specimen (catalog number CAVE 2169) is listed in the CAVE locality files as from the "Bat Cave seating area," which is located near the natural entrance of Carlsbad Cavern and was received from Ela Hammond on December, 5, 1957. CAVE 2169 consists entirely of postcranial elements, mostly phalanges or toe bones, including six proximal phalanges, two medial phalanges, and five distal or ungual phalanges, as well additional fragments (Fig. 3).

In addition to comparing CAVE 2169 to similar elements in three species of large cats, we also compared it to toes of the two other families of large carnivores known from Pleistocene deposits in CAVE, Canidae (wolves) and Ursidae (bears). The proximal, medial, and ungual phalanges of CAVE 2169 are all diagnostic of family Felidae. The ungual phalanges have a dorsoventrally deep but mediolaterally thin bony core that would have underlain the actual keratinous claw, which is not preserved. At the base of the claw core is a prominent, broad bony sheath. An ungual phalanx with this morphology would have supported the highly curved, thin, and retractile claw typical of cats. Both wolves and bears have a much smaller, blunter, and more gently curved claw core with a reduced bony sheath at the base of the ungual phalanx, due to their non-retractile claws. The medial phalanges of CAVE 2169 also display a felid morphology, with the shaft distinctly curved and the distal end offset, both reflecting how the claws are retracted backward at an angle to the long axis of the shaft. The medial phalanges of canids and ursids are more symmetrical with a rather straight shaft. The six complete proximal phalanges of CAVE 2169 are similar in size and proportions to those of large cats. The proximal phalanges of wolves (†*Canis dirus* and *C. lupus*) are smaller and more slender, whereas the proximal phalanges of ursids have a comparatively broader or more robust shaft.

After confirming the phalanges of CAVE 2169 are most similar to those of a large felid, we compared them to phalanges of three living species of large cats at the Museum of Southwestern Biology (MSB). These include two species identified from Pleistocene deposits in New Mexico, *Puma concolor* and *Panthera onca*, and one of which, *Panthera leo* (African lion), is similar to †*Panthera atrox*. We focused on the proximal phalanges because there are six well-preserved specimens of this element associated with CAVE 2169. The proximal phalanges of the Carlsbad Cavern felid and the three living large cat species are very similar in morphology, with the primary difference between them being size. The phalanges of CAVE 2169 are considerably larger than those of *P. concolor* from New Mexico (e.g., MSB 142873) and *P. onca* from Mexico (e.g., MSB 14248). The felid phalanges from Carlsbad Cavern are also somewhat larger than toes of *Panthera leo* (e.g., MSB 55400), but are otherwise similar. Two large, extinct felids in the same general size range as the Carlsbad Cavern cat have been identified from Pleistocene deposits in New Mexico (Morgan and Harris, 2015), †*Panthera atrox* and the sabertooth cat †*Smilodon fatalis*. The proximal phalanges of *Smilodon* are shorter and more robust than those of CAVE 2169. The Carlsbad Cavern felid phalanges are very similar in both size and morphology to phalanges of †*P. atrox* (Merriam and Stock, 1932), and we refer CAVE 2169 to that species. †*P. atrox* has also been identified from Muskox Cave (Logan, 1981; see account of that cave) based on two specimens, a P4 and a metapodial (both USNM uncatalogued; Morgan, personal observation). Most authors consider †*P. atrox* to be a separate species, but it has also been considered a large, extinct subspecies of *P. leo* (e.g., Kurtén and Anderson, 1980).

Procyonidae: The remains of several *Bassariscus astutus* have been found in the main Carlsbad Cavern. All have been left *in situ*, except for one skull that was collected and curated in the CAVE museum collections. A few of these specimens were encased in flowstone. There is a mummified ringtail specimen also preserved in the cave. The age of these specimens is uncertain; no radiometric dating has been performed on them. They may date from the Holocene instead of the Pleistocene.

C-02 - Slaughter Canyon Cave

Slaughter Canyon Cave (previously known as New Cave) is located in Slaughter Canyon, about 14 km southwest of Carlsbad Cavern. The cave entrance is protected by a locked gate with public access permitted during ranger-led tours. The cave has a large, walk-in opening and several hundred meters of mapped passageways (Hill, 1987). The area outside the entrance is steep, but not a vertical cliff face, allowing access to the cave by small- to medium-sized nonvolant mammals (i.e., non-bats). Slaughter Canyon Cave contains extensive, fine-grained sediment deposits as much as 3 m thick, most of which represent decomposed or altered bat guano. These guano deposits were commercially mined for fertilizer until the 1950s. The sediment deposits in Slaughter Canyon Cave contain a remarkable sample of vertebrate fossils representing at least 28 species, overwhelmingly dominated by thousands of specimens of the free-tailed bat †*Tadarida constantinei*.

Vertebrate fossils were first discovered in Slaughter Canyon Cave in 1938 by Harry Tourtelot of the University of Nebraska State Museum (UNSM), who collected two nearly complete skeletons of the extinct Frick's mountain deer †*Navahoceros fricki* (field notes of H. Tourtelot provided by George Corner of the UNSM). One of these two skeletons, a male with well-developed antlers, is on display at the UNSM, whereas the second skeleton, a female, is housed in the UNSM vertebrate paleontology collection (Kurtén, 1975). Tourtelot also collected small samples of other mammals, including a bighorn sheep and



FIGURE 3. CAVE 2169, †*Panthera atrox*, proximal phalanges from the bat seating area at the natural entrance to Carlsbad Cavern. The identity of CAVE 2169 was previously the subject of debate between CAVE staff, with differing hypotheses of †*P. atrox* and *P. onca* (NPS Photo).

several species of rodents and bats. Denny Constantine of CAVE collected a sample of fossil skulls, lower jaws, and limb bones of bats from Slaughter Canyon Cave in 1958. He sent these fossils to Barbara Lawrence at the Museum of Comparative Zoology (MCZ) at Harvard University, who described this sample as a new species of extinct free-tailed bat, †*Tadarida constantinei* (Lawrence, 1960). Donald McFarlane from Claremont College in California collected an additional sample of †*T. constantinei* from Slaughter Canyon Cave in 1988 (later transferred to the NMMNH), and also obtained samples of the flowstone overlying the fossil deposit that were dated using the Uranium-series method (Lundberg and McFarlane, 2006; see discussion of dating below). In 2002 and 2003, field crews led by GSM, consisting of staff and volunteers from the NMMNH, Kartchner Caverns in Arizona, and CAVE, excavated two test pits in the guano deposits in Slaughter Canyon Cave. They collected fossils in-place from the two test pits, including land tortoises, medium-sized, non-volant mammals (e.g., antilocaprids), and complete skulls of †*T. constantinei*, and also removed several hundred kg of sediment for screenwashing to obtain specimens of smaller vertebrates, including bats, rodents, rabbits, birds, lizards, a snake, and a toad or frog. Morgan (in prep.) will present a more detailed discussion of the vertebrate paleontology, geology, and age of Slaughter Canyon Cave.

There are samples of fossils from Slaughter Canyon Cave in the vertebrate paleontology collections of the MCZ, NMMNH, and UNSM. These samples mostly consist of bats, but also include four extinct species of artiodactyls, a peccary, two antilocaprids, and a cervid, and a variety of small, nonvolant vertebrates (see below). In addition, we discuss several fossil specimens in the CAVE collection and unpublished records. These previously unreported specimens add five species to the faunal list from this cave, two species of dogs in the genus *Canis*, the camel *Camelops*, the porcupine *Erethizon dorsatum*, and the ringtail *Bassariscus astutus*.

Amphibia

Anura. Two postcranial elements of a toad or frog were identified from Slaughter Canyon Cave (Morgan, in prep.).

Reptilia

Testudinidae: The Sonoran desert tortoise *Gopherus morafkai* (= *G. agassizii*, in part) is identified from Slaughter Canyon Cave based on a sample of about 15 isolated shell elements and limb bones (Morgan, 2002, in prep.; Morgan and Lucas, 2006).

Phrynosomatidae: A cranial element with two "horns" of the horned lizard *Phrynosoma* was reported from this cave in Morgan and Lucas (2006).

Sauria: Two maxillae, a partial mandible, and several postcranial elements of small lizards were identified from this cave. The maxillae represent two different species of lizards (Morgan, in prep.).

Serpentes: A single, unidentified fossil snake vertebra has been collected from Slaughter Canyon Cave (Morgan, 2003a; Morgan and Lucas, 2006).

Aves

The ungual phalanx or claw core of an unidentified raptor was found in the cave (Morgan, 2002; Morgan and Lucas, 2006). A smaller ungual phalanx with a different morphology represents a second species of bird. The avian sample also includes a partial coracoid and partial humerus that should be identifiable with further comparisons (Morgan, 2002, in prep.).

Mammalia

Rodentia

Heteromyidae: An unidentified species of pocket mouse, either *Chaetodipus* or *Perognathus*, is documented based on a maxilla from Slaughter Canyon Cave (Morgan, 2003a; Morgan and Lucas, 2006).

Cricetidae: A mandible similar to *Neotoma* (woodrat or packrat) is documented from Slaughter Canyon Cave (Morgan, 2002). About 10 additional specimens of small rodents, including an edentulous mandible and maxilla, incisor, and various postcranial elements, are not identifiable to the genus or species level. However, based on the range of sizes of these fossils, several species of small rodents appear to be represented.

Erethizontidae: A skull, plus an associated right mandible with molars and incisor, of *Erethizon dorsatum* (North American porcupine) from Slaughter Canyon Cave is housed in CAVE museum collections.

Lagomorpha

Leporidae: Isolated teeth and postcranial elements collected from Slaughter Canyon Cave by a NMMNH field crew represent two genera of leporids, the smaller *Sylvilagus* (cottontail) and larger *Lepus* (jackrabbit) (Morgan, 2002, in prep.).

Chiroptera

Molossidae: Hundreds of thousands of specimens of †*Tadarida constantinei* are preserved in several deposits of bat guano (up to 3 m thick) located in Slaughter Canyon Cave (Fig. 4; Morgan, 2002, 2003a, 2003b, 2004). The holotype skull, as well as an additional sample of skulls, mandibles, and postcranial elements, of this species were collected from Slaughter Canyon Cave in the 1950s by Denny Constantine of CAVE and are housed in the Museum of Comparative Zoology collections at Harvard University in Cambridge, Massachusetts (Lawrence, 1960). A large sample of *T. constantinei,* numbering in the thousands of specimens, including more than 100 complete skulls, was collected by NMMNH and CAVE field crews in 2002–2003.

Morgan and Harris (2015) also list a smaller species of *Tadarida* from the site, cf. *T. brasiliensis* based on a small sample of limb bones. The co-occurrence of *T. brasiliensis* and *T. constantinei* in Slaughter Canyon Cave confirms that the latter is a valid species and not a large Pleistocene form of the extant *T. brasiliensis*.

Vespertilionidae: Three species of vespertilionid bats, *Eptesicus fuscus* (big brown bat) and two unidentified species of *Myotis*, a small species and a medium-sized species, are known from Slaughter Canyon Cave based on a small sample of mandibles, humeri, and other limb bones (Morgan and Harris, 2015; Morgan, in prep.).

Carnivora

Canidae: Internal park reports document an unidentified specimen of *Canis* from Slaughter Canyon Cave. We tentatively identify two species of *Canis* from Slaughter Canyon Cave based on several partial limb bones, including a radius, ulna, and femur. Full details on these specimens and their identification will be provided in Morgan (in prep.).

A partial radius and partial ulna of a medium-sized carnivore were collected in Slaughter Canyon Cave by K. A. Richey and received by the NPS on September 1, 1945. The label associated with these two limbs says "possibly puma," which may be the basis for park reports of *Puma concolor* from Slaughter Canyon Cave (Unpubl. NPS Report, 2019). The radius and ulna are very similar in size and morphology to those elements in *Canis latrans* (coyote), are similar to but smaller than the radius and ulna of *C. lupus* (gray wolf), and are much smaller than the extinct †*C. dirus* (dire wolf). We tentatively refer these specimens to *C. latrans* pending the recovery of more diagnostic cranial material. *C. latrans* is widely distributed in North American Irvingtonian faunas that are similar in age to Slaughter Canyon Cave (Tedford et al., 2009).

The distal half of a femur from the "New Cave [= Slaughter Canyon Cave] guano deposits" is identified on the CAVE catalog card as "Dog bones of some kind, *Canis* sp. Intermediate in size between coyote and gray wolf." The femur is larger than the femur of *C. latrans* and agrees closely in size with the femur of *C. lupus baileyi* (Mexican wolf). Lacking more diagnostic cranial or dental material, we hesitate to identify the canid femur to the species level. Moreover, North American fossil records of *C. lupus* are primarily late Rancholabrean (Tedford et al., 2009), whereas radioisotopic dates indicate the Slaughter Canyon Cave fauna is Irvingtonian in age. The typical wolf-sized canid from Irvingtonian faunas is the extinct species †*C. armbrusteri*, originally described from the late Irvingtonian Cumberland Cave in Maryland and also known from several other Irvingtonian faunas that are similar in age to Slaughter Canyon Cave (Tedford et al., 2009).

A maxillary fragment with teeth of a small fox was collected from Slaughter Canyon Cave (Morgan and Lucas, 2006). Morgan and Harris (2015) identify that specimen as either *Vulpes velox* (swift fox) or *Vulpes macrotis* (kit fox), and Morgan (in prep.) refers this specimen to *Vulpes* cf. *macrotis*. Both species occur in the CAVE area today (Findley et al., 1975). A metacarpal and medial phalanx of a small canid also probably belong to *V.* cf. *macrotis*.

Mephitidae. A complete femur of a small carnivore from Slaughter Canyon Cave is identified as the spotted skunk *Spilogale* sp. (Morgan, in prep.).

Procyonidae: Internal park reports document the presence of *Bassariscus astutus* remains, possibly fossilized, from Slaughter Canyon Cave (Unpubl. NPS Reports, 2019).

Artiodactyla

Tayassuidae. A proximal phalanx from Slaughter Canyon Cave is referred to †*Platygonus* sp., an extinct genus of peccary (Morgan, in prep.). The common peccary in Rancholabrean faunas in western North America is †*P. compressus*, whereas a larger species referred to †*P. vetus* occurs in Irvingtonian faunas. A single toe is inadequate for a species identification.

Camelidae: CAVE 2164 is the distal end of a metapodial of the large extinct camel †*Camelops hesternus* (Fig. 5). This specimen was found by guano miners and turned over to NPS employees in 1957. It has not been published on previously.

Cervidae: Kurtén (1975) listed Slaughter Canyon Cave as a locality from which †*Navahoceros fricki* was reported. This was likely based on two skeletons collected from the cave for the University of Nebraska State Museum (UNSM) by Harry Tourtelot in 1938 (Morgan and Lucas, 2006). A mounted skeleton of †*N. fricki* from Slaughter Canyon Cave, on display at the UNSM in Lincoln, Nebraska, is the most complete specimen known of this extinct deer.

Antilocapridae: †*Capromeryx furcifer* (diminutive pronghorn) is recorded from Slaughter Canyon Cave based on a several isolated teeth, a distal radius-ulna, distal tibia, and several foot bones that represent a very small ruminant (Morgan, 2002; White and Morgan, 2011). A vertebra initially thought to represent an ursid (Morgan, 2002) was later tentatively identified as †*Stockoceros* cf. *conklingi* (Stock's pronghorn), together with an astragalus (Morgan and Harris, 2015; Morgan, in prep.).

Bovidae. A mandible of the bighorn sheep *Ovis canadensis*, collected in Slaughter Canyon Cave by Harry Tourtelot in 1938, is in UNSM collection (Morgan, in prep.). This species was also identified from Muskox Cave (Logan, 1981). Bighorn sheep were eradicated from the Guadalupe Mountains within the past century (Findley et al., 1975).

C-04

Aves

Cathartidae: Cave surveyors documented a *Cathartes aura* (turkey vulture) skeleton from the cave. The age of this specimen is unknown, but it retains feathers and naturally mummified skin. Natural mummification can occur shortly after death, so this specimen may be recent in age or much older.



FIGURE 4. Assorted †*Tadarida constantinei* bones (dark objects) deposited within guano at Slaughter Canyon Cave. The guano within this cave contains hundreds of thousands of bat bones. Boxes on scale bar are 1 cm square (NPS Photo).

Mammalia

Two localities in the cave have mammalian fossils of unknown identity.

Chiroptera

Cave surveyors report numerous bat bones and skeletons inside C-04. These remains have not been identified or dated.

C-05 - Lechuguilla Cave

Lechuguilla Cave is the eighth longest cave in the world and the sixth deepest cave in the United States. Except for a small surficial entryway, the entirety of the explored area of the cave was discovered and mapped within the last three and half decades. Only CAVE staff and approved researchers are allowed inside. The cave is difficult to traverse, requiring many steep vertical drops to access and being full of tight spaces. The entrance to the bulk of Lechuguilla Cave was uncovered in 1986, with most vertebrate paleontological finds and study taking place in the following decade and a half. Discovery of vertebrate remains was usually incidental to cave exploration.

While a fantastic location for Permian paleontology, the cave has not produced as large a sample of Quaternary fossils (Kottkamp et al., 2020). A bear, originally identified as *Ursus arctos* (brown or grizzly bear) and here reidentified as *U. americanus*, was collected from the cave's entrance room in 1960. Bones of *Puma concolor*, a *Bassariscus astutus* encased in flowstone, and a juvenile †*Nothrotheriops shastensis* skeleton were all discovered by surveying parties in the 1990s (Jablonsky, unpubl. report to NPS, 2004). The *Puma*, *Ursus*, and †*Nothrotheriops* specimens were collected, while the *Bassariscus* was left *in situ*. Patricia Jablonsky, of the Denver Museum of Nature and Science, identified and analyzed the chiropteran component of Lechuguilla Cave's fossil assemblage during the 1990s (Jablonsky, unpubl. reports to NPS, 1996, 2004). Exploration of and research within Lechuguilla Cave continues to this day, but no significant vertebrate remains have been found in the last two decades. This is likely because the deep interior of the cave is inaccessible to most animals; most



FIGURE 5. †*Camelops hesternus* distal metapodial from Slaughter Canyon Cave in the CAVE museum collections. †*Camelops hesternus* was not previously known from Slaughter Canyon Cave; this is one of several fossils housed in CAVE's museum collections that have not been documented in publications (NPS Photo).

non-bat remains in Lechuguilla Cave were found relatively close to the entrance.

Mammalia

Pilosa

†Nothrotheriidae: A partial associated skeleton of a very young juvenile †*Nothrotheriops shastensis* (Shasta ground sloth) was collected from Lechuguilla Cave (Santucci et al., 2001; Graham, 2007; McDonald and Jefferson, 2008; McDonald and Morgan, 2011). The specimen is curated in the CAVE paleontology collection (CAVE 8201) and is currently under study by Greg McDonald and Patricia Jablonsky.

Chiroptera

Vespertilionidae: The remains of a diverse set of bat species can be found in Lechuguilla Cave, including: *Myotis cilliolabrum* (western small-footed bat); *Myotis velifer* (cave myotis); *Myotis volans* (long-legged myotis); *Myotis yumanensis* (Yuma myotis); *Eptesicus fuscus* (big brown bat); *Lasiurus* (= *Aeorestes*) *cinereus* (hoary bat); and *Corynorhinus townsendii* (Townsend's big-eared bat). The primary survey of bat species was accomplished by Patricia Jablonsky during several projects in the 1990s and early 2000s (Jablonsky, unpubl. report to NPS, 1996). Jablonsky (unpubl. report to NPS, 2004) summarized that all chiropteran bones tested dated to the Holocene, and further hypothesized that none of the bat remains from Lechuguilla Cave actually date to the Pleistocene. The fossil chiropteran fauna from Lechuguilla Cave is similar to the species of fossil bats identified from Carlsbad Cavern (Baker, 1963).

Carnivora

Felidae: Bones of *Puma concolor* were collected from Lechuguilla Cave and are currently housed in the CAVE museum collections (Jablonsky, unpubl. report to NPS, 2004).

Ursidae: A specimen in the CAVE museum collection (CAVE 2481) from Lechuguilla Cave is accompanied by a label that reads "Metacarpal bone probably of grizzly bear, *Ursus horribilis*, received 3/10/60 from park staff." This fossil was almost certainly found near the entrance to Lechuguilla Cave because it was collected in 1960, long before the discovery of the vast extent of this cave in the 1980s. The grizzly bear has since been merged with the Holarctic brown bear under the species name *Ursus arctos*. This specimen is reported in Jablonsky (unpubl. report to NPS, 2004).

We compared CAVE 2481 to specimens, measurements, and illustrations of metapodials of the two common ursids in New Mexico Pleistocene cave deposits, the living black bear *Ursus americanus* and the extinct giant short-faced bear †*Arctodus simus* (Kurtén, 1966, 1967; specimens in MSB). CAVE 2481 is here identified as the left metacarpal 3 of *U. americanus* based on the length, relatively symmetrical overall shape, and the morphology of the proximal articulation that is rather elongated anteroposteriorly, broader anteriorly, and narrower posteriorly. Measurements (in mm) of the metacarpal 3 of *U. americanus* from Lechuguilla Cave (CAVE 2481) are: total length, 78; proximal width, 18; proximal depth, 24; distal width, 16. These measurements are similar to measurements of the metacarpal 3 in *U. americanus* (e.g., MSB 61219, 85637) and are considerably smaller than the metacarpal 3 of *Arctodus simus* with a total length ranging from 104 to 117 mm (Kurtén, 1967). The original identification of CAVE 2481 as *U. horribilis* (= *U. arctos*) is rejected based on its smaller size compared to the larger *U. arctos*, as well as the absence of published records of *U. arctos* from Pleistocene cave deposits in New Mexico (Morgan and Harris, 2015).

Procyonidae: A *Bassariscus astutus* skeleton encased in flowstone was found by Lechuguilla surveyors and CAVE staff in the 1990s (Jablonsky, unpubl. report to NPS, 2004). The specimen was left *in situ*.

C-07

Mammalia

Artiodactyla

Cave surveyors report unidentified caprine or cervid bones from this cave. This cave is known for having a large number of domestic goat bones, which may account for at least some of these unidentified specimens (Unpubl. NPS Report, 2019).

C-08

Mammalia

Chiroptera

Fossilized bones, and associated guano, of unidentified bat species are found in this cave. These deposits occur apart from those associated with modern bat habitation sites (Unpubl. NPS Report, 2019).

C-09

Mammalia

Rodentia

Erethizontidae: Cave surveyors reported several skulls of *Erethizon dorsatum* from C-9.

Artiodactyla

Antilocapridae: Cave surveyors reported *Antilocapra americana* (extant pronghorn) fossils from this cave. Most identifications of *A. americana* from Pleistocene cave deposits in New Mexico are in error. They are actually the medium-sized pronghorn †*Stockoceros* or some other type of ruminant (Morgan and Harris, 2015). Alternatively, given that no radiocarbon dates are available for these remains, they may be of Holocene age *A. americana*.

C-10

Mammalia

Stan Allison (CAVE physical science technician), Paula Provencio (Sandia National Laboratories), and Victor Polyak (Senior Research Scientist, University of New Mexico) found a significant deposit of large mammal bones in a dry pool basin while investigating C-10 (Unpubl. report to NPS, 2000). They did not identify any of the taxa during their survey, but speculated that the fossils were likely of Pleistocene age, given their condition. Other pits in the cave are suspected to be bear dens based on depth and shape, also hypothesized by Stan Alison to be of Pleistocene age.

Rodentia

Rodent bones belonging to undetermined taxa were found in C-10 at several locations by Stan Alison, including the dry pool discussed above (Unpubl. report to NPS, 2000).

Chiroptera

Bat bones belonging to undetermined taxa are found in C-10, separate from the dry pool basin discussed above (Unpubl. report to NPS, 2000).

C-11

Mammalia

Artiodactyla

A partial proximal scapula belonging to a small ruminant artiodactyl is the only fossil recorded and collected from this cave by park staff. The age of the specimen is unknown. The scapula is housed in the park museum collections as CAVE 2383 (Unpubl. NPS Report, 2019).

C-12

Mammalia

This cave contains a number of unidentified small mammal bones and a large mammal sternum fragment (Unpubl. NPS Report, 2019).

Artiodactyla

Surveyors reported finding the head of a tibia from an unidentified artiodactyl (Unpubl. NPS Report, 2019).

C-13

Mammalia

Rodentia

Stan Allison documented several localities that contain unidentified small mammal bones, including skulls (Unpubl. NPS Report, 2002).

C-15

Mammalia

Artiodactyla

Bovidae: The skull and horns of *Ovis canadensis* (bighorn sheep) were collected by park staff (Unpubl. NPS Report, 2019).

C-20

Mammalia

Artiodactyla

Cervidae: Dale Pate, CAVE Cave Specialist, reported bones of *Odocoileus hemionus* (mule deer). The age of the specimens is unknown (Unpubl. NPS Report, 1999).

Bovidae: Pate also reported *Ovis canadensis* bones. The age of the specimens is unknown.

C-22

Mammalia

Unidentified large and small mammal bones, encrusted with calcite growth, are known from two localities here (Unpubl. NPS Report, 2019).

Chiroptera

Cave surveyors reported several unidentified bat skulls deposited in guano. The age of the skulls is unknown (Unpubl. NPS Report, 2019).

C-24

Mammalia

Stan Allison reported three unidentified mammal bones encrusted by calcite (Unpubl. NPS Report, 2004). Two were found in the same room and the third in a separate room. An earlier biological survey reported finding three mammal bones, which were assumed to be canid. It is unclear if these two reports are the same three bones or different specimens. All material is of unknown age.

Chiroptera

Chiropteran bones have been reported from the cave.

C-25

Mammalia

Artiodactyla

Subfamily Caprinae: Dale Pate, CAVE Cave Specialist, identified the skull, vertebrae, and leg bones of a medium-sized mammal as belonging to Caprinae (Unpubl. NPS Report, 1999). The age of the bones is unknown. Historical evidence of goat shepherding in the vicinity of this cave indicates a strong probability that they are recent remains of *Capra aegagrus hircus* (domestic goat).

C-28

Aves

Remains of unidentified birds were documented by the surveyors.

Mammalia

Surveyors found several unidentified medium- to large-sized animal bones in a single locality.

Chiroptera

This cave contains unidentified bat bones of unknown age deposited in associated bat guano.

Artiodactyla

Cervidae: An *Odocoileus* skull was recovered from this cave and accessioned into park museum collections. It is not recorded if this was from the same locality as the other large bones.

C-29

Mammalia

Chiroptera

Cave surveyors reported finding bat bones in C-29. Age and species of these remains are unknown.

Carnivora

A large, disarticulated carnivoran skeleton with a partial skull was found and photographed by CAVE physical science technicians Stan Allison and Shawn Thomas (Unpubl. NPS Report, 2008), who speculated that it was a canid (Fig. 6). The specimen was left *in situ*. Based on braincase shape, the atlas,

and overall size, the specimen is most likely that of *Canis latrans* (GSM, personal observation, 2020).

C-30

Mammalia

Artiodactyla

Cervidae: This cave contains several unidentified cervid skeletons of unknown age.

C-32

All specimens collected from C-32 by Lloyd Logan and Charlie Peterson (Unpubl. report to NPS, 1974) are kept in collections at Texas Tech University. The specimens were accidentally catalogued using a Guadalupe Mountains National Park (GUMO) accession number. We were not able to access these specimens firsthand; all information comes from a faunal list and survey report written in 1974 by Lloyd Logan, then a graduate student at Texas Tech University, and Charlie Peterson, Cave Specialist at CAVE.

Reptilia

Viperidae: Logan and Peterson collected a vertebra of *Crotalus* (rattlesnake) from this cave in 1974 (Unpubl. report to NPS, 1974).

Aves

Unidentified avian remains were collected by Logan and Peterson in 1974 (Unpubl. report to NPS, 1974).

Cathartidae: Lloyd Logan collected a humerus of †*Coragyps occidentalis* (Pleistocene black vulture) from this cave in 1974. While the rest of the assemblage suggests a Holocene age, this vulture indicates the presence of some Pleistocene material in C-32 (Unpubl. report to NPS, 1974).

Mammalia

Rodentia

Sciuridae: Logan and Peterson recovered unspecified bones of both *Neotamias* (chipmunk) and *Otospermophilus variegatus* (rock squirrel) (Unpubl. report to NPS, 1974). Teeth of *O. variegatus* were also collected at that time. Later cave surveyors found a nearly complete skeleton of *O. variegatus* (identification by primary author based on photographs). It is unknown if this specimen was found in the same location from which Logan and Peterson collected.

Geomyidae: Logan and Peterson collected specimens of *Cratogeomys castanops* (yellow-faced pocket gopher) and *Thomomys bottae* (Botta's pocket gopher) (Unpubl. report to NPS, 1974). Both species still live in the vicinity of CAVE.

Cricetidae: Logan and Peterson collected specimens of *Neotoma mexicana* (Mexican woodrat), *Peromyscus* sp. (deer mouse), and *Sigmodon hispidus* (cotton rat) (Unpubl. report to NPS, 1974).

Erethizontidae: Logan and Peterson collected one or more specimens of *Erethizon dorsatum* (North American porcupine) (Unpubl. report to NPS, 1974). Additionally, a femur, a scapula, and a pelvic fragment in the CAVE museum collections may have been collected from C-32 (Unpubl. NPS Report, 1958).

Carnivora

Canidae: Unspecified *Canis latrans* remains were collected from C-32 by Logan and Peterson (Unpubl. report to NPS, 1974).

Procyonidae: Unspecified *Bassariscus astutus* fossils were collected from C-32 by Logan and Peterson (Unpubl. report to NPS, 1974).

Artiodactyla

Cervidae: Unspecified remains of *Odocoileus hemionus* are included on a faunal list from 1974 by Logan and Peterson (Unpubl. report to NPS, 1974).

Antilocapridae: Logan and Peterson collected *Antilocapra americana* (extant pronghorn) fossils from this cave in 1974. As previously mentioned, most identifications of *A. americana* from Pleistocene cave deposits in New Mexico are in error (see discussion in Morgan and Harris, 2015). The faunal list from C-32 indicates that much of the material in the cave was thought to be of Holocene age based on: the fossil assemblage containing taxa typical of the Holocene; a relatively thin sediment layer; and modern plant remains mixed into the sediment. This makes the presence of *A. americana* more probable (Unpubl. report to NPS, 1974).

C-33 - Muskox Cave

Muskox Cave has a small entrance that opens into a larger room, with the cave floor some 35 m below the surface (Logan, 1981). The main Pleistocene entrance was a sinkhole approximately 20 m wide that functioned as a natural trap but is now mostly filled with breakdown. Vertebrate fossils were first discovered in Muskox Cave in 1954, and a small sample was collected in 1969 (Santucci et al., 2001). A joint expedition of the Smithsonian Institution, Texas Tech University, and the National Park Service, including Ron Kerbo and Lloyd Logan, made extensive collections from Muskox Cave in 1976 and 1977, now housed at the U. S. National Museum of Natural History (USNM). Smaller collections from Muskox Cave are housed at CAVE and the Texas Memorial Museum (TMM) at the University of Texas, Austin.

Logan (1981) identified 50 species of mammals from Muskox Cave, almost half of which are either extinct, including 11 members of the Pleistocene megafauna, or are extralimital species no longer found in the Guadalupe Mountains. We provide updated identifications for several of these species based on more recent taxonomic studies (e.g., Jass et al., 2000; White and Morgan, 2011) and an examination of the Muskox Cave collection in the USNM by one of us (GSM, personal observation, 2012). The Muskox Cave sample also includes unidentified bones of snakes and birds. Radiocarbon dates on bone collagen from Muskox Cave (species dated unknown) range from 18,140 to 25,500 yrBP, which places this fauna during and just prior to the maximum extent of the late Wisconsin glaciation or Last Glacial Maximum (Logan, 1981).

Reptilia

Serpentes: Morgan (personal observation, 2012) identified snake vertebrae among the Muskox Cave assemblage housed in the USNM collection.

Aves

Morgan (personal observation, 2012) noted a large sample of unidentified bird fossils among the materials from Muskox Cave housed in the USNM collection.

Cathartidae: Santucci et al. (2001) and Graham (2007) refer to an "extinct Pleistocene vulture" found in Muskox Cave. No such specimen is mentioned in Logan (unpubl. report to NPS, 1979; 1981) nor in reviews of New Mexico Pleistocene vertebrate paleontology (Morgan and Lucas 2006; Morgan and Harris 2015). Neither Santucci et al. (2001) nor Graham (2007) cite the original reference for this vulture, and park records accessed by the primary author did not reference the specimen. The primary author did not have access to all types of cave records, and it is possible the original reference for this specimen is an internal memo or letter that was not kept with the Resource Science and Stewardship (RSS) office's file for Muskox Cave.

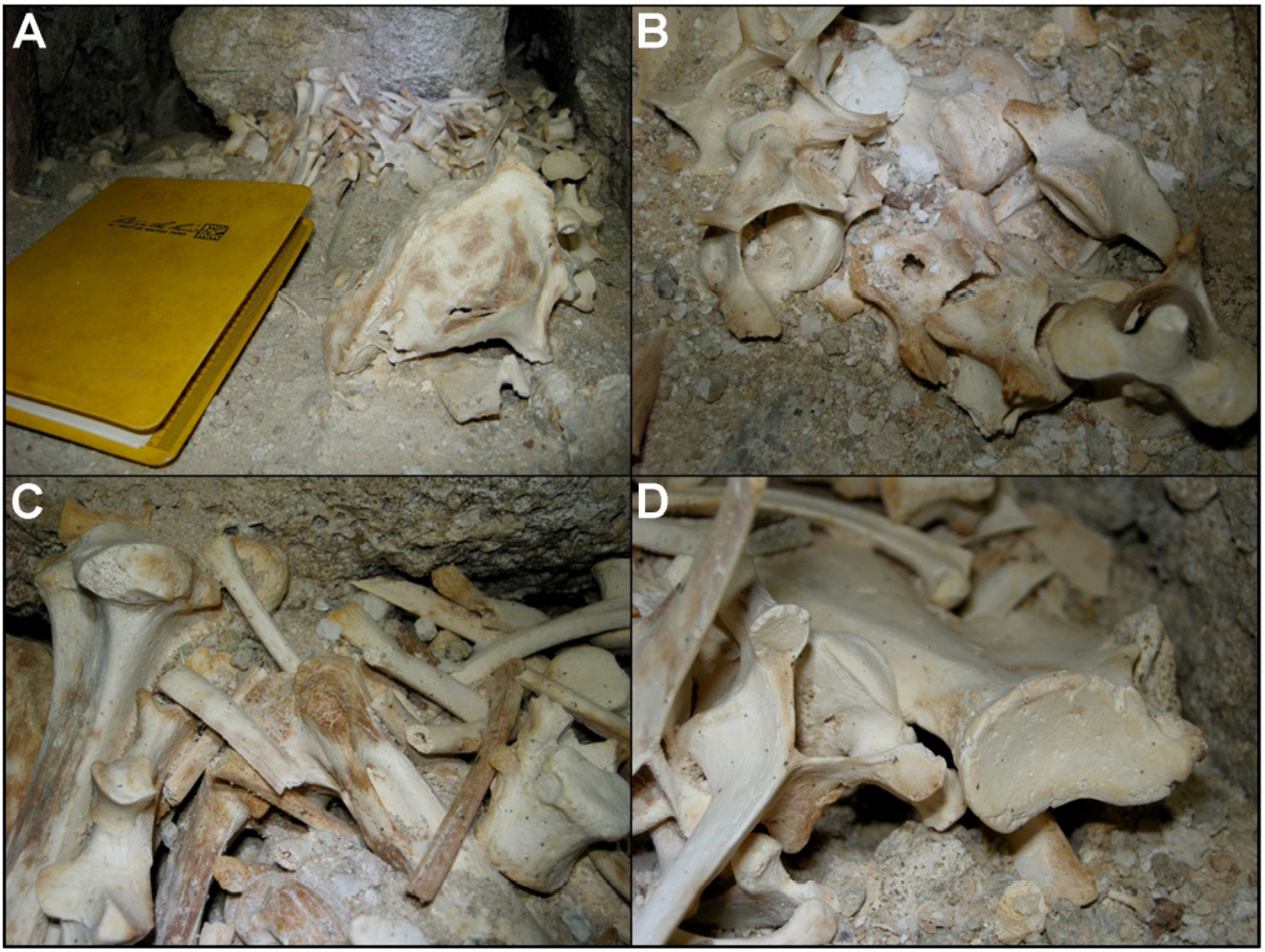


FIGURE 6. A series of photos of a disarticulated carnivoran skeleton in C-29. This specimen was tentatively identified as *Canis latrans* (NPS Photo).

Mammalia

Rodentia

Sciuridae: Four species of the squirrel family were documented from Muskox Cave by Logan (unpubl. report to NPS, 1979; 1981), including: *Marmota flaviventris* (yellow-bellied marmot); *Neotamias* sp. (chipmunk); *Spermophilus variegatus* (= *Otospermophilus variegatus*; Helgen et al., 2009); and *Tamiasciurus hudsonicus* (American red squirrel).

Heteromyidae: *Perognathus merriami* (Merriam's pocket mouse) was reported from Muskox Cave by Logan (1981).

Geomyidae: *Thomomys* cf. *bottae* was reported from Muskox Cave by Logan (1981).

Cricetidae: Logan (unpubl. report to NPS, 1979) reported finding 11 species from this rodent family in Muskox Cave. These species are: *Microtus mogollonensis* (Mogollon vole) (Morgan and Harris, 2015; as *M. mexicanus* in Logan, 1981); *Microtus pennsylvanicus* (meadow vole); *Microtus ochrogaster* (prairie vole); *Neotoma leucodon* (= *N. albigula*, in part) (white-toothed woodrat); *Neotoma cinerea* (bushy-tailed woodrat); *Neotoma mexicana*; *Neotoma micropus* (southern plains woodrat); *Neotoma* sp.; *Ondatra zibethicus* (muskrat); *Onychomys leucogaster* (northern grasshopper house); *Onychomys arenicola* (= *O. torridus*) (southern grasshopper mouse); *Peromyscus* sp. (deer mouse); and Cricetidae cf. *Reithrodontomys fulvescens* (fulvous harvest mouse). *M. pennsylvanicus*, *N. cinerea*, and *O. zibethicus* are especially important as paleoecological indicators (see discussion below under Paleoecological Implications).

Erethizontidae: *Erethizon dorsatum* was reported from Muskox Cave by Logan (1981).

Lagomorpha

Leporidae: Logan (unpubl. report to NPS, 1979; 1981) reported *Sylvilagus* cf. *S. floridanus* (eastern cottontail) from Muskox Cave as well as *Sylvilagus* cf. *S. nuttallii* (mountain cottontail). The latter is also mentioned in Harris (1993), and is a mountain-dwelling rabbit no longer found in southern New Mexico.

Soricomorpha (= Insectivora, in part)

Soricidae: Logan (unpubl. report to NPS, 1979; Logan, 1981) reported a diverse fauna of seven species of shrews from Muskox Cave, several of them important paleoecological indicators. The taxa he reported include: *Cryptotis parva* (least shrew); *Notiosorex crawfordi* (= †*Notiosorex dalquesti*; Dalquest's shrew according to Carraway, 2010); *Sorex cinereus* (masked shrew); *Sorex merriami* (Merriam's shrew); *Sorex monticolus* (montane shrew; as *S. vagrans* in Logan, 1979); *Sorex neomexicanus* (New Mexico shrew) (Morgan and Harris, 2015); and *Sorex palustris* (water shrew).

Chiroptera

Molossidae: *Tadarida* (free-tailed bat) is reported from Muskox Cave (Logan, 1981; Morgan and Harris, 2015).

Vespertilionidae: Logan (unpubl. report to NPS, 1979; Logan, 1981) reported several taxa of bats from Muskox Cave, including: *Antrozous pallidus* (pallid bat); *Corynorhinus townsendi* (Townsend's big-eared bat); *Eptesicus fuscus* (big brown bat); *Myotis thysanodes* (fringed myotis); and *Myotis velifer* (cave myotis).

Carnivora

Felidae: Four felids are known from Muskox Cave, including: *Lynx rufus* (bobcat) (Logan, unpubl. report to NPS, 1979; Logan, 1981); †*Miracinonyx trumani* (American cheetah-like cat), represented by a radius and three associated metatarsals (Adams, 1979; Logan, 1981; GSM personal observation, 2012); †*Panthera atrox* represented by a P4 and a metapodial (Logan, 1981; GSM personal observation, 2012); and *Puma concolor* (Logan, 1981).

Canidae: †*Canis dirus* specimens were collected from Muskox Cave and reported in Logan (1981), including two nearly complete skulls and numerous postcranial elements. The species is the most abundant large carnivore in the assemblage (Logan, unpubl. report to NPS, 1979; Morgan, personal observation, 2012). Logan (unpubl. report to NPS, 1979) also reported other, unidentifiable, specimens of *Canis* from the cave. These specimens may be additional †*C. dirus* with an absence of diagnostic features, or they may be a smaller canid such as *Canis latrans*.

Mustelidae: Logan (unpubl. report to NPS, 1979; 1981) reported collecting *Mustela frenata* (long-tailed weasel) from Muskox Cave.

Mephitidae: Logan (unpubl. report to NPS, 1979; 1981) reported two skunk taxa from Muskox Cave, *Conepatus* (hognose skunk) and *Spilogale gracilis* (western spotted skunk).

Procyonidae: *Bassariscus astutus* was collected and reported from the cave by Logan (1981).

Perissodactyla

Equidae: Logan (unpubl. report to NPS, 1979) reported collecting †*Equus conversidens* (extinct Mexican horse) from Muskox Cave, in addition to unidentified specimens of another *Equus* species. After observing the Muskox Cave material housed in the Smithsonian, the unidentified species is probably the larger †*Equus occidentalis* (western horse) (GSM, personal observation, 2012).

Artiodactyla

Camelidae: Logan (Logan, unpubl. report to NPS, 1979; Logan, 1981) reported having collected a specimen of Camelidae cf. †*Camelops hesternus* (yesterday's camel) from Muskox Cave. However, Morgan (personal observation, 2012) did not find *Camelops* among the material Logan collected from Muskox Cave housed at in the USNM collection (Lesser et al., 2012). The presence of this species in Muskox Cave requires further examination of the fossil sample.

Antilocapridae: †*Stockoceros conklingi* (Conkling's pronghorn) is known from Muskox Cave, having been excavated during the 1976 excavation (Logan, unpubl. report to NPS, 1979; Logan, 1981). †*Capromeryx furcifer* (diminutive pronghorn) is also present (White and Morgan, 2011). The CAVE museum collection has a pronghorn specimen from Muskox Cave identified as *Antilocapra americana* (extant pronghorn), and Logan (1981) also identified cf. *Antilocapra americana* from Muskox Cave in addition to *Stockoceros*. However, given that Muskox Cave is primarily a Pleistocene deposit, this identification is likely in error (Morgan, personal observation, 2019). This specimen probably pertains to *S. conklingi*, which overlaps in size with small individuals of *A. americana*.

Bovidae: †*Euceratherium collinum* (shrub ox) is the most abundant large vertebrate in the fossil assemblage of Muskox Cave (Fig. 7; Fig. 8). The cave's name comes from an initial misidentification of this taxon. A large sample, including a skull and mandibles, was collected in 1976 (Fig. 7) and is now housed at the US National Museum of Natural History, Smithsonian Institution (Fig. 8; Logan, unpubl. report to NPS, 1979; Logan, 1981; Morgan and Harris, 2015). Additional specimens are curated in the Texas Memorial Museum collection (Rickard Toomey, personal commun. 2020) and the CAVE paleontology collection. Other bovids found in the cave include †*Oreamnos harringtoni* (Harrington's extinct mountain goat) (Jass et al., 2000) and *Ovis canadensis* (bighorn sheep) (Logan, unpubl. report to NPS, 1979; Logan, 1981).

C-34

Mammalia

Rodentia

This cave contains an unidentified rodent skull and bones, found by cave surveyors (Unpubl. NPS Report, 2019). The remains are of unknown age.

Sciuridae: The same survey also found an *Otospermophilus variegatus* skeleton. The skeleton is of unknown age.

C-49

Mammalia

Rodentia

CAVE Assistant Cave Specialist David Ek reported a large assemblage of rodent bones from this cave, including several nearly complete skeletons conspicuously missing their skulls (Unpubl. NPS Report, 1990). The presence of these fossils was corroborated by a later survey conducted by CAVE Physical Science Technicians Erin Lynch and Aria Maldice (Unpubl. NPS Report, 2018). The age and species identification of these specimens are unknown.

C-54

Mammalia

Artiodactyla

Cervidae: CAVE Physical Science Technicians Erin Lynch, David Brumbough, and Aria Maldice documented an articulated skeleton of unknown age. The group tentatively identified the specimen as a juvenile *Odocoileus hemionus* (Unpubl. NPS Report, 2017).

C-56

Mammalia

Rodentia

Erethizontidae: Charlie Peterson, CAVE Cave Specialist, reported that this cave contains *Erethizon dorsatum* bones and quills of unknown age (Unpubl. NPS Report, 1972).

C-60

Cave investigation reports mention a "fairly fossilized" rib of unidentified class and age.

C-62

A cave investigation report mentions "possible Pleistocene vertebrate remains" without further detail (Unpubl. NPS Report, 1990). Other cave investigation reports and cave survey reports include the following specimens, without an estimate of age.



FIGURE 7. A †*Euceratherium* skull (center left) as it was found in Muskox Cave, with other bones covered with mineralization (NPS Photo/RON KERBO).

Mammalia

Rodentia

Small rodent bones, a mouse jaw among them, were reported in the most recent visits the cave by park staff and surveyors (Unpubl. NPS Report, 2019).

Erethizontidae: Older records, circa 1977, report the presence of *Erethizon dorsatum* bones inside the cave (Unpubl. NPS Report, 1977). However, surveys from the 1990s onward failed to find these specimens, and photographs referred to in the 1977 report could not be located (Unpubl. NPS Reports, 1990, 2019).

C-64

Mammalia

This natural trap cave contains an assemblage of unidentified small mammal bones, in addition to remains of two identified taxa, below.

Carnivora

Canidae: A cave survey undertaken prior to 1970 reported bones of *Vulpes* (fox).

Rodentia

Erethizontidae: The aforementioned survey also documented unspecified and undated bones of *Erethizon dorsatum*

C-77

Mammalia

An unspecified number of unidentified mammal bones were reported from this cave by Stan Allison and Paul Burger, NPS hydrologist (Unpubl. NPS Report, 2004).

Carnivora

Felidae: C-77 contains a *Puma concolor* jaw of unknown age, which was reported by Stan Allison in the same survey report as the other bones.

C-86

Stan Allison and volunteer surveyor L.P. Lawrence reported many unidentified bones of small animals from deposits in the cave, in addition to the specimens discussed below (Unpubl. NPS Report, 1998).

Mammalia

Rodentia

Cave surveyors reported finding an unidentified rodent incisor in C-86.

Carnivora

Procyonidae: C-86 contains a *Bassariscus astutus* skeleton. At one time this skeleton was complete and articulated, but a flooding event transported it deeper into the cave, disarticulated it, and scattered several bones.

Artiodactyla

An unidentified ruminant vertebra was documented by Stan Allison.

C-87

Mammalia

Carnivora

Procyonidae: Erin Lynch, CAVE physical science technician, and Jake Tholin, Geoscientist-in-the-Parks intern, found and photographed the bones and skull of a procyonid in C-87 (Unpubl. NPS Report, 2018). The specimen was tentatively identified by the surveyors as either *Bassariscus astutus* or *Procyon lotor* (raccoon).

C-90

Photographs of this cave depict a high abundance of bone strewn over the floor (Fig. 9). The age of the remains is uncertain. No written report or cave survey detailing these bones could be found, but the photographs are attributed to Stan Allison and David Kohuth, volunteer surveyor. The bones range in size from small to large, and most are mammalian. Rod Horrocks (personal observation, 2020) hypothesizes that this locality was a carnivoran den, and that most of the bones are likely from prey animals. The presence of carnivore scat, or claw marks on the bones, could confirm this.

C-92

Mammalia

Stan Allison and Gosia Allison-Kosior, volunteer surveyor, reported that this cave contains a limb bone of a large unidentified mammal (Unpubl. NPS Report, 2002).

C-93

Mammalia

Rodentia

A rodent skeleton with some skin remaining has been reported from this cave by surveyors. It may be mummified. The specimen is of unknown age. It was tentatively identified as *Neotoma* by Stan Allison (Unpubl. NPS Report, 2002).

C-94

Surveyors observed the unidentified bones of a "ringtail-sized animal" in this cave (Unpubl. NPS Report, 2019).

PALEOECOLOGICAL IMPLICATIONS

Vertebrate remains found in CAVE have provided substantial evidence for significant climate change in the region since the Pleistocene (Logan, unpubl. report to NPS, 1979; Logan, 1981; Harris, 1985, 1997). Murray (1957) hypothesized that the Guadalupe Mountains, including CAVE, underwent a series of climatic and ecological shifts towards progressively more arid and less woody conditions over the Quaternary. This caused floras and faunas to move latitudinally and altitudinally in response (Metcalf, 1977; Logan, unpubl. report to NPS, 1979). At the time, the primary evidence was a series of successional faunal assemblages preserved in Burnet Cave and other caves (Schultz and Howard, 1935). Murray (1957) specifically referred to *Marmota flaviventris* (yellow-bellied marmot) as a species indicating an advance of xeric environments to the north and up-altitude, across New Mexico upon the retreat of the last glaciation. Today in New Mexico, *Marmota flaviventris* is restricted to higher elevations (above ~2,400 m) on mountains in the northern part of the state. Several other boreal indicator species from Guadalupe Mountains caves are also referred to in Murray (1957), such as *Lepus townsendii* (white-tailed jackrabbit) and *Microtus longicaudus* (long-tailed vole), but these taxa have never been found inside the boundaries of CAVE.

Murray's (1957) hypothesis was later supported by Pleistocene cave assemblages at CAVE and GUMO. These assemblages contain extinct or extant taxa adapted for boreal or woodland habitats, and no longer live in the Guadalupe Mountains or Chihuahuan desert (Baker, 1963; Metcalf, 1977; Logan, unpubl. report to NPS, 1979; Logan, 1981; Morgan and Lucas, 2006). Vertebrate examples include: †*Oreamnos harringtoni*, which likely lived in the alpine zone above the timberline (Jass et al., 2000); *Ondatra zibethicus* and *Sorex palustris*, which are semi-aquatic (Logan, unpubl. report to NPS, 1979); *Microtus pennsylvanicus* and *Sylvilagus floridanus* (eastern cottontail), which require or greatly prefer mesic environments (Logan, unpubl. report to NPS, 1979); the montane *Sorex neomexicanus*, *Marmota flaviventris*, *Sylvilagus nuttallii* (mountain cottontail), and *Neotoma cinerea* (Logan, unpubl. report to NPS, 1979; G. Morgan, personal observation, 2019); *Lasiurus blossevillii*, *Lasiurus* (=*Aeorestes*) *cinereus* (Baker, 1963; Jablonsky, unpubl. report to NPS, 1996; Morgan and Lucas, 2006), and *Tamiasciurus hudsonicus* (Logan, unpubl. report to NPS, 1979), which need trees and forested regions; *Gopherus morafkai*, which cannot withstand prolonged periods below freezing (Morgan and Harris, 2015); and †*Euceratherium collinum*, which is hypothesized to have preferred a cooler and more mesic climate than the modern Guadalupe Mountains (Logan, unpubl. report to NPS, 1979; Morgan and Lucas, 2006). Open grasslands, mountain meadows, or wide forest glades must have been present given the presence of highly specialized cursorial animals such as the pronghorns †*Capromeryx furcifer* and †*Stockoceros conklingi* and the extinct American cheetah-like cat †*Miracinonyx trumani* (Logan, unpubl. report to NPS, 1979; Van Valkenburgh et al., 1990; Martin, 1998). These taxa become rarer or disappear in the latest Pleistocene and early Holocene cave sediments (Logan and Peterson, unpubl. report to NPS, 1974; Logan, unpubl. report to NPS, 1979), and xeric-adapted or tolerant taxa such as *Cratogeomys castanops* (Logan and Peterson, unpubl. report to NPS, 1974; Lyman, 1983), *Notiosorex* (Logan, unpubl. report to NPS, 1979; Carraway, 2010), and plants such as *Opuntia* (prickly pear cactus) become more common until the assemblage wholly resembles the recent fauna (Logan, 1981).

Examples of Pleistocene invertebrates from the area around CAVE, mostly land snails, include: *Vallonia perspectiva*, *Gastrocopta contracta*, *Pupilla blandii*, *Fossaria modicella*, and *Stagnicola cockerelli* (Metcalf, 1977). The latter two are aquatic, and the former three prefer more pluvial conditions than exist today where their fossils have been recovered (Metcalf, 1977). Furthermore, in Dry Cave (outside of CAVE, but nearby in the same limestone), early Holocene sediments cease to include *Pupilla blandii*. *Gastrocopta* and *Vallonia* become rarer, and fossils of xeric-adapted gastropods native to the area today, *Succinea grosvenori* and *Hawaiia minuscula*, dominate the assemblage. This contrasts with Pleistocene sediments in the same cave that are dominated by the pluvial and aquatic taxa previously mentioned, indicating an onset of more arid conditions in the Holocene (Metcalf, 1977).

In general, evidence suggests that during the Pleistocene the area around CAVE was wetter and more grassy or forested than at present, depending on ecologic zone (Logan, unpubl. report to NPS, 1979). The boreal to steppe-woodland environments that would have dominated the area at that time are now found farther northward and/or at higher elevations (Harris, 1985). The Chihuahuan Desert at large retains some juniper woodlands and other savanna or woodland type environments at higher elevations. Most of it, and all of CAVE lands, have transitioned to various desert environmental zones (mostly scrubland), though micro-climate regions created by canyons are also common (Harris, 1985). When the habitat of a given taxon ceased to be found in the northern Chihuahuan Desert, that taxon was either extirpated (if it migrated to northern refugia) or went extinct (if it was trapped in shrinking montane refugia). It is difficult to differentiate "northern" from "montane" taxa, and it is possible that no real distinction exists. Such taxa likely had connected populations in the Pleistocene that became separated as changing climate isolated some relict populations on mountain refugia (Murray, 1957; Metcalf, 1977; Logan, unpubl. report to NPS, 1979). Fossils corresponding to different types of extirpated environments may indicate the assemblages are time-averaged over the drying trend or that there were adjacent and coexisting environments. Both are probably true, given the nature of the depositional environments and visible gradation of environment by altitude and latitude in the modern time. Furthermore, the Pleistocene itself had alternating pluvial and inter-pluvial periods, and any significantly time-averaged assemblage will likely contain specimens from multiple types of environment even if consisting exclusively of Pleistocene material (Harris, 1985). The ecological changes brought on by this aridification trend have important implications for modern ecology and biologic resource management, as they may help predict the migration, extirpation, or extinction of species dependent on specific environments and levels of precipitation (Dietl et al., 2015).

CONCLUSIONS

Fossils are a non-renewable resource that provide the only reliable basis for understanding evolution and ecosystems on a geological timescale, making them critically important for public education and scientific research. The 2019 CAVE paleontological resource inventory (Kottkamp et al., 2020) provides the park's first compiled document on all its known fossils. This includes many finds previously known only from internal park reports or other unpublished documents, reported publicly for the first time. The information in this article represents only the segment of the inventory covering Pleistocene vertebrates. It especially highlights the scientific significance of the paleoecological implications of the park's Pleistocene and Holocene paleontological resources. The inventory provides the park with a foundation of data essential for developing paleontological research and resource management policies best suited to protecting, preserving, and interpreting its significant fossil record (Santucci and Koch, 2003).

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APPENDIX

TABLE 1. List of Pleistocene and Holocene vertebrates from Carlsbad Caverns National Park (CAVE). The orders and families of mammals follow Wilson and Reeder (2005). Within mammalian families, the genera and species are listed in alphabetical order. Extinct species are indicated by a dagger (†) following the name; extralimital species are indicated by an asterisk (*). Species with both went extinct sometime after being extirpated from the vicinity of CAVE. A question mark (?) indicates an occurrence whose identification is uncertain or viewed with skepticism by the authors."

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
AMPHIBIA					
Anura					
Unidentified toad/frog	Toad/Frog	Unknown	Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
REPTILIA					
Testudines					
Xerobates (= *Gopherus*) cf. *morafkai* (= *G. agassizii*, in part) *	Sonoran Desert Tortoise	Testudinidae	Morgan and Lucas (2006)	Desert sand hills to rocky foothills, anywhere that provides soft enough soil to burrow into or provides natural shelters.	C2
Lacertilia					
Phrynosoma sp.	Horned Lizard	Phrynosomatidae	Black (1953); Morgan and Lucas (2006)	Arid to semi-arid.	C1; C2
Unidentified Lizard #1	Lizard	Unknown	Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Unidentified Lizard #2	Lizard	Unknown	Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Serpentes					
Serpentes	Snake	Unknown	Morgan and Lucas (2006); Morgan (pers. obs. 2012)	Highly adaptable in terms of habitat.	C2; C33
Crotalus sp.	Rattlesnake	Viperidae	Unpubl. NPS report (1974)	Highly adaptable in terms of habitat.	C32
AVES					
Cathartidae, unspecified genus (†)	Extinct Vulture	Cathartidae	Santucci et al. (2001); Graham (2007)	Highly adaptable in terms of habitat.	C33
Cathartes aura	Turkey Vulture	Cathartidae	Unpubl. NPS report (2019)	Highly adaptable in terms of habitat.	C4
Coragyps occidentalis (†)	Pleistocene Black Vulture	Cathartidae	Logan (pers. commun. 2020)	Highly adaptable in terms of habitat.	C32?
Unidentified	Large sample (~100 bones) of small unidentified bird fossils	Unknown	Morgan (pers. obs. 2012)	Highly adaptable in terms of habitat.	C33
Unidentified	Unidentified Birds	Unknown	Morgan (in prep.); Unpubl. NPS reports (1974, 2019)	Highly adaptable in terms of habitat.	C2 (two species); C28; C32
Unidentified Raptor	Bird of Prey (Uncertain what type)	Unknown	Morgan and Lucas (2006)	Highly adaptable in terms of habitat.	C2

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
MAMMALIA					
Xenarthra					
Nothrotheriops shastensis (†)	Shasta Ground Sloth	Nothrotheriidae (†)	Hill and Gillette (1987a) for CC; Jablonsky (unpubl. NPS report, 2004) for Lechuguilla; McDonald and Jefferson (2008) and McDonald and Morgan (2011) for both	Open savanna/scrubland.	C1; C5
Rodentia					
*Marmota flaviventris**	Yellow-Bellied Marmot	Sciuridae	Murray (1957); Logan (unpubl. NPS report, 1979); Harris (1993); Morgan and Lucas (2006)	Meadows in high woodlands; evidence of more mesic conditions than present.	C33
Neotamias sp.	Chipmunk	Sciuridae	Logan (unpubl. NPS report, 1979); Morgan (pers. obs., December 2019)	Highly adaptable in terms of habitat.	C32; C33
Otospermophilus variegatus	Rock Squirrel	Sciuridae	Logan (unpubl. NPS report, 1979); Unpubl. NPS report (1974); Helgen et al. (2009)	Prefers environs similar to modern, from arid scrublands to rocky foothills.	C32; C33; C34; A13
*Tamiasciurus hudsonicus**	Red Squirrel	Sciuridae	Logan (unpubl. NPS report, 1979)	Mixed coniferous, spruce-fir forests, and associated montane regions. Presence indicates past spruce-fir forests in region.	C33
Perognathus merriami	Merriam Pocket Mouse	Heteromyidae	Logan (unpubl. NPS report, 1979)	Sandy/gravelly soiled arid regions with sparse vegetation, similar to modern.	C33
Perognathus/ Chaetodipus sp.	Pocket Mouse	Heteromyidae	Morgan and Lucas (2006); Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Cratogeomys castanops	Yellow-faced Pocket Gopher	Geomyidae	Lyman (1983); Unpubl. NPS report (1974)	Prefers shortgrass prairie.	C32
Thomomys bottae	Botta's Pocket Gopher	Geomyidae	Logan (1981); Unpubl. NPS report (1974)	Mountain valleys and meadows. Found in modern Guadalupes.	C32; C33; A13
Microtus mexicana	Mexican Vole	Cricetidae	Logan (unpubl. NPS report, 1979); Harris (1993); Morgan and Lucas (2006)	Montane grasslands in ponderosa and mixed forests. Only currently extant vole in the Guadalupe Mountains.	C33
*Microtus ochrogaster**	Prairie Vole	Cricetidae	Logan (unpubl. NPS report, 1979)	Xeric and prairie environs.	C33
*Microtus pennsylvanicus**	Meadow Vole	Cricetidae	Logan (unpubl. NPS report, 1979)	Restricted to hydrosere conditions no longer found in the vicinity of CAVE.	C33
Neotoma albigula	White-Throated Woodrat	Cricetidae	Logan (unpubl. NPS report, 1979)	Rocky desert brushland.	C33

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
*Neotoma cinerea**	Bushy-tailed Woodrat	Cricetidae	Logan (unpubl. NPS report, 1979); Harris (1993); Morgan and Lucas (2006)	Highly adaptable in terms of habitat.	C33
Neotoma mexicana	Mexican Woodrat	Cricetidae	Logan (unpubl. NPS report, 1979); Unpubl. NPS report (1974)	Higher elevations in the Guadalupes today, especially like canyons.	C32; C33
Neotoma micropus	Southern Plains Woodrat	Cricetidae	Logan (unpubl. NPS report, 1979)	Desert shrublands.	C33
Neotoma sp.	Woodrat	Cricetidae	Logan (unpubl. NPS report, 1979); Morgan and Lucas (2006)	Highly adaptable in terms of habitat.	C2; C33; C93
Ondatra zibethicus	Muskrat	Cricetidae	Logan (unpubl. NPS report, 1979)	Near fluvial and lucustrine systems. Semi-aquatic and needs permanent water.	C33
Onychomys leucogaster	Northern Grasshopper Mouse	Cricetidae	Logan (unpubl. NPS report, 1979)	Sandy grasslands and mesquite stands. Does not indicate change from present.	C33
Onychomys torridus	Southern Grasshopper Mouse	Cricetidae	Logan (unpubl. NPS report, 1979)	Prefers clay soil and desert pavements in low elevations. Doesn't indicate climate change.	C33
Peromyscus sp.	Deer Mouse	Cricetidae	Logan (unpubl. NPS report, 1979); Unpubl. NPS report (1974)	Highly adaptable in terms of habitat.	C32; C33
Reithrodontomys fulvescens	Fulvous Harvest Mouse	Cricetidae	Logan (unpubl. NPS report, 1979)	Grasslands interspersed with shrubs. Does not indicate climatic change, though it is not present in the region today.	C33
Sigmodon hispidus	Hispid Cotton Rat	Cricetidae	Unpubl. NPS report (1974)	Highly adaptable in terms of habitat.	C32
Erethizon dorsatum	Common Porcupine	Erethizontidae	Logan (unpubl. NPS report, 1979); Unpubl. NPS reports (1974, 2019)	Highly adaptable in terms of habitat.	C2; C9; C32; C33; C56; C64; A13
Lagomorpha					
Lepus sp.	Jackrabbit	Leporidae	Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Sylvilagus audubonii	Desert Cottontail	Leporidae	Morgan and Lucas (2006)	Desert scrubland.	C2
Sylvilagus floridanus	Eastern Cottontail	Leporidae	Logan (unpubl. NPS report, 1979)	Either boreal habitats in the mountains (where it exists in NM today) or in riparian environs.	C33
*Sylvilagus nuttalli**	Nuttall's Cottontail	Leporidae	Logan (unpubl. NPS report, 1979); Harris (1993); Morgan and Lucas (2006)	Sagebrush to timber.	C33
Sylvilagus sp.	Cottontail	Leporidae	Unpubl. NPS report (2019); Morgan (in prep.)	Highly adaptable in terms of habitat.	C2; A13

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
Eulipotyphla	–	–	–	–	–
*Cryptotis parva**	Least Shrew	Soricidae	Logan (unpubl. NPS report, 1979)	Grassland steppe, uncommonly found in woodlands.	C33
Notiosorex crawfordi	Crawford's Gray Desert Shrew	Soricidae	Logan (unpubl. NPS report, 1979); Carraway (2010) as †*C. dalquesti*	Commonly found in desert scrubland, but adaptable.	C33
Notiosorex dalquesti (†)	Dalquest's Shrew	Soricidae	Carraway (2010); Harris (1993)	Commonly found in desert scrubland, but adaptable.	C33
*Sorex cinereus**	Masked Shrew	Soricidae	Logan (unpubl. NPS report, 1979)	Prefers to be near water, but adaptable.	C33
*Sorex merriami**	Merriam's Shrew	Soricidae	Logan (unpubl. NPS report, 1979)	Dry woodlands and sagebrush.	C33
*Sorex monticolus**	Montane Shrew	Soricidae	Logan (unpubl. NPS report, 1979) as *S. vagrans*	In montane and hydrosere communities.	C33
Sorex neomexicanus	New Mexico Shrew	Soricidae	Logan (unpubl. NPS report, 1979); Morgan (pers. obs., 2019)	Montane communities in SE New Mexico.	C33
*Sorex palustris**	Water Shrew	Soricidae	Logan (unpubl. NPS report, 1979)	Semi-aquatic, requires permanent water.	C33
Chiroptera					
Unidentified Chiroptera	Bat	Unknown	Unpubl. NPS report (2019)	Highly adaptable in terms of habitat	C4; C8; C10; C22; C28; C29
Tadarida brasiliensis mexicana	Mexican Free Tailed Bat	Molossidae	Baker (1963); Morgan (in prep.)	Colonial, cave rooster. Highly adaptable.	C1; C2
Tadarida constantinei (†)	Constantine's Free Tailed Bat	Molossidae	Lawrence (1960); Baker (1963); Polyak et al. (2006)	Colonial, cave rooster.	C1; C2
Antrozous pallidus	Pallid Bat	Vespertilionidae	Logan (unpubl. NPS report, 1979)	Highly adaptable in terms of habitat.	C33
Corynorhinus townsendi	Townsend's Big Eared Bat	Vespertilionidae	Jablonsky (unpubl. NPS reports, 1991, 1996); Morgan and Lucas (2006)	Cave-roosting bat; otherwise widespread in terms of habitat	C1; C5; C33
Eptesicus fuscus	Big Brown Bat	Vespertilionidae	Baker (1963); Jablonsky (unpubl. NPS reports, 1991, 1996); Logan (1979); Morgan (in prep.)	Highly adaptable in terms of habitat.	C1; C2; C5; C33
Eptesicus fuscus grandis	Big Brown Bat, Pleistocene subspecies	Vespertilionidae	Baker (1963); Jablonsky (unpubl. NPS report, 1991); Logan (1979)	Highly adaptable in terms of habitat.	C1; C33
Lasiurus blossevillii	Western Red Bat	Vespertilionidae	Morgan and Lucas (2006); (Morgan pers. obs., December 2019)	Tree-roosting bat	C1
Aeorestes cinereus	Hoary bat	Vespertilionidae	Baker (1963); Jablonsky (unpubl. NPS report, 1996)	Tree-roosting bat	C1; C5

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
Myotis ciliolabrum	Western small-footed bat	Vespertilionidae	Jablonsky (unpubl. NPS reports, 1991, 1996)	Common in arid environments, but may extend into juniper or pine forests at high elevation	C1; C5
Myotis thysanodes	Fringed Myotis	Vespertilionidae	Logan (unpubl. NPS report, 1979)	Desert grassland to yellow pine zone.	C33
Myotis velifer	Cave Myotis	Vespertilionidae	Jablonsky (unpubl. NPS reports, 1991, 1996); Logan (1979)	Cave-roosting bat; otherwise widespread in terms of habitat	C1; C5; C33
Myotis volans	Long-Legged Myotis	Vespertilionidae	Jablonsky (unpubl. NPS reports, 1991, 1996)	Highly adaptable in terms of habitat.	C1; C5
Myotis yumanensis	Yuma Myotis	Vespertilionidae	Jablonsky (unpubl. NPS reports, 1991, 1996)	Prefer proximity to water, but otherwise highly adaptable	C1; C5
Myotis sp.	Mouse-Eared Bats	Vespertilionidae	Baker (1963); Morgan and Lucas (2006); Morgan (in prep.)	Highly adaptable in terms of habitat.	C1; C2 (two species, one small-sized and one medium-sized)
Carnivora					
Lynx rufus	Bobcat	Felidae	Logan (unpubl. NPS report, 1979)	Highly adaptable in terms of habitat.	C33; S9?
Miracinonyx trumani (†)	American Cheetah	Felidae	Logan (unpubl. NPS report, 1979); Adams (1979); Martin (1998);	Open country; likely savannah, steppe, or other grasslands.	C33
Panthera atrox (†)	American Lion	Felidae	Logan (unpubl. NPS report, 1979); Pate (1999); Kottkamp et al. (this report)	Found in varied assemblages.	C1; C33
Puma concolor	Cougar	Felidae	Logan (unpubl. NPS report, 1979); Santucci et al. (2001)	Highly adaptable in terms of habitat.	C1; C5; C33; C77; S9?
Canis armbrusteri (†)	Armbruster's Wolf	Canidae	Kottkamp et al. (this report); Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Canis dirus (†)	Dire Wolf	Canidae	Logan (unpubl. NPS report, 1979)	Highly adaptable in terms of habitat.	C33
Canis latrans	Coyote	Canidae	Unpubl. NPS report (1974); Morgan (in prep.)	Highly adaptable in terms of habitat.	C2; C29?; C32
Canis sp.	Wolf/Dog	Canidae	Logan (unpubl. NPS report, 1979); Unpubl. NPS report (2019)	Highly adaptable in terms of habitat.	C2; C33
Vulpes cf. *macrotis*	Kit Fox	Canidae	Morgan and Lucas (2006); Morgan and Harris (2015); Morgan (in prep.)	Deserts and other regions of high aridity.	C2
Vulpes sp.	Fox	Canidae	Unpubl. NPS report (2019)	Highly adaptable in terms of habitat. Most extant fox species in the region are adapted to xeric environments.	C64

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
Ursus americanus	Black Bear	Ursidae	Unpubl. NPS report (2019)	Highly adaptable in terms of habitat.	C5
Mustela frenata	Long-Tailed Weasel	Mustelidae	Logan (unpubl. NPS report, 1979)	Highly adaptable in terms of habitat.	C33
Spilogale gracilis	Western Spotted Skunk	Mephitidae	Logan (unpubl. NPS report, 1979)	Desert, brushland, and grassland. Can be found in sparse woodlands.	C33
Spilogale sp.	Spotted Skunk	Mephitidae	Morgan (in prep.)	Desert, brushland, and grassland. Can be found in sparse woodlands.	C2
Bassariscus astutus	Ringtail	Procyonidae	Logan (unpubl. NPS report, 1979); Morgan and Lucas (2006); unpubl. NPS report (2019)	Rocky habitats and deserts, though it has been found in other environs as well	C2?; C5; C10; C32; C33; C86; C87?
Procyon lotor?	Raccoon	Procyonidae	Unpubl. NPS report (2019)	Highly adaptable in terms of habitat.	C87?
Perissodactyla					
Equus conversidens (†)	Mexican Horse	Equidae	Morgan and Lucas (2006); Morgan (pers. obs. 2012); Harris (1993)	Preferred open country, but adaptable to other environs and many climates.	C33
Equus occidentalis (†)*	Western Horse	Equidae	Morgan and Lucas (2006); Morgan (pers. obs., December 2019)	Preferred open country, but adaptable to other environs and many climates.	Morgan's Smithsonian Inventory indicates the unidentified *Equus* in Logan (1979) may be this species
Equus sp.	Horse	Equidae	Logan (unpubl. NPS report, 1979)	Prefers open country, but adaptable to other environs and many climates.	C33; A13
Artiodactyla					
Platygonus sp. (†)	Extinct Peccary	Tayassuidae	Morgan (in prep.)	Highly adaptable in terms of habitat.	C2
Camelops hesternus (†)	Yesterday's Camel	Camelidae	Logan (unpubl. NPS report, 1979); Harris (1993); Morgan (in prep.)	Not a good climate indicator.	C2; C33
Navahoceros fricki (†)	Frick's Mountain Deer	Cervidae	Morgan and Lucas (2006); Harris (1993)	Historically considered to be adapted to montane environments, but some studies disagree.	C2
Odocoileus hemionus	Mule Deer	Cervidae	Unpubl. NPS report (1974)	Highly adaptable in terms of habitat.	C20; C32; C54
Antilocapra americana?	Extant Pronghorn	Antilocapridae	Logan (unpubl. NPS report, 1979); (unpubl. NPS report, 2019)	Open country; likely plains.	C9; C32; C33

Taxon	Common Name	Family	Reference	Habitat	Cave or Site
Capromeryx furcifer (†)	Diminutive Pronghorn	Antilocapridae	Morgan and Lucas (2006); White and Morgan (2011); Morgan (pers. obs., December 2019) for C33	Open country; plains and savanna.	C2; C33
Stockoceros conklingi (†)	Conkling's Pronghorn	Antilocapridae	Logan (unpubl. NPS report, 1979); Morgan and Harris (2015)	Open country; likely foothills.	C2; C33
Bison sp.	Bison	Bovidae	Morgan and Lucas (2006); (unpubl. NPS report, 2019)	Open country.	S1
Euceratherium collinum (†)	Shrub Ox	Bovidae	Logan (unpubl. NPS report, 1979); Morgan and Lucas (2006)	Open country; likely foothils, and likely preferred cooler/more mesic conditions than the modern Guadalupes.	C33
Oreamnos harringtoni (†)	Harrington's Extinct Mountain Goat	Bovidae	Jass et al. (2000)	Alpine Zone, above timberline.	C33
*Ovis canadensis**	Bighorn Sheep	Bovidae	Logan (unpubl. NPS report, 1979); (unpubl. NPS report 2019); Morgan (in prep.)	Variety of mountain habitats, no change suggested from present.	C2; C15; C20; C33