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Mammals of Carlsbad Caverns National Park, New Mexico

Kenneth N. Geluso

Keith Geluso

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Mammals of Carlsbad Caverns National Park, New Mexico

Kenneth N. Geluso
Keith Geluso



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University of Nebraska State Museum
Volume 17 · 2004

Cover: A Townsend's big-eared bat (*Corynorhinus townsendii*) drinking from a small pond.
Photograph by J. Scott Altenbach.

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University of Nebraska State Museum

Volume 17

Mammals of Carlsbad Caverns
National Park, New Mexico

by
Kenneth N. Geluso
and
Keith Geluso



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Outflight of Brazilian free-tailed bats (*Tadarida brasiliensis*) from Carlsbad Cavern.
Photograph by Ronal C. Kerbo.

To those who greatly influenced our careers as mammalogists:

(for KING — in order of the first time we met)

Troy L. Best, James S. Findley, Don E. Wilson, J. Scott Altenbach, and Cliff A. Lemen
and

(for KG — in alphabetical order)

Troy L. Best, Michael A. Bogan, James H. Brown, James S. Findley, and my father (KING)

We thank you for sharing your knowledge with us and for the friendship
and support you have given us through the years.

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University of Nebraska State Museum
Volume 17

Mammals of Carlsbad Caverns National Park,
New Mexico

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Abstract. Carlsbad Cavern was established as a national park on 14 May 1930, after being designated as a national monument for nearly seven years. The park is located in southeastern New Mexico, and today it encompasses 189.3 km² (73.1 mi²). Eighty-eight percent of the park lies in the rugged Guadalupe Mountains, while 12% is located on relatively flat land along the base of the mountains. The park contains a variety of habitats ranging from desert scrub at the lowest elevations to coniferous woodlands on the highest summits.

Five months after Carlsbad Cavern was declared a national monument, Vernon Bailey conducted a survey of animals in the cavern

and surrounding lands. The survey lasted from March to May 1924, and results were published in a monograph titled *Animal Life of the Carlsbad Cavern* (Bailey 1928). During his survey, Bailey documented 39 species of mammals within the present-day boundaries of Carlsbad Caverns National Park.

Approximately 50 years after Bailey's survey, we conducted surveys of mammals in the park (1973-2000), and results of our surveys are the basis for the present volume. Herein we also report and summarize information from Bailey's book, other scientific literature, museum specimens, field notes of previous investigators, park documents, and interviews with people associated with the park.

Since Bailey's survey in 1924, several species of mammals have been extirpated from the park, several species are now present due to introductions by humans, and many others have been confirmed in the park that were not detected by Bailey. In recent years (1949-2000), 63 species of mammals (excluding humans and their domestic animals) have been documented in the park—1 shrew, 15 bats, 2 lagomorphs, 27 rodents, 13 carnivores, and 5 ungulates. For 58 species, records exist from 1990 to 2000. The most recent records for the remaining five species are as follows: western spotted skunk (*Spilogale gracilis*) 1985, pronghorn (*Antilocapra americana*) 1965, pocketed free-tailed bat (*Nyctinomops femorosaccus*) 1956, big free-tailed bat (*Nyctinomops macrotis*) 1956, and house mouse (*Mus musculus*) 1949.

The present volume includes a descriptive narrative for each of the 63 contemporary species of mammals. We also provide accounts for five species that were extirpated during the past 150 years and for another 11 species with uncertain status. For contemporary species, accounts include detailed information on habitat, reproduction, and collection locali-

ties. A distribution map also is available for most species. In addition, we discuss changes in population size or shifts in distribution for the following 12 species: Brazilian free-tailed bat (*Tadarida brasiliensis*), black-tailed prairie dog (*Cynomys ludovicianus*), banner-tailed kangaroo rat (*Dipodomys spectabilis*), Merriam's kangaroo rat (*D. merriami*), white-footed mouse (*Peromyscus leucopus*), southern plains woodrat (*Neotoma micropus*), house mouse (*Mus musculus*), collared peccary (*Pecari tajacu*), elk (*Cervus canadensis*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), and aoudad (*Ammotragus lervia*).

Carlsbad Caverns National Park is one of the most ecologically diverse parks in the United States, and we hope that information in this volume will stimulate additional research on mammals and other organisms in the park. Understanding the distribution, abundance, and types of plants and animals on public lands is important because it provides necessary information for making sound management decisions and for designing accurate interpretive programs for education of the general public.

PREFACE

Our research on mammals at Carlsbad Caverns National Park began in May 1973. At that time one of us (KNG) began to investigate whether pesticides were affecting the population of Brazilian free-tailed bats living in Carlsbad Cavern. KNG conducted this research with Scott Altenbach of the University of New Mexico and Don Wilson of the National Museum of Natural History (Geluso *et al.* 1976, 1981). Eventually, KNG's investigations broadened to include other species of bats at the park and resulted in a nontechnical booklet designed primarily for visitors and employees of the park (Geluso *et al.* 1987). To date over 40,000 copies of *Bats of Carlsbad Caverns National Park* have been sold.

The coauthor (KG) became involved in mammalian studies at the park in August 1988, while he was a student at the University of New Mexico. That summer we intensified our study of bats and planned to publish a technical paper together.

Sometime in 1990, we examined a checklist of mammals published by the National Park Service (West 1985) and realized that little was known about rodents inhabiting the park. The checklist mentioned many species that probably occurred in the park but had not

been confirmed within its boundaries. Thus, we decided to expand our research to include rodents.

Because it would take several years to complete a rodent survey, we first thought of publishing a paper on bats and then a separate publication on rodents. However, our negative feelings about publishing things in bits and pieces prevailed, and we decided to put it all together in a single, comprehensive volume that included information on all mammals.

During our studies from 1973 to 2000, we captured over 700 rodents in the park and netted more than 800 bats, not including the thousands of free-tailed bats that we captured during outflights from Carlsbad Cavern. We recorded over 500 observations of larger mammals and took hundreds of photographs of wildlife and habitats. In addition, we examined all scientific literature involving mammalian studies in the park and personally examined all but 14 museum specimens collected at the park. The present volume incorporates all of this information.

— Ken Geluso and Keith Geluso
8 March 2004

UNIVERSITY OF
Nebraska
Omaha



The University of New Mexico

Animal Life of the Carlsbad Cavern

By VERNON BAILEY



*The story of animal life in America's newest
wonder — the great caverns of
Carlsbad, New Mexico*

Animal Life of the Carlsbad Cavern was published in 1928 by the American Society of Mammalogists.
The design of the book's jacket is shown above.

INTRODUCTION

On 25 October 1923, Carlsbad Cavern was proclaimed a national monument by President Calvin Coolidge, and on 14 May 1930, it obtained park status by a congressional act. Carlsbad Caverns National Park is located in southeastern New Mexico and encompasses 189.3 km² (73.1 mi²; Fig. 1). Most of the park lies in the rugged Guadalupe Mountains, which are remains of a fossil reef that formed along an inland sea millions of years ago. The remainder of the park is located along the base of the mountains; this relatively flat landscape was once part of a vast seabed.

Elevations in the park range from 1,095 m (3,595 ft) in desert-scrub habitats of the seabed to 1,990 m (6,535 ft) in coniferous woodlands on the highest summits of the reef. Rocky terrain of the reef and fine-grained and gravelly soils of the seabed support a wide variety of plants, many of which have affinities with the Chihuahuan Desert. Due to the diversity of habitats in the park, it also supports a rich mammalian fauna.

More than 70 years ago, Vernon Bailey wrote *Animal Life of the Carlsbad Cavern* (see opposite page). This book was the product of

a survey that he and members of the National Geographic Society conducted from March to May 1924. The book was published in 1928 and represents the first documentation of mammals in Carlsbad Caverns National Park. Specimens from Bailey's survey are currently housed in the United States National Museum of Natural History along with his field journal and catalog.

Since Bailey's book, the only other publications about mammals on a park-wide basis are annotated checklists compiled by the park's staff in the 1960s and by West (1985). Besides the book and checklists, we are aware of 35 scientific publications that report on mammals in the park. Citations of these publications are listed at the end of the present volume.

This volume incorporates all of our studies of mammals in the park from May 1973 to December 2000. In addition, the volume includes and summarizes information from Bailey's book and other scientific literature, museum specimens housed in various museums, field notes of previous investigators, park documents, and interviews with park employees and other persons associated with the park.

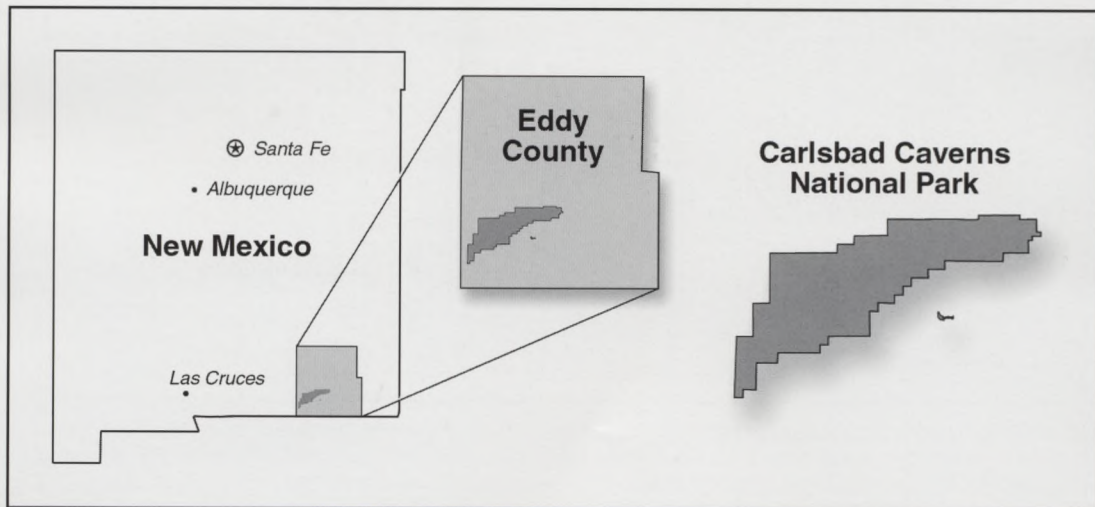


Fig. 1. Carlsbad Caverns National Park is located in southeastern New Mexico.

DESCRIPTION OF PARK

Boundaries of Carlsbad Caverns National Park surround an area of 189.3 km² or 73.1 mi² (Fig. 2). Most of the park lies in the Guadalupe Mountains, which form part of the northern boundary of the Chihuahuan Desert (Johnston 1979). These mountains, composed largely of limestone and dolomite, are remains of an ancient reef that formed along the edge of an inland sea >250 million years ago. Today a long and curved escarpment stands above the surrounding plains and clearly shows the edge of the fossil reef (Fig. 3). While most of the park lies on this reef, the remainder is located on relatively flat land along the base of the escarpment; this flat landscape

was once a seabed. Descriptions of how the Guadalupe Mountains were formed and of the region's geomorphology are summarized by King (1948), Hayes (1964), Hill (1987), and Jagnow and Jagnow (1992). Throughout this volume, we refer to the mountainous portion of the park as the reef and the low-lying lands along the base of the mountains as the seabed.

Reef. Eighty-eight percent of the park is situated on the reef (Fig. 2). The escarpment begins to rise above the seabed at the park's eastern end and gains elevation at a rate of 22.7 m/km until it reaches the western boundary. The seabed also rises from east to west

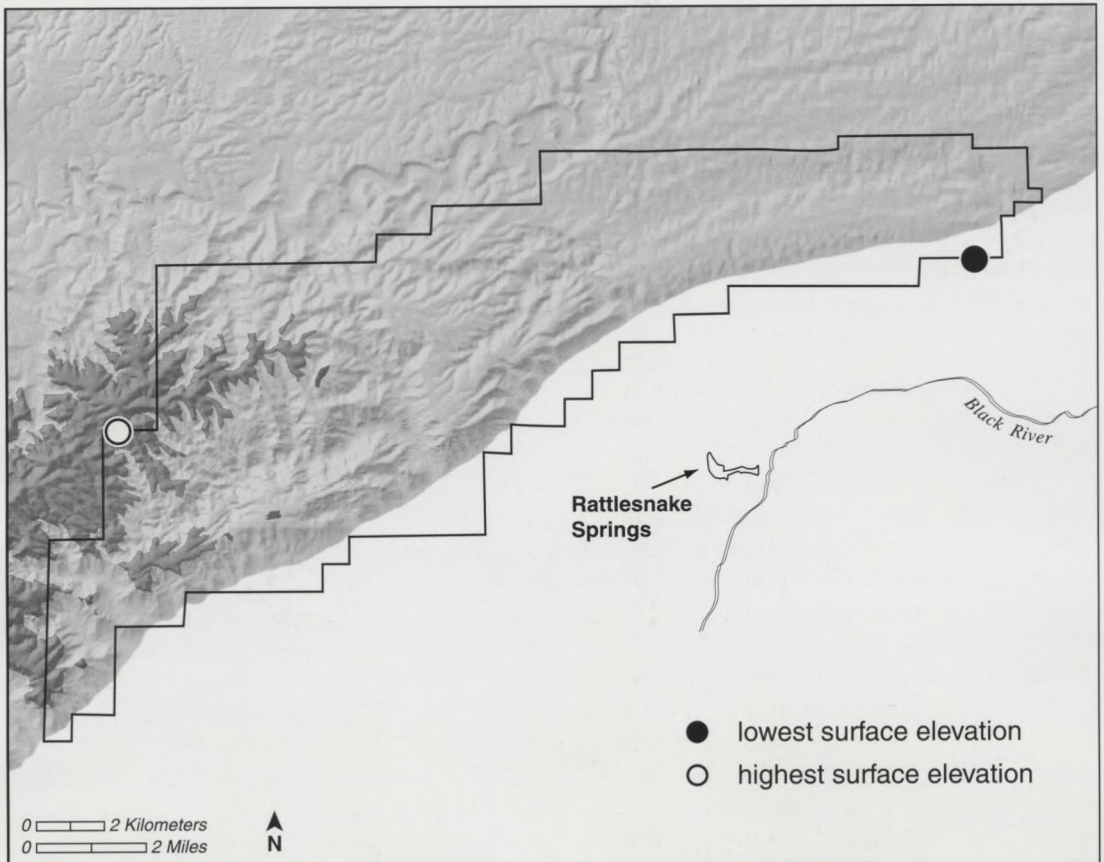


Fig. 2. Outline of Carlsbad Caverns National Park. Most of the park lies in the Guadalupe Mountains (shaded area). The remainder of the park is located in the lowlands (white area) and includes a narrow strip of land along the base of the mountains and a small detached parcel of land named Rattlesnake Springs. Dark shading represents areas $\geq 1,830$ m or $\geq 6,000$ ft based on a digital elevation model of the park. The closed circle represents the lowest surface elevation (1,095 m or 3,595 ft) in the park, and the open circle represents the highest surface elevation (1,990 m or 6,535 ft) in the park.



Fig. 3. The Guadalupe Mountains stand above the surrounding plains. The mountains are remains of a fossil reef that formed along an inland sea millions of years ago, and the flat landscape along its base was once an ancient seabed. Today the lower edge of the long and curved escarpment marks the junction between the fossil reef and old seabed. The arrow points to a large building on the reef—the Visitor Center (photograph by Jeep Harding).

but at a lower rate, 11.7 m/km. Therefore, the escarpment's face becomes taller as it approaches the western boundary, and here it stands 455 m (1,500 ft) above the lowlands. Along its entire length, the top edge of the escarpment rises only slightly and gradually as it extends into interior portions of the reef. The highest elevation in the park is 1,990 m (6,535 ft), which occurs near Putman Cabin (Figs. 2 and 4).

At intervals along the face of the escarpment, numerous gullies and ravines have been eroded by water; however, areas with excessive erosion have created wide and deep canyons that penetrate deep into the reef's interior. Some of these canyons include Walnut, Rattlesnake, Nuevo, Slaughter, Midnight, Yucca, Lefthook, Double, and South Double canyons (Fig. 5).

Seabed. Although most of the park lies on the reef, 12% (22.5 km² or 8.7 mi²) is located on the seabed. The largest portion is a strip of

land that lies along the base of the escarpment; it extends southwestward for 32.2 km and measures 2.0 km at its widest point (Fig. 2). At the eastern end of the seabed, the elevation is 1,095 m (3,595 ft) and represents the lowest surface elevation in the park. At the western end of the park, the seabed reaches 1,510 m (4,960 ft). The only other portion of the seabed in the park is a small detached parcel of land known as Rattlesnake Springs. This 0.32-km² (80 acres) parcel is near the Black River and ranges from 1,105 to 1,120 m (3,620–3,670 ft) in elevation (Fig. 2).

Climate. Climate of the region is characterized by limited amounts of precipitation, mild winters, and hot summers. Based on climatic data from 1973 to 2000, precipitation averages 417 mm (16.4 inches) per year in the park, with 65.1% falling from June to September (Appendix 1). During the rainy season, precipitation often is associated with thunderstorms, and most lightning-caused

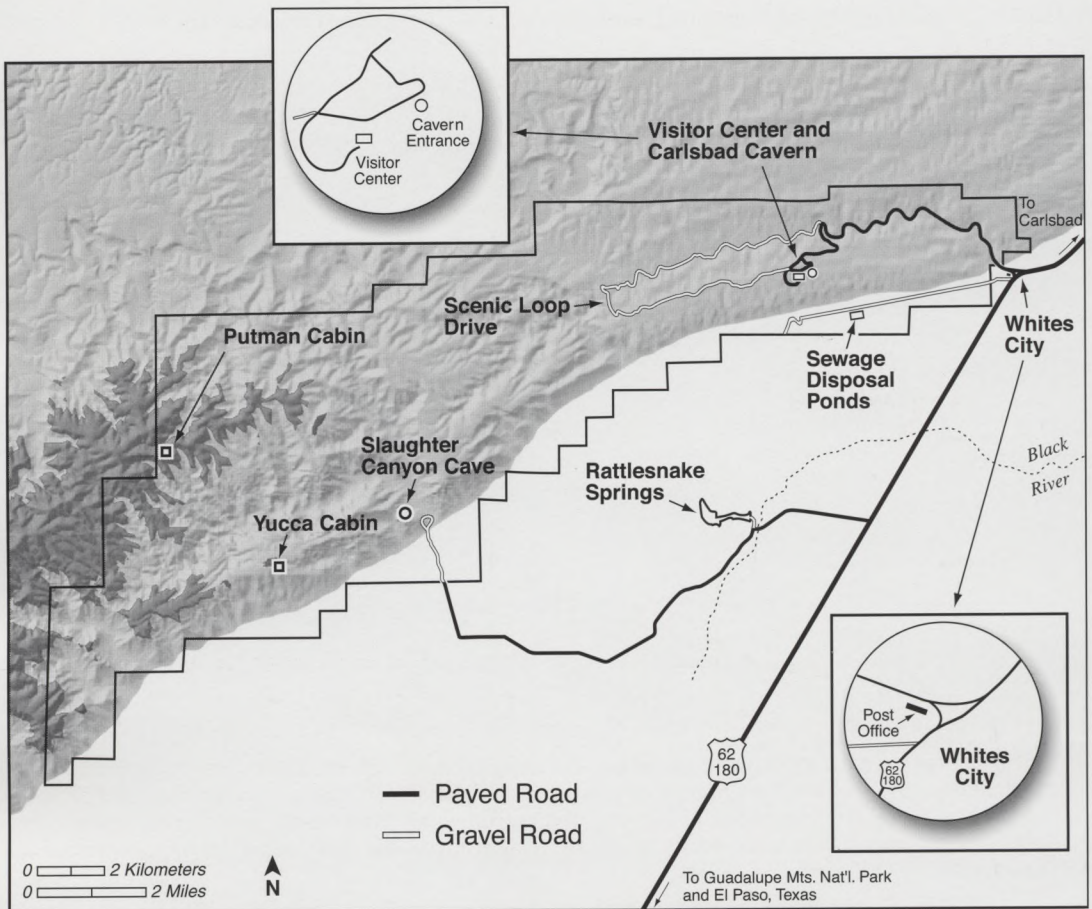


Fig. 4. Map of Carlsbad Caverns National Park showing roads and various places mentioned in the text.

fires in the park occur in late June and early July. During short periods of heavy rain, flooding is known to occur along canyon floors. For example, a 142 mm rainfall (5.6 inches) at the park on 26 September 1980, allowed park personnel to raft down Walnut Canyon (R. C. Kerbo, *pers. comm.*). In winter, snow occasionally falls, but it seldom remains on the ground for any length of time before melting. The park also is subject to periodic droughts; the most recent dry year was 1998 (Appendix 1). Based on mean high and low surface temperatures in the park, June, July, and August are the warmest months, while December and January are the coldest (Appendix 1).

Description of habitats. We divided the park into habitats based upon vegetation, substrate, topography, and elevation (Tables 1 and 2). Each habitat is described below. In each description, we state specific sites where

we set traps to capture shrews and rodents and where we used nets to capture bats. Habitats on the reef are described first and are followed by those on the seabed. Water holes occur in both regions of the park and are treated in a separate section. Lastly, we provide information about caves in the park.

To date the National Park Service does not have an accurate map showing major habitats or vegetational communities of the park. Therefore, in Figure 6, we have indicated the best places in the park to observe six of the major habitats listed in Tables 1 and 2. In descriptions of habitats, we list common plants that occur in each habitat. In general, the most conspicuous or numerous plants are listed first, with grasses listed separately from shrubs and trees. Grasses are listed in alphabetical order. Scientific names of plants mentioned in the text are given in Appendix 2.

TABLE 1. Habitats on reef at Carlsbad Caverns National Park.

-
- A. Face of escarpment
 - 1. Exposed slopes
 - 2. Gullies and ravines
 - B. Summits
 - 1. Juniper peneplain
 - 2. Grassy-oak areas
 - 3. Pine-juniper woodland
 - C. Canyonsides
 - 1. Exposed slopes
 - 2. Gullies and ravines
 - 3. Rock outcrops
 - 4. Cliffs
 - D. Canyon floors
 - 1. Desert-scrub areas
 - 2. Grassy areas
 - E. Water holes
 - F. Caves
-

TABLE 2. Habitats on seabed at Carlsbad Caverns National Park.

Along base of escarpment

-
- A. Desert scrubland
 - 1. Open areas
 - a. with lechuguilla
 - b. without lechuguilla
 - 2. Grassy areas
 - a. with tall shrubs
 - b. with short shrubs
 - B. Arid grassland
 - C. Juniper plain
 - D. Alluvial fans
 - E. Drainage areas
 - 1. Arroyos
 - 2. Wide draws
 - F. Water holes

At Rattlesnake Springs

-
- A. Woodlots
 - B. Dense grass
 - C. Weedy areas
 - D. Shrubby areas
 - 1. Cropped grass
 - 2. Exposed soil
 - 3. Desert scrub
 - 4. Mesquite
 - E. Water holes
-

Habitats on Reef

Face of escarpment. Numerous gullies and ravines cut into the face of the escarpment along its entire length; between these eroded areas, there are wide stretches of exposed slope. From a distance, slopes appear convex, and the curved sides form the gullies and ravines (Fig. 7). The substrate of these slopes, gullies, and ravines consists of numerous exposed rocks, including boulders and large flat slabs. Because these rocky habitats are subjected to the same general exposure (south or southeast), floristic differences are minimal along the entire face of the escarpment. Common plants include lechuguilla, sotol, ocotillo, prickly pear, catclaw, oreganillo, skeletonleaf goldeneye, and juniper; some areas also contain mariola, mescal bean, and oak. Among exposed rocks of the escarpment, grasses are sparse to moderately dense, and common species include mesa muhly, rough tridens, sideoats grama, and threeawn. On the escarpment, the densest and largest plants generally are associated with gullies and ravines. Additional plants in these protected areas include evergreen sumac, Mexican orange, Mexican buckeye, Texas madrone, mountain mahogany, cliff fendlerbush, littleleaf lead tree, and eggleaf silktassel. We set traps to capture rodents in gullies, in ravines, and on exposed slopes along the entire escarpment. Our lowest trapsites were at 1,145 m (3,760 ft) in elevation and the highest ones reached 1,620 m (5,320 ft).

Summits. Habitats on top of the reef (*i.e.*, summits) begin along the upper edge of the escarpment and continue to interior portions of the reef. The nearly flat areas of land on summits are interrupted by canyons, leaving a number of gently rounded hilltops, saddles, and irregular patches of relatively flat ground.

At elevations about 1,465 m (4,800 ft) and below, summits are dominated by scattered red berry junipers (Fig. 8), and throughout this volume we refer to these summits as the juniper peneplain. Although some junipers are >2 m in height, most are 0.9-1.2 m tall. Other common plants in this habitat include sotol, lechuguilla, prickly pear, cane cholla,

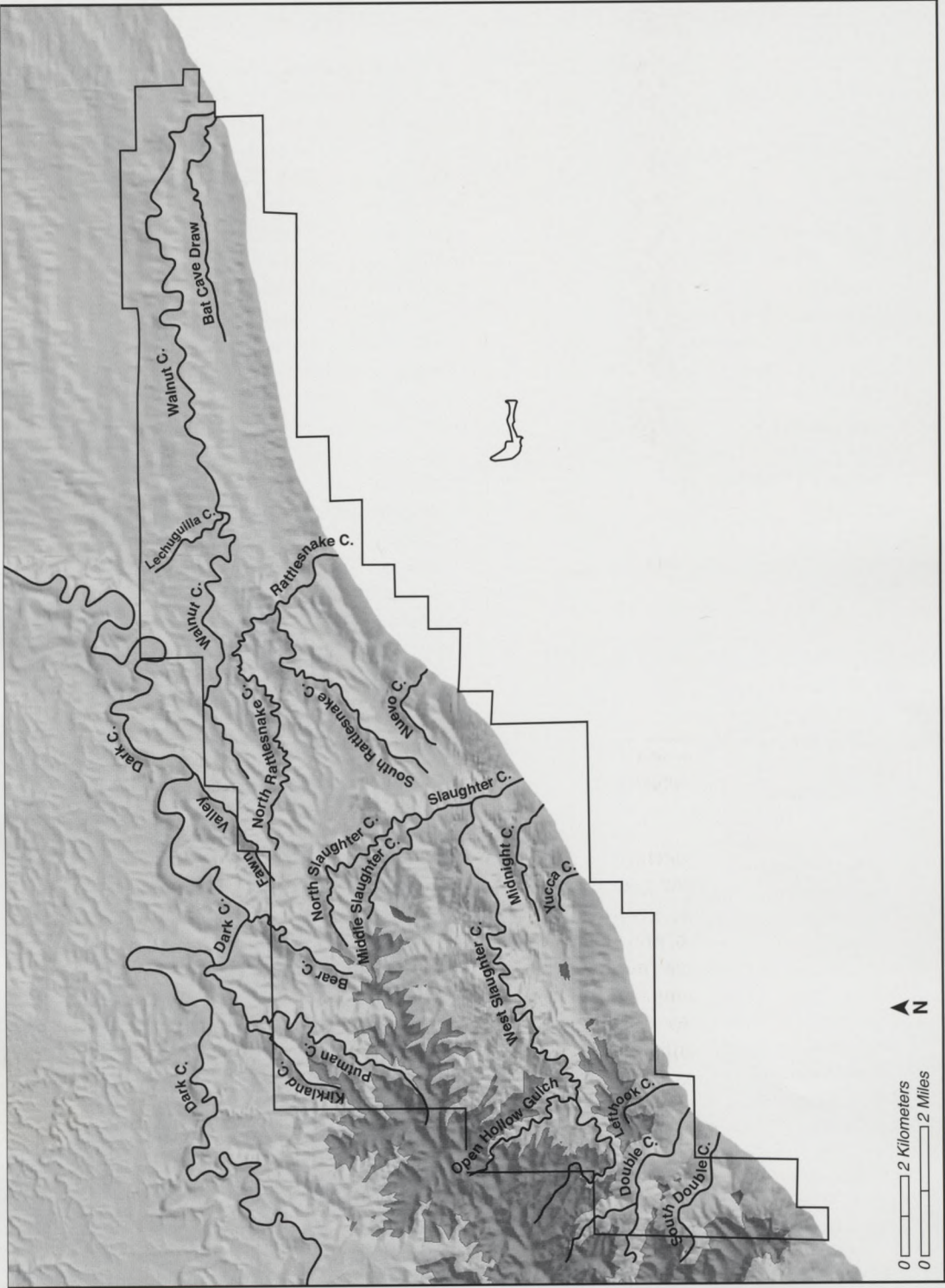


Fig. 5. Major canyons (including Bat Cave Draw, Open Hollow Gulch, and Fawn Valley) on the reef in Carlsbad Caverns National Park.

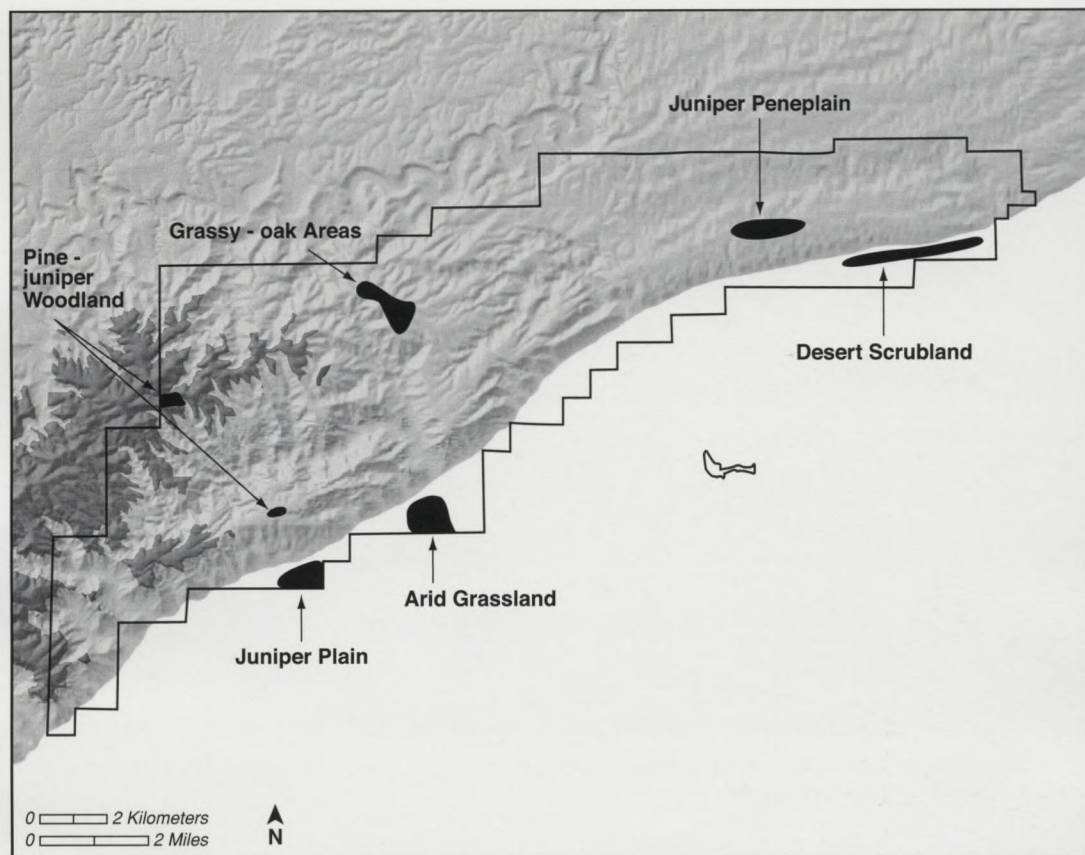


Fig. 6. Black areas represent the best places to observe six of the major habitats in Carlsbad Caverns National Park. These blackened areas represent only part of each habitat in the park.

Spanish dagger, catclaw acacia, catclaw mimosa, agarito, mariola, bear grass, javelina bush, ocotillo, scrub oak, gray oak, cliff fendlerbush, Texas madrone, and skeletonleaf goldeneye. Common grasses include grama, muhly, and threeawn; in some areas they are sparse, while in others they are moderately dense. On these low summits, the substrate consists of numerous stones, rocks, and slabs of flat rock. In addition, tiers of low, rocky ledges often occur on gentle slopes. Throughout the text, stones refer to small rocks less than or equal to 4 cm in length.

The juniper peneplain encompasses large areas of the park that are quite accessible. For example, this habitat is prevalent along the first 6.6 km of the Scenic Loop Drive, along the last 2.3 km of paved road leading to the Visitor Center from Whites City, and around service roads leading to the residences, maintenance area, and park headquarters. Along

these roads, we trapped at elevations 1,340-1,425 m (4,400-4,680 ft).

In the north-central part of the park, summits have a different appearance. Here knolls and saddles are covered by large patches of gray oak growing among moderately dense grasses (Fig. 9). The most common grasses include feather grass, grama, love grass, and muhly. Other vegetation on these summits consist of mountain mahogany, desert ceanothus, catclaw acacia, fragrant sumac, sotol, bear grass, prickly pear, New Mexico agave, lechuguilla, datil yucca, and some alligator junipers. The substrate consists of rocks, stones, and areas of exposed soil. On these summits, we trapped along Guadalupe Ridge at elevations 1,720-1,785 m (5,640-5,860 ft; Figs. 6 and 10).

Highest summits of the reef ($\geq 1,800$ m or $\geq 5,900$ ft) also have a different appearance. Here broad and nearly flat expanses of land



Fig. 7. Face of the escarpment showing a series of exposed slopes separated by ravines. The large canyon on the right is Yucca Canyon (photograph taken 20 March 1993).



Fig. 8. Near the Visitor Center, summits of the reef are dominated by scattered red berry junipers. This habitat is referred to as the juniper peneplain (photograph taken 21 May 1992).



Fig. 9. Along Guadalupe Ridge in the north-central portion of the park, summits of the reef are covered by moderately dense grasses and patches of gray oak (photograph taken 30 July 1991).

are covered with scattered conifers (Fig. 11). Some hill tops and saddles contain only alligator juniper and pinyon pine, but most contain alligator juniper, pinyon pine, and ponderosa pine. Some of the tallest ponderosa pines reach 10.7 m in height. In some areas of this woodland habitat, grasses are moderately dense among stones and large flat rocks that occur between trees, but in other areas, grasses are sparse. On these highest summits, grasses consist of big bluestem, feather grass, June grass, muhly, panicum, plains love grass, sand dropseed, and sideoats grama. Other common plants include mountain mahogany, bear grass, desert ceanothus, prickly pear, sotol, New Mexico agave, datil yucca, fragrant sumac, scrub oak, chinkapin oak, and Texas madrone. Only a small part of the park consists of these high summits, and they are located in some of the most inaccessible places in the park. Most of our trapping in this habitat was conducted near Putman and Yucca cabins at elevations ranging from 1,800 to 1,975 m (5,900-6,480 ft; Fig. 4). Al-

though we indicate the location of Yucca Cabin in Figure 4, the cabin was dismantled in April 1996.

Canyonsides. Canyons (including major draws, gulches, and valleys; Fig. 5) cut deeply into interior portions of the reef and create a number of habitats associated with their steep slopes. Gullies and ravines cut into canyonsides, and these eroded areas are better protected than exposed slopes on either side. Gullies, ravines, and exposed slopes are rocky and contain everything from small rock fragments to large boulders (Fig. 12). Many slopes also have tiered sections of rock outcrops and some have tall, vertical cliffs (Figs. 13 and 14).

The lushest vegetation on the reef occurs at high elevations in gullies, ravines, and narrow canyon heads with northerly exposures. These habitats support a high diversity of plants including many types of trees. Trees at these mesic sites include alligator juniper, ponderosa pine, pinyon pine, Rocky Mountain juniper, bigtooth maple, chinkapin oak, Texas

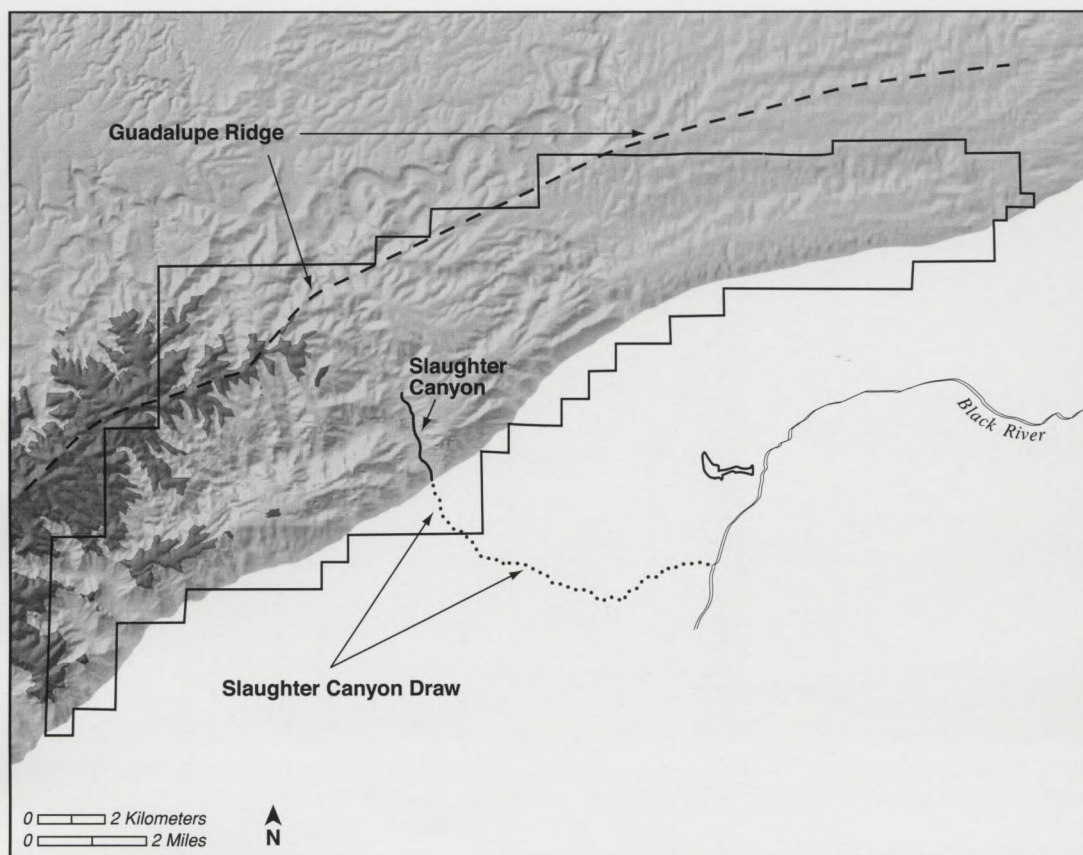


Fig. 10. Guadalupe Ridge divides north-draining watersheds from south-draining watersheds. Slaughter Canyon Draw is the broad drainage area that lies below the mouth of Slaughter Canyon.

madrone, and velvet ash. Smaller plants at these sites consist of mountain mahogany, scrub oak, fragrant sumac, Mexican orange, serviceberry, sotol, eggleaf silktassel, prickly pear, and grasses. At elevations 1,755-1,905 m (5,750-6,250 ft), we set traps in upper parts of Putman Canyon, in mesic gullies near Putman Cabin, and in mesic ravines and gullies near Yucca Cabin.

At lower elevations, gullies, ravines, and canyon heads are drier and contain smaller and fewer numbers of trees and a different association of plants. In dry gullies and ravines, common plants include scrub oak, gray oak, juniper, Texas madrone, mescal bean, evergreen sumac, catclaw, sotol, agarito, and a variety of grasses. We set traps to capture rodents in gullies of Walnut and Slaughter canyons at elevations <1,385 m (4,550 ft) and in a gully of Lefthook Canyon at 1,525-1,615 m (5,000-5,300 ft).

Vegetation associated with exposed slopes, rock outcrops, and cliffs also varies with elevation and exposure. Plants present at all elevations include oak, juniper, sotol, lechuguilla, fragrant sumac, evergreen sumac, and grasses. Plants limited to high elevations include desert ceanothos, mountain mahogany, Mexican orange, bear grass, datil yucca, New Mexico agave, and eggleaf silktassel. Plants generally associated with low elevations include acacia, agarito, prickly pear, Spanish dagger, mariola, littleleaf sumac, ocotillo, oreganillo, mescal bean, cane cholla, netleaf hackberry, and skeletonleaf goldeneye.

We set traps to capture rodents along cliff faces and rock outcrops at a variety of elevations. Highest cliffs surveyed were at 1,920 m (6,300 ft) near Putman Cabin, and highest outcrops ranged from 1,800 to 1,950 m (5,900-6,400 ft) near Putman and Yucca cabins. At



Fig. 11. Highest summits of the reef are covered with scattered conifers. This photograph was taken near Yucca Cabin where the woodland is comprised of alligator juniper, pinyon pine, and ponderosa pine (photograph taken 12 July 1998).



Fig. 12. An exposed slope in Walnut Canyon with clumps of lechuguilla growing among the rocks (photograph taken near the Chihuahuan Desert Exhibit on 22 October 1999).



Fig. 13. Rock outcrops along Guadalupe Ridge. Outcrops of several sizes can be observed in this photograph. The largest one is curved and includes the exposed rocks in the foreground. Smaller outcrops can be seen above and in the distance (photograph taken 30 July 1991).



Fig. 14. A cliff in Walnut Canyon (photograph taken 22 October 1999).



Fig. 15. Desert scrub is prevalent on the floor of Walnut Canyon at the park's east entrance near Whites City. Plants in this photograph include tarbush, viscid acacia, creosote bush, lechuguilla, prickly pear, and juniper (photograph taken 9 July 1998).

lower elevations, we surveyed these same formations along Guadalupe Ridge at 1,645–1,735 m (5,400–5,700 ft). The lowest sites surveyed ($\leq 1,370$ m or $\leq 4,500$ ft) occurred on cliffs in Walnut Canyon and rock outcrops in Bat Cave Draw. At these low elevations, we also trapped rodents on exposed slopes in Walnut, Slaughter, and Rattlesnake canyons and set pitfall traps to capture shrews along rock outcrops in Bat Cave Draw.

Canyon floors. Floors of major canyons are broad, relatively flat areas that extend between bases of canyon sides. Canyon floors consist of two major components—creek beds and their banks. Creek beds cut into floors and meander down canyons. During rains, creek beds are first to collect runoff from slopes, but water may overflow onto the banks during heavy rains. While creek beds typically consist only of exposed rock with small amounts of vegetation, their banks contain fairly well-developed soils that support a wide variety of plants. Because of the paucity of plants in

creek beds, we set most traps on vegetated-covered banks. We trapped the floor of Walnut Canyon at elevations 1,120–1,385 m (3,680–4,540 ft), Bat Cave Draw at 1,305 m (4,280 ft), and Slaughter Canyon at 1,300 m (4,260 ft).

At the lowest elevations in Walnut Canyon ($\leq 1,130$ m or $\leq 3,700$ ft), the floor has a unique vegetational community. Here desert scrub is prevalent, and this part of Walnut Canyon is the only place on the reef where a desert-scrub community occurs (Fig. 15). This habitat certainly was continuous with desert-scrub communities on the seabed before Whites City was built. Common shrubs include tarbush, viscid acacia, creosote bush, mesquite, lechuguilla, javelina bush, sotol, mariola, agarito, prickly pear, Spanish dagger, cane cholla, and skeletonleaf goldeneye. Less abundant plants include juniper, catclaw mimosa, fragrant mimosa, bear grass, Apache plume, catclaw acacia, Roemer acacia, little walnut, mescal bean, oreganillo, desert willow, ocotillo, allthorn, and littleleaf sumac.



Fig. 16. At elevations 1,160-1,385 m (3,800-4,540 ft), canyon floors are covered with moderately dense grasses and a wide variety of scattered shrubs and succulents. In this section of Walnut Canyon, junipers and Spanish dagger are common (photograph taken 1.96 mi. W, 1.17 mi. N Whites City in August 1992).

This portion of Walnut Canyon also contains a variety of grasses, including blue grama, bush muhly, cottontop, plains bristle grass, sideoats grama, threeawn, and tobosa. Grasses are sparse in most areas, and stones, rocks, and some boulders are present on the canyon floor.

At higher elevations on canyon floors (1,160-1,385 m or 3,800-4,540 ft), various shrubs and other plants are scattered throughout grassy areas; however, shrubs such as tarbush and creosote bush are absent (Fig. 16). At these higher elevations, most grasses are moderately dense, but at some locations, alkali sacaton occurs in dense patches and bush muhly is dense around bases of shrubs. Other common species of grasses include blue grama, curlyleaf muhly, green sprangletop, hairy grama, longleaf squirrel-tail, Nealley threeawn, plains bristle grass, sand dropseed, sideoats grama, Springfield bluestem, and vine mesquite. Shrubs and succulents scattered among grasses and along

creek beds include juniper, sotol, prickly pear, catclaw, viscid acacia, agarito, Apache plume, soaptree yucca, bear grass, cane cholla, mariola, mescal bean, oreganillo, littleleaf sumac, mesquite, little walnut, netleaf hackberry, desert willow, Spanish dagger, splitleaf brickellia, and skeletonleaf goldeneye. In some areas of the canyon floor, the ground is stony and in others, rocks also are present.

Habitats on Seabed along Base of Escarpment

Desert scrubland. Within the park's boundaries, desert scrubland is most prevalent at lower elevations of the seabed along the base of the escarpment (Fig. 6). This habitat is dominated by various combinations of shrubs and succulents, including viscid acacia, creosote bush, tarbush, javelina bush, mariola, lechuguilla, sotol, prickly pear, Spanish dagger, soaptree yucca, cane cholla, Christmas cholla, agarito, allthorn, mesquite,



Fig. 17. On the seabed, lechuguilla is abundant in areas of desert scrub that contain numerous rocks (photograph taken along gravel road leading to Sewage Disposal Ponds on 21 March 1993).

littleleaf sumac, juniper, and skeletonleaf goldeneye. Within the scrubland, there are areas without much grass ("open areas") and areas where the ground is covered with relatively large amounts of it ("grassy areas").

In most areas of desert scrubland, grasses grow sparsely among widely spaced shrubs. In these "open areas," grasses include burro grass, grama (blue, black, red, and sideoats), muhly, Nealley threeawn, tridens (hairy and slim), and vine mesquite. In the scrubland, lechuguilla has a patchy distribution. In open areas containing numerous rocks, lechuguilla grows abundantly in small clumps and in large patches (Fig. 17). In contrast, lechuguilla is absent in other open areas where ground surfaces are relatively smooth and contain a fine-textured soil intermixed with stones and a few rocks (Fig. 18).

Although most of the scrubland contains open areas with sparse grass, some areas are covered with moderately dense grass. These "grassy areas" usually are associated with

soils that have been washed down from escarpment gullies and have spread over the terrain as dry, relatively flat washes. Presence of well-developed soils and runoff from gullies not only supports grasses that are moderately dense, but these soils also support shrubs and succulents that are larger than in open areas (Fig. 19). Important grasses in these washes include blue grama, bush muhly, cottontop, Nealley threeawn, plains bristle grass, sand dropseed, sandy muhly, sideoats grama, and tobosa. In grassy areas, some soil is exposed between clumps of grass, but under some shrubs, bush muhly is dense. Lechuguilla is absent because few rocks are present on the surface. In desert scrubland, grassy areas are contiguous with open habitats—edges of grassy areas simply abut substrates of open areas.

A second type of grassy habitat in desert scrubland occurs only sporadically in patches. These consist of small to large areas of grass not associated with washes. Although grasses



Fig. 18. On the seabed, lechuguilla is absent in areas of desert scrub where fine-textured soils contain many stones and few rocks. One such area is shown in this photograph taken near the Sewage Disposal Ponds. Dominant shrubs in this view include creosote bush and viscid acacia (photograph taken on 21 March 1993).



Fig. 19. Within desert scrubland, many flat washes contain areas with moderately dense grasses and tall shrubs and succulents. Shrubs and succulents in this photograph include tarbush, littleleaf sumac, mesquite, soap tree yucca, and cane cholla (photograph taken near Sewage Disposal Ponds on 21 May 1992).



Fig. 20. Arid grassland occurs at mid-elevations on the seabed, where a wide variety of grasses and shrubs dominate the landscape (photograph taken west of Slaughter Canyon Draw on 23 October 1999).

in these areas are as dense as those associated with washes, shrubs and succulents are usually smaller. We surveyed these grassy areas as small as 435 m² (0.11 acres) and as large as 90,000 m² (22.2 acres).

Open and grassy areas of desert scrubland are widespread along the gravel road leading to and beyond the Sewage Disposal Ponds in eastern portions of the park (Figs. 4 and 6). Along this road, we set traps in areas of desert scrub at elevations 1,105-1,240 m (3,620-4,070 ft).

Arid grassland. Arid grassland occurs at mid-elevations on the seabed, where many species of grasses and scattered shrubs dominate the landscape (Fig. 20). Dominant grasses include blue grama, hairy tridens, Halls panicum, Nealley threeawn, plains bristle grass, sand dropseed, sandy muhly, sideoats grama, tobosa, and vine mesquite. Shrubs at mid-elevations include littleleaf sumac, viscid acacia, Spanish dagger, soaptree yucca, ocotillo, javelina bush, sotol,

prickly pear, agarito, mescal bean, cane cholla, allthorn, broom snakeweed, skeleton-leaf goldeneye, red berry juniper, and some mesquite.

Arid grassland is most prevalent and easily accessible west of Slaughter Canyon Draw (Figs. 6 and 10). In areas where grass is sparse, this habitat looks similar to open areas in the scrubland, but close examination reveals almost a complete lack of creosote bush and tarbush. Similar to desert scrubland, dry washes also cross the grassland, but they are more difficult to recognize because grasses of the wash are continuous with those of the grassland.

In 1991 and 1992, we set traps to capture rodents in the grassland west of the gravel road leading to the parking lot of Slaughter Canyon Cave. Traps were set at elevations 1,245-1,280 m (4,090-4,200 ft). Fires swept through this area in 1989 and 1990, and grasses responded positively to these burns. Grasses were moderately dense and tall when



Fig. 21. At high elevations on the seabed, expanses of land are dominated by scattered red berry junipers. This habitat is referred to as the juniper plain (photograph taken in the southeast corner of Section 33, T25S, R23E on 21 March 1992).

we trapped, although some areas had sparse grass. In areas with moderately dense grasses, some bare ground was observed. Stones and some rocks were present on the ground, although they seemed less abundant where grasses were densest, and lechuguilla was present on the few rock piles that occurred in the area.

Juniper plain. At high elevations on the seabed, expanses of land are dominated by scattered red berry junipers, and we refer to this habitat as the juniper plain (Fig. 21). The juniper plain resembles the juniper penepain on the reef because both are dominated by scattered red berry junipers (compare Figs. 8 and 21). The primary difference between these juniper-dominated habitats is substrate. Unlike the juniper penepain, the juniper plain does not have slabs of flat rock or low rocky ledges. Substrate of the juniper plain varies from areas of soil intermixed with stones to stony areas with rocks.

In the juniper plain, grasses are sparse in many spots, but in some open areas they are moderately dense. Common grasses include hairy grama, hairy tridens, Halls panicum, mesa muhly, sideoats grama, and threeawn. Besides junipers and grasses, other vegetation includes littleleaf sumac, viscid acacia, Roemer acacia, fragrant mimosa, sotol, prickly pear, lechuguilla, agarito, javelina bush, bear grass, Spanish dagger, soaptree yucca, oreganillo, fragrant sumac, mariola, ocotillo, cane cholla, skeletonleaf goldeneye, and some oak.

The juniper plain is most prevalent west of the arid grassland in parts of Sections 32 and 33 (T25S, R23E; Fig. 6). We set traps to capture rodents in these sections at elevations 1,320-1,385 m (4,330-4,550 ft).

Alluvial fans. Erosion of gullies, ravines, and canyons has carried materials down from the reef onto the seabed forming alluvial fans at many locations along the base



Fig. 22. An alluvial fan along the base of the escarpment at the mouth of Yucca Canyon. The fan is outlined by a dashed line (photograph taken 21 March 1992).

of the escarpment. These fan-shaped deposits form distinct areas having intermediate inclines between steep slopes of the escarpment and gentle slopes of the seabed. Alluvial fans, which we consider as part of the seabed, are dominated by gramas and other grasses that are moderately dense (Fig. 22). Widely scattered plants found on most fans include juniper, sotol, lechuguilla, oreganillo, prickly pear, Spanish dagger, javelina bush, catclaw acacia, littleleaf sumac, viscid acacia, and skeletonleaf goldeneye. Vegetation grows on a stony substrate containing some rocks.

At low elevations, alluvial fans run into scrubland; at mid-elevations, they merge with the grassland; and at high elevations, they merge with the juniper plain. We trapped alluvial fans at elevations of 1,205 m, 1,355 m, and 1,410 m (3,960 ft, 4,450 ft, and 4,630 ft).

Drainage areas. Not only has erosive power of water formed gullies, ravines, and canyons on the reef, but it also cut channels

into the floor of the seabed forming arroyos of various sizes and wide draws. Arroyos and draws enter the seabed at various intervals from drainages along the entire escarpment. Small drainages from the reef, such as gullies and ravines, form relatively narrow channels in the seabed called arroyos. Large drainages from the reef, such as canyons, form broad and shallow channels called draws.

Arroyos have rocky floors, and vegetation generally is larger than on adjacent banks. Conspicuous plants in arroyos include oak, juniper, Texas madrone, little walnut, Mexican buckeye, desert willow, netleaf hackberry, littleleaf sumac, evergreen sumac, fragrant sumac, mescal bean, Apache plume, sotol, Spanish dagger, oreganillo, prickly pear, acacia, catclaw, agarito, cane cholla, skeletonleaf goldeneye, and honeysuckle. At low elevations, many arroyos contain mariola, creosote bush, tarbush, javelina bush, and mesquite. Some arroyos contain sparse grass while

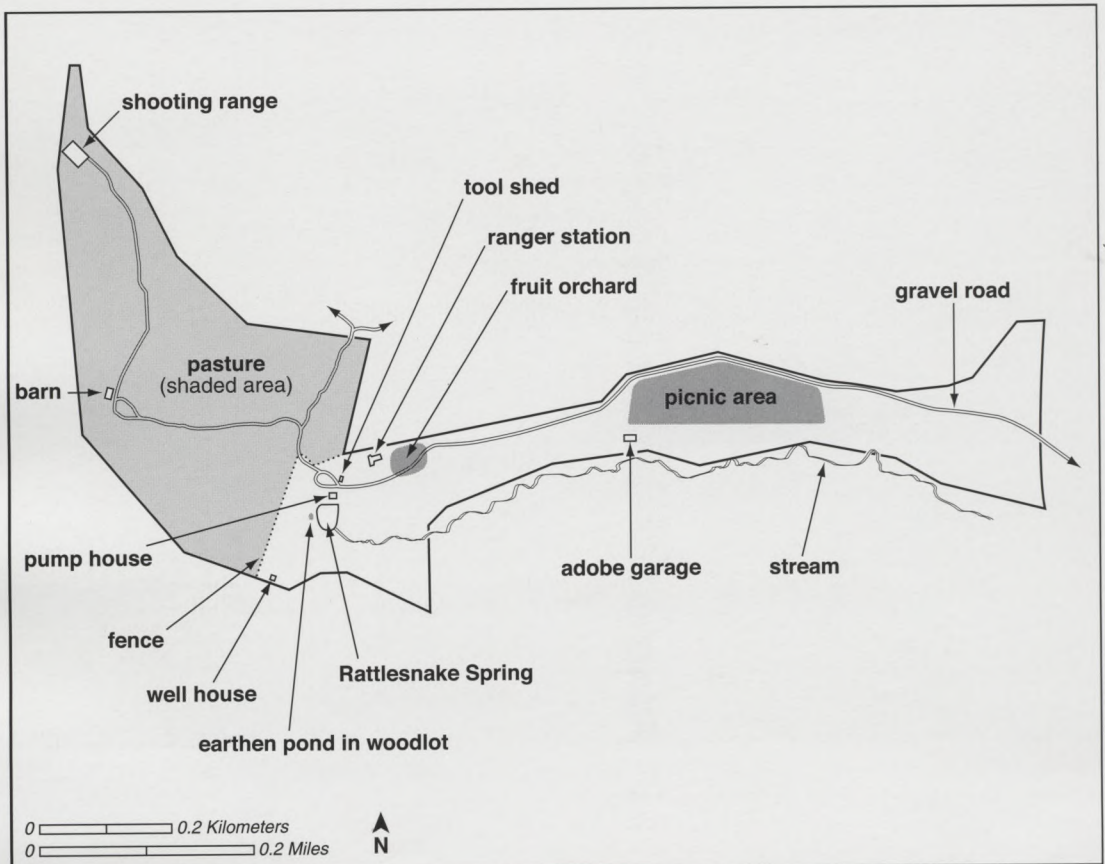


Fig. 23. Rattlesnake Springs, a small detached parcel of land on the seabed, is part of Carlsbad Caverns National Park. The adobe garage and tool shed no longer exist on this parcel of land.

others have grasses that are moderately dense. Principal grasses in arroyos include cane bluestem, Nealley threeawn, plains bristle grass, sandy muhly, sideoats grama, other gramas, and vine mesquite.

We set traps to capture rodents in arroyos that cut through habitats of the scrubland, grassland, and juniper plain at elevations 1,135-1,510 m (3,720-4,960 ft). We set traps in arroyos that were wide (54.9 m), narrow (3.0 m), deep (10.7 m), and shallow (1.5 m).

Draws lie below mouths of Slaughter, Double, and South Double canyons, the widest canyons in the park. Within these draws, a number of separate arroyos cut into the seabed, leaving banks between them. These banks are rocky, containing stones, large rounded rocks, and clusters of small boulders. Common vegetation on the banks of Slaughter

Canyon Draw include littleleaf sumac, juniper, oak, agarito, catclaw mimosa, viscid acacia, mescal bean, Spanish dagger, soaptree yucca, ocotillo, lechuguilla, mariola, prickly pear, sotol, javelina bush, mesquite, oreganillo, cane cholla, desert willow, Apache plume, and skeletonleaf goldeneye. Grasses in this draw are sparse to moderately dense and consist of grama, threeawn, and others. Common plants near the mouth of Double Canyon include oak, sotol, evergreen sumac, juniper, Texas madrone, Apache plume, little walnut, javelina bush, and mountain mahogany.

We set traps on banks of wide draws below mouths of Slaughter Canyon and Double Canyon at elevations of 1,270 m (4,160 ft) and 1,450 m (4,760 ft), respectively. We did not trap in the wide draw below South Double Canyon.



Fig. 24. This rock-lined storage pond is named Rattlesnake Spring. The limestone-block wall surrounding the pond was constructed in 1941. Woodlots are established on both sides of the pond. The west woodlot can be seen in the background on the right side (photograph taken 23 October 1999).

Habitats on Seabed at Rattlesnake Springs

Rattlesnake Springs is a small, detached parcel of land on the seabed located 7.4 km south-southwest of the Visitor Center (Figs. 4 and 23). A natural spring on this property supplies water to Rattlesnake Springs, the Visitor Center, and other buildings on the reef. Today the springwater is contained in a rock-lined storage pond, which measures 41.6 by 35.7 m (Fig. 24). In some areas, water is about 1.8 m deep. In this volume, we refer to the storage pond as Rattlesnake Spring. The name Rattlesnake Springs refers to the entire 0.32-km² site (80 acres; Fig. 23).

Water leaves Rattlesnake Spring by a cement aqueduct, by a pump in the well house, and by a natural stream. The aqueduct starts at the northeast corner of the storage pond and transports water via gravity to sections of Rattlesnake Springs for watering of lawns and fields (Fig. 25); however, a powerful pump

is necessary to transport water from the spring to the top of the reef. Until May 2000, the pump was located in the pump house (Figs. 23 and 26). Although the pump house is still present, it no longer contains a pump. Today a submersible pump below the well house moves water through a long pipe to the base of the escarpment near the Visitor Center, and booster pumps at the base of the escarpment help move water to the top of the reef.

Flowing from the southeastern corner of Rattlesnake Spring, a narrow, perennial stream flows through a small section of the park and continues to the east, just outside the park's southern boundary on property owned by The Nature Conservancy. This stream widens as it flows across conservancy land and forms large, permanent pools of water, which occasionally cross onto park property (Fig. 23).

The National Park Service maintains a picnic area at the eastern end of Rattlesnake



Fig. 25. Cement aqueduct at Rattlesnake Springs. This portion of the aqueduct is near the picnic area. Earthen mounds formed by pocket gophers can be seen in the grass next to the aqueduct. The fence on the right runs along the northern boundary of the park and separates the park from property owned by Washington Ranch. Part of the picnic area and gravel road can be seen in the upper left-hand corner (photograph taken 31 December 1998).



Fig. 26. Pump house next to Rattlesnake Spring. During summer months, fecal droppings from night-roosting bats can be observed on the floor and walls of the front porch (photograph taken 4 August 1996).



Fig. 27. During warmer months, the picnic area at Rattlesnake Springs is shaded by tall cottonwoods (photograph taken 22 October 1999).

Springs. Here grass is kept short, and the entire area is covered with a canopy of tall cottonwoods (Fig. 27). Mowed fields of grass and weeds occur adjacent to the picnic area on its western border. The western end of Rattlesnake Springs contains a 0.16-km² plot of land (40 acres), which park personnel refer to as “the pasture” (see description of shrubby areas below). Until 1997, horses owned by the park were kept in the fenced pasture. A corrugated metal barn and shooting range also are located within the pasture (Fig. 23).

A ranger station is located near the center of Rattlesnake Springs and is currently used as a residence for park personnel (Fig. 23). South of the station, large pecans and white mulberries grow on the front lawn (Fig. 28), and east of the station is an orchard containing a variety of fruit trees, including apple and pear trees (Fig. 29). Weeping willows line the northern edge of the orchard.

To capture bats at Rattlesnake Springs, we used mist nets over the storage pond and under the canopy of trees on the front lawn of the ranger station. Occasionally we also placed nets among trees in the orchard. In addition to netting bats, we periodically inspected structures at Rattlesnake Springs for roosting bats, including the ranger station, pump house, and a wooden tool shed located near the ranger station (Fig. 23). The tool shed was dismantled sometime after 1991. Bats also have been collected by others in an adobe garage once located at the southwest corner of the picnic area; the garage was dismantled in the 1950s (Fig. 23).

Rattlesnake Springs can be divided into four major habitats—those dominated by trees, grasses, weeds, and shrubs (Table 2). Below we describe each habitat in detail. Most of the northern boundary and part of the eastern, western, and southern boundaries of Rattlesnake Springs are bordered by Washington Ranch. Rattlesnake Springs is



Fig. 28. Ranger station at Rattlesnake Springs. Large deciduous trees on the front lawn include pecans and mulberries (photograph taken 22 March 1993)



Fig. 29. The orchard at Rattlesnake Springs includes apple and pear trees (photograph taken 20 March 1995).

close to the Black River, and parts of Washington Ranch lie adjacent to the river (Fig. 4). Desert scrub surrounds Rattlesnake Springs and Washington Ranch, as well as land of The Nature Conservancy and other nearby private property.

Woodlots. A small stand of deciduous trees is established on the east and west sides of Rattlesnake Spring (Fig. 24). These stands are situated beyond the mowed grass and spikerush that surround the rock perimeter of the pond. The most noticeable trees are cottonwood, white mulberry, Goodding willow, weeping willow, elm, netleaf hackberry, and Russian olive. In the eastern woodlot, the narrow stream mentioned above flows through the trees, and marshy areas with muddy ground and standing water exist in some places. Marshy areas contain dense stands of bulrush and sedges intermixed with sunflowers and goldenrods. Areas away from the stream are dry with fallen logs, leaves, and other debris on the floor. Small annuals are widely scattered on exposed soil, and some bushes grow under the canopy of trees. A narrow band of trees (mostly cottonwood, netleaf hackberry, Russian olive, Goodding willow, and patches of soapberry) follows the stream along its entire course as it passes through property of the park and conservancy. The woodlot on the west side of Rattlesnake Spring contains a fairly dense thicket of trees and shrubs, much fallen debris, and a small earthen pond surrounded by bulrush. We set traps to capture rodents in both woodlots and along the narrow band of trees following the stream. We also netted bats over the small natural pond in the west woodlot and placed pitfall traps along the pond's edge.

Dense grass. Three areas of dense grass occur at Rattlesnake Springs. These areas are not grazed by horses or cattle, and with few exceptions, bare ground is not visible when grass is parted by hand. One area of dense grass is located by the picnic area. Here the largest expanse of dense grass grows between the lawn of the picnic area and the stream flowing along the park's southern boundary. Grasses grow to the edge of the stream, and in some areas they are

matted down and grow with bulrush on soggy ground (Fig. 30). Otherwise, grasses stand tall and grow on drier ground; these areas are usually farther from the stream. Bermuda grass, cane bluestem, and Johnson grass are dominant grasses. A few Russian olives grow in the grass, and in some areas grasses are covered by a canopy of cottonwoods. Another area of dense grass grows on dry ground adjacent to the woodlots by Rattlesnake Spring. In this area, alkali sycamore and Indian grass provide the principal ground cover. Scattered shrubs grow among these grasses and include littleleaf sumac, mesquite, and fourwing saltbush. The last area of dense grass lies along the northern boundary of Rattlesnake Springs at its east end. Here Johnson grass is dense under some tall cottonwoods, and scattered Russian olives also are in the area. We trapped in all three areas of dense grass.

Weedy areas. Fields containing forbs and various amounts of grass are located on both sides of the gravel road at the east entrance to Rattlesnake Springs (Fig. 31). On the south side, small amounts of grass grow among forbs. In areas with standing forbs, some soil is exposed, but in areas with matted vegetation, no soil is visible. On the north side of the road, grasses and forbs are less dense, and the ground is more exposed. In some areas on this side of the road, grasses and forbs grow on raised dikes of earth. Common forbs in weedy areas include wormwood, golden aster, velvet-leaf gaura, and frog-fruit; grasses include cane bluestem, Johnson grass, sideoats grama, and others; and the few scattered shrubs include prickly pear, soaptree yucca, fourwing saltbush, and mesquite. We set traps in weedy areas on both sides of the road.

Shrubby areas. Four types of shrubby areas occur at Rattlesnake Springs—(1) an area of cropped grass growing between shrubs, (2) an area of exposed soil with no grass between shrubs, (3) an area of desert scrub, and (4) an area dominated by mesquite (Table 2). We set traps to capture rodents in all four of these habitats.

A large part of the western end of Rattlesnake Springs is dominated by closely



Fig. 30. The fence near the center of this photograph runs along the southern boundary of Rattlesnake Springs and separates the park from property owned by The Nature Conservancy. Open water on the left is on conservancy land. Coarse vegetation in the foreground is bulrush. Dense grasses in the background include Bermuda grass, cane bluestem, and Johnson grass (photograph taken near the picnic area on 20 March 1995).



Fig. 31. Field containing forbs and grasses south of gravel road at east entrance to Rattlesnake Springs (photograph taken 22 March 1993).



Fig. 32. Shrubby area near horse barn at Rattlesnake Springs. The most common shrubs include littleleaf sumac, fourwing saltbush, tarbush, and catclaw acacia (photograph taken 21 May 1992).

spaced shrubs. This area also was grazed by horses until 1997 and is referred to as "the pasture" by park personnel (Fig. 23). In 1991 we trapped rodents near the fence in the southeastern section of the pasture. At that time, littleleaf sumac was the most common shrub in the area, but mesquite, fourwing saltbush, and agarito were also present. Clumps of alkali sacaton grew among shrubs and were noticeably cropped by horses. Soil in this area was fine-textured and visible between plants. Most shrubs were removed from this end of the pasture by park personnel soon after we trapped in 1991.

Shrubs have not been removed from the remaining parts of the pasture. The shrubby area near the corrugated metal horse barn differs from the southeast section because grass is absent between shrubs and only small amounts of grass grow under them. Fine, dusty soil containing few stones exists between littleleaf sumac, fourwing saltbush, tarbush, and catclaw acacia (Fig. 32). Small stands of soapberry, a small human-made

pile of rocks, and several woodpiles also are present near the corrugated metal barn.

Within the pasture, a small area of desert scrub exists in the northwestern part of Rattlesnake Springs near the shooting range (Fig. 33). Common vegetation in this area includes creosote bush, tarbush, viscid acacia, catclaw acacia, littleleaf sumac, mariola, agarito, soaptree yucca, fourwing saltbush, and small amounts of grass. In this shrubby area, the substrate is comprised mostly of rocks and stones, but in some spots, fine-textured soil is present.

At the east end of Rattlesnake Springs, another shrubby area occurs between the picnic area and weedy area south of the entrance road. Here a fairly dense stand of mesquite grows with fourwing saltbush, allthorn, soaptree yucca, catclaw acacia, and Russian olive. Grasses are sparse to moderately dense at this location and consist of sideoats grama, plains bristle grass, and slim tridens. Soil in this area contains some stones.



Fig. 33. The small area of desert scrub near the shooting range at Rattlesnake Springs. The most common shrubs include creosote bush, tarbush, viscid acacia, catclaw acacia, and littleleaf sumac (photograph taken 21 May 1992).

Water Holes

Although surface water is scarce in the park, it is available to wildlife from seeps, springs, and temporary pools. Most seeps and springs flow throughout the year and form marshy areas and sometimes open pools. Temporary sources are most abundant during and after the rainy season when water collects in natural rock basins and in human-made depressions. Most information about bats in the park was gathered by netting them over water holes. Locations of water holes are shown in Fig. 34, and other information about these water holes is given in Table 3 and in the following paragraphs.

Seabed. On the seabed, two large water holes provide places for wildlife to drink—Rattlesnake Spring and Sewer Lagoon Tank. Rattlesnake Spring provides the largest surface area of fresh water (Table 3). In addition, water is available from a small earthen

pond in the woodlot next to Rattlesnake Spring (Fig. 23). This small pond is natural and is the result of seepage from the spring. Wildlife also can obtain water along the stream and aqueduct that originate from Rattlesnake Spring.

At an elevation of 1,135 m (3,720 ft), four Sewage Disposal Ponds are located on flats along the base of the escarpment (Fig. 4). Each waste disposal pond is 41.1 by 111.9 m. Although bats have been observed over these ponds, we are not sure whether they drink from the ponds or only feed on insects in the area. We never placed a net over the ponds, but we netted bats at an earthen pond 251 m away. This human-made pond is named Sewer Lagoon Tank, which measures 32.0 by 17.4 m when full of rain water (Table 3 and Fig. 35). The tank is intersected by a grassy wash containing tall bushes, and the surrounding area is desert scrub.

Reef. On the reef, we netted over water holes associated with drainage systems of

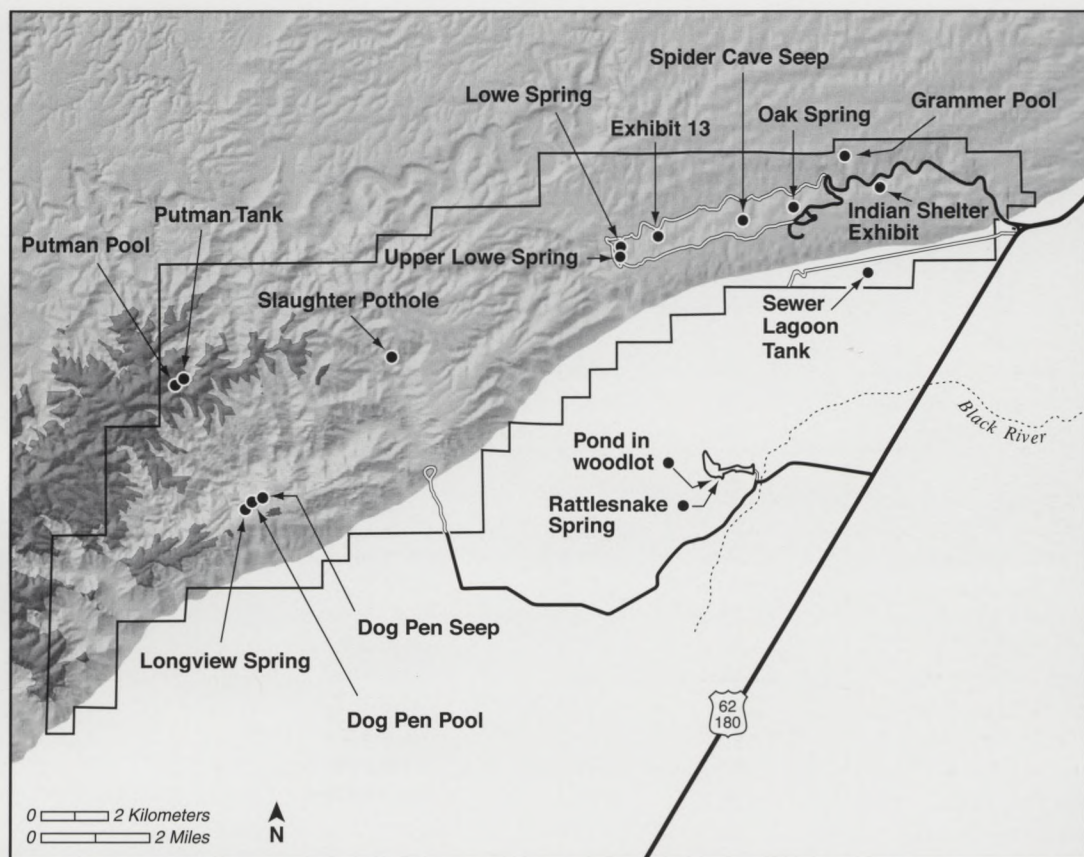


Fig. 34. Location of water holes in Carlsbad Caverns National Park where we attempted to capture bats in mist nets.

Walnut, Slaughter, and Putman canyons. Many of the park's water holes are located along creek beds in small canyons that lead into Walnut Canyon. These include Oak Spring, Spider Cave Seep, Lowe Spring, Upper Lowe Spring, and Grammer Pool. Of these springs and seeps, only Oak Spring has a permanent pool; the other springs and seeps usually have pools except during dry years. Water flows continuously from Spider Cave Seep and Lowe Spring, but the pool that forms at Lowe Spring is always small (Table 3). Upper Lowe Spring flows intermittently and normally forms a marshy area that seldom has open water; however, a pool sometimes accumulates 33 m downstream during wet years. Grammer Pool is a small rock basin that collects water near Upper West Grammer Seep. The seep is situated on a canyon side and drains into a narrow creek

bed. Grammer Pool lies 78 m downstream from the seep (Fig. 36), and although water flow is continuous at the seep, the distant pool is occasionally dry.

Besides seeps and springs, some rock basins collect and hold water during wet years. For example, the floor of Walnut Canyon contains at least two areas where rock basins regularly hold rain water for significant amounts of time. One is located at Exhibit 13 along the Scenic Loop Drive, and the other is located at the Indian Shelter Exhibit along the paved road to the Visitor Center. In both cases, basins lie along the base of steep-walled cliffs (Fig. 37).

In the drainage system of Slaughter Canyon, several springs, seeps, and rock basins provide sources of water for wildlife. Located along the southern rim of West Slaughter Canyon just below the pine woodland, Longview

TABLE 3. Water holes at Carlsbad Caverns National Park where we attempted to capture bats in mist nets. Except for Rattlesnake Spring, amount of water at each netting site varied throughout the study. Dimensions represent the greatest diameter or length and width of surface water that we observed during the study. Water holes are listed from east to west within each region of the park.

Water hole	Elevation		Dimensions (meters)		
	meters	feet	length	width	diameter
<i>On seabed</i>					
Sewer Lagoon Tank	1,120	3,680	32.0	17.4	—
Rattlesnake Spring	1,105	3,630	41.6	35.7	—
Pond in woodlot	1,105	3,630	—	—	5.5
<i>On reef</i>					
Indian Shelter Exhibit	1,195	3,920	—	—	9.1 ^a
Grammer Pool	1,280	4,200	6.1	3.0	—
Oak Spring	1,285	4,220	2.4	2.1	—
Spider Cave Seep	1,315	4,320	7.6	0.9	—
Exhibit 13	1,330	4,360	9.1	2.4	—
Lowe Spring	1,365	4,480	0.8	0.5	—
Upper Lowe Spring	1,380	4,520	9.1	1.8	—
Slaughter Pothole	1,425	4,680	3.0	2.3	—
Dog Pen Seep	1,755	5,760	5.5	3.0	—
Dog Pen Pool	1,720	5,640	—	—	1.5
Longview Spring	1,760	5,770	12.2	2.4	—
Putman Tank	1,810	5,940	9.4	3.7	—
Putman Pool	1,825	5,980	6.1	3.7	—

^aTwo adjacent pools, each with a diameter of 9.1 m.

Spring is one of the highest permanent sources of water in the park (Table 3). In the early 1900s, goat ranchers installed an iron pipe and dug a shallow earthen tank at this spring. With periodic maintenance, a long and narrow pool (12.2 by 2.4 m) formed on a ledge away from background cliffs and vegetation. In the 1980s or early 1990s, park managers decided to let the spring return to its natural state. Today only a small pool (0.9 m in diameter) lies above the dry, human-altered depression. We netted only over the long and narrow pool.

Dog Pen Seep lies in a mesic ravine near Longview Spring. On some occasions a pool forms near the seepage and in rock basins along its drainage. One basin lies 259 m downstream from the seep, and we refer to it as Dog Pen Pool. Another water hole associated with the drainage of Slaughter Canyon is named

Slaughter Pothole. Here a deep rock basin that holds rain water for long periods is situated on the floor of North Slaughter Canyon.

In Putman Canyon, two rock basins occur on its mesic floor near the head of the canyon. One basin, Putman Tank, collects rain water and also is fed by an unnamed seep 61 m upstream. Putman Pool, the other basin, occasionally collects rain water and is located 91 m upstream from the seep. At 1,790 m (5,880 ft) in elevation, Log Cabin Seep is 322 m downstream from Putman Tank; we never set a net in this area of soggy ground because of lack of open water.

Because dense sedges and grasses occur around the perimeter of some water holes, we set traps to capture rodents in several of these moist areas, including Oak Spring, Upper Lowe Spring, and Log Cabin Seep. Monocots surrounding Oak Spring include



Fig. 35. This human-made pond is named Sewer Lagoon Tank. The pond is located on the seabed along the base of the escarpment near the Sewage Disposal Ponds. When this photograph was taken on 22 July 1995, the earthen tank was full of rain water.



Fig. 36. Grammer Pool is a small rock basin that collects water near Upper West Grammer Seep (photograph taken 23 July 1993).



Fig. 37. Rock basin at Indian Shelter Exhibit with rain water (photograph taken in Walnut Canyon on 22 October 1999).

sedges, Bermuda grass, brome, cane bluestem, Johnson grass, and plains love grass. In addition, a small stand of trees grows next to the spring and consists of bigtooth maple, chinkapin oak, netleaf hackberry, lanceleaf sumac, juniper, and chokecherry. At Upper Lowe Spring, prairie wedgescale and spikerush provide dominant ground cover, and nearby vegetation includes juniper, netleaf hackberry, evergreen sumac, mescal bean, and elbowbush. In Putman Canyon, the area adjacent to Log Cabin Seep contains patches of prickly pear growing in a field dominated by sideoats grama, silver bluestem, and other grasses. Other vegetation near this seep includes bigtooth maple, oak, fragrant sumac, bear grass, and weedy vegetation.

Caves

More than 300 caves have been discovered in the Guadalupe Mountains, and 94 of them are in Carlsbad Caverns National Park. The most recent discovery of a cave in

the park occurred on 12 December 2000. In the park, three caves are regularly visited by the public—Carlsbad Cavern, Slaughter Canyon Cave, and Spider Cave. Visitors may take self-guided and ranger-guided tours of Carlsbad Cavern every day of the year except Christmas Day. Ranger-guided tours through undeveloped Slaughter Canyon Cave are available on weekends throughout the year and daily in summer. Ranger-guided tours of Spider Cave are offered year round on Sundays. To enter other caves, special access permits must be obtained from the Cave Resources Office. Locations of entrances to Carlsbad Cavern and Slaughter Canyon Cave are shown in Fig. 4. By request of the National Park Service, we have not indicated the location of other caves. For reasons of safety, conservation, and protection, these locations are available only at the Cave Resources Office.

Of the 94 caves in the park, Carlsbad Cavern has been explored most extensively, and to date, only two natural openings are known. The larger opening is perpendicular

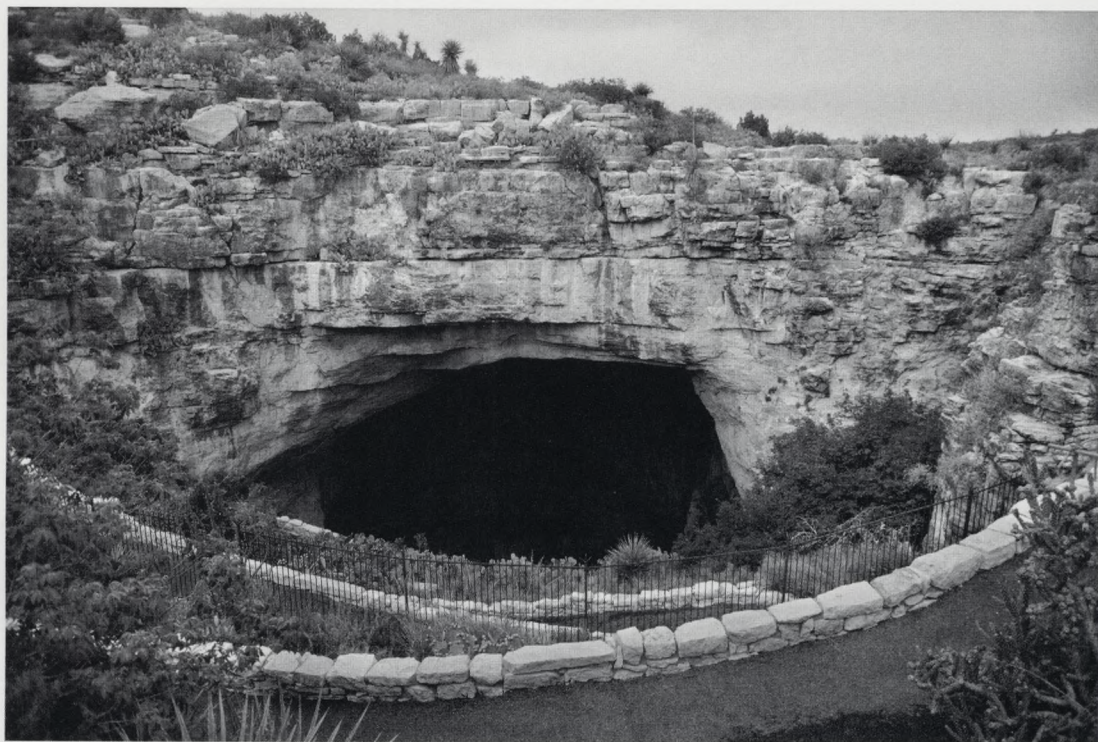


Fig. 38. Large natural opening to Carlsbad Cavern (photograph taken 22 July 1993).

to the surface and is situated in a sinkhole 300 m northeast of the Visitor Center. This opening measures 21 by 12 m, and except for the switchback trail leading into it, the opening has not been altered or enlarged (Fig. 38). In 1963 a stone amphitheater was built in front of the large opening for visitors to observe evening outflights of Brazilian free-tailed bats (*Tadarida brasiliensis*; Fig. 39). The smaller opening lies in the same plane as the surface and is located 400 m east of the large opening. The small opening measures 6.4 by 3.4 m and is surrounded by a chain link fence (Fig. 40).

In the early 1900s, human-made shafts were blasted through the roof of the cavern to reach and remove guano. In March 1981, both shafts were sealed to restore the cave to its natural condition—one shaft, located 204 m east of the small natural opening, was opened in 1906; the other shaft, located 32 m east of the small opening, was excavated several years prior to 1906 (exact date is unknown).

Visitors can enter Carlsbad Cavern by walking through the large natural opening or by using an elevator located in the Visitor Center. The public only observes about 10% of known passageways in the cavern, including the Main Corridor, Lunch Room, and Big Room. Although the Lunch Room is 229 m (750 ft) below the Visitor Center, the deepest part of the cave lies in a section named Lake of the Clouds. This section lies 299 m below the surface of the ground (see page 67). Two sections of the cavern not open to the public are Bat Cave and the back portion of Left Hand Tunnel. During warm months of the year, nursery colonies of bats are present at the end of both tunnels—Brazilian free-tailed bats (*T. brasiliensis*) in Bat Cave and fringed myotis (*Myotis thysanodes*) in Left Hand Tunnel (see page 67). Besides Carlsbad Cavern, many other caves in the park are used by bats and other mammals for shelter (Appendix 3). Species known to use these caves are discussed in *Accounts of Species*.

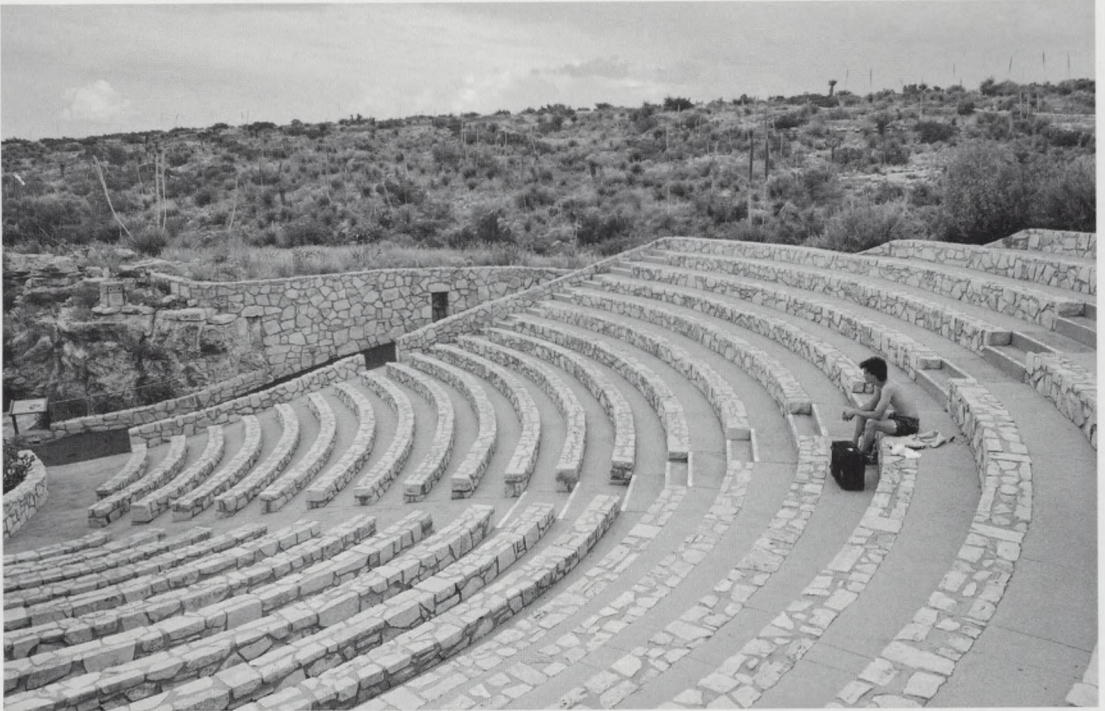


Fig. 39. Stone amphitheater in front of the large natural opening to Carlsbad Cavern. Each evening from spring to autumn, visitors may attend a free bat flight program sponsored by the park and watch Brazilian free-tailed bats (*Tadarida brasiliensis*) exit the cavern. Visitors observe outflights from the amphitheater (photograph taken 9 July 1997).



Fig. 40. Small natural opening to Carlsbad Cavern. This opening is 400 m east of the large natural opening and is surrounded by a chain link fence (photograph taken 30 July 1996).

METHODS AND MATERIALS

Field Techniques

Shrews. Because of the difficulty associated with catching small species of shrews in Sherman live-traps (Williams and Braun 1983), we used pitfall traps to determine if shrews were present. Two traps (plastic containers 19 cm deep and 14 cm in diameter) were set along limestone ledges near the large opening of Carlsbad Cavern. Both were sunk in soil with their rims flush with the surface of the ground. Another pair was set along the edge of the small earthen pond in the west woodlot at Rattlesnake Springs. All four traps were set, monitored at irregular intervals, and removed in 1991. When not monitored, lids were placed on traps. Traps near the cavern were set 16 March and removed 14 August; each trap was open a total of 83 nights. At Rattlesnake Springs, traps were set 12 March; one trap was removed 24 April (open a total of 43 nights), and the other was removed 13 August (open a total of 97 nights). Any shrew captured was kept and prepared as a voucher specimen.

Bats. We determined the presence and distribution of bats by netting them (1) over water holes scattered throughout the seabed and reef, (2) among trees at Rattlesnake Springs, (3) at the natural openings to Carlsbad Cavern, and (4) within tunnels of Carlsbad Cavern. Some additional information was gathered by searching buildings and caves for roosting individuals.

During our study, we netted at 13 water holes on the reef a total of 23 nights and at three water holes on the seabed a total of 19 nights (Table 3). We netted water holes in 1974, 1976, 1984-1986, 1988, 1990-1993, 1995-1997, and 2000. In addition, we netted bats among trees at Rattlesnake Springs. Nets were set a total of 15 nights under canopies of trees in the front yard of the ranger station (1986, 1988, 1990, 1991, 1993, 1995, and 2000) and five nights under and next to canopies in the orchard (1988, 1990, 1995, 1997, and 2000). Bats were netted at water holes or among trees as early as 13 March and as late as 8 October; we did not set mist nets November-February.

At netting sites, mist nets were deployed before evening twilight. On most nights, nets were tended for at least 3 h after darkness, but occasionally they were tended until dawn. Captured bats were removed from nets, and each bat was placed individually in a 0.35-l (12-ounce) drinking cup. Cups were covered with plastic lids and marked with time of capture. After nets were closed at night or during the following morning, bats were removed and examined one by one. For each individual, we recorded time of capture, species, sex, reproductive condition, and age (individuals were considered young of the year if cartilaginous epiphyseal plates in finger joints were visible to the unaided eye when the wing was transilluminated; Anthony 1988). One night each at Sewer Lagoon Tank and at Putman Pool, we marked bats ($n = 41$) with nail polish on claws of their thumbs and released them at night immediately after recording data. None of these bats was recaptured later in the evening. On two occasions, we did not use cups or nail polish (the first time we netted Longview Spring and Spider Cave Seep). On these occasions, bats also were released at night immediately after recording data; some individuals (probably none) might have been captured more than once that evening.

Most bats were released after processing at the capture site, but some were kept as voucher specimens. Because of difficulty in distinguishing California myotis (*Myotis californicus*) from western small-footed myotis (*M. ciliolabrum*), we kept many as specimens to verify their identity using cranial characteristics; individuals ($n = 14$; 32%) released without confirmation are not included in *Results of Surveys* or *Accounts of Species*.

Although 94 caves are known within the park's boundaries, we mainly studied bats in Carlsbad Cavern. This included netting individuals at night as they flew along the cavern's tunnels and as they exited the small and large natural openings. Although most of our netting at the cavern occurred during summers of 1973-1976, we also netted bats at the cavern in 1980, 1981, 1983, 1985, 1988,

1990-1992, 1995-1997, 1999, and 2000. Because we rarely studied bats in other caves, most information from these caves came from specimens examined in museums, scientific literature, and park documents. Lastly, we obtained information on bats by periodically inspecting the ranger station, pump house, and tool shed at Rattlesnake Springs for day- and night-roosting individuals.

Rodents. Systematic trapping was carried out during midwinter (18 January-14 February), late winter/early spring (8-28 March), mid-spring (21 April-27 May), and midsummer (18 July-14 August). Most trapping was conducted in 1991, but some was done in 1992 (March, May, and August) and 1993 (July). To capture most species of rodents, we used two sizes of Sherman live-traps—7.6 by 7.6 by 25.4 cm and 7.6 by 8.9 by 22.9 cm. Occasionally we used larger live-traps (Sherman, 7.6 by 9.4 by 30.5 cm; Tomahawk, 13.9 by 13.9 by 40.6 cm) around burrows constructed by banner-tailed kangaroo rats (*Dipodomys spectabilis*).

We used two methods of trapping to determine distribution and abundance of heteromyid and murid rodents. In the first method, each habitat in the park was trapped multiple times; however, each trapline was left at a site for one night. Thus, each site was never trapped more than once. When possible, we set traplines concurrently in habitats of the seabed and reef; otherwise, we alternated trapping between the two regions from day to day. The only exception was when we worked in the back country and remained there for several days. In the first method, traps were set in late afternoon and checked the following morning. We identified each mammal captured and recorded its sex, reproductive condition, and age (based on body size, pelage color, or both). Most individuals were released at the capture site, but some from each trapline were prepared as voucher specimens.

In the second method, traplines were left at a single site for up to seven consecutive days. Here we attempted to capture individuals or species reluctant to enter traps. Traps initially were set in late afternoon. Each morning they were checked and rebaited un-

til the end of the trapping period. All animals were permanently removed from these traplines; some were released in other areas of the park, and others were kept as voucher specimens.

For both methods, traps were set about 9 m apart and baited with a mixture of birdseed and rolled oats. Traplines generally ranged from 25 to 50 traps, although shorter and longer lines occasionally were employed. We classified each trapline to a type of habitat (Tables 1 and 2), and if a trapline passed through more than a single habitat, we recorded number of traps in each habitat and the type of habitat where each animal was captured. Lastly, a color photograph was taken at each trapline, and these photographs are permanently on file at the park.

We used information from both methods of trapping to calculate number of individuals captured per 100 trap nights for each species in each habitat. A trap night was defined as one trap set for a single overnight period. For these calculations, we used information based on all captures in the first method (636 animals in 3,303 trap nights) where traplines were left at a site for one night. Data from the second method also were included, but we used captures only from the first night (49 animals in 329 trap nights). Total number of trap nights used to calculate capture rates in each habitat is shown in Table 4. When comparing rates of capture of a species across habitats in *Accounts of Species* below, we used rates (= trapping success) as gross indicators of abundance.

Information on animals collected from the second to seventh night in our second trapping method (46 animals) was included in *Accounts of Species* only if it represented information not previously documented from the first method or first night of the second method. Rates of capture were not calculated for sciurid rodents because only two squirrels were captured in our traplines. We also gathered information on some species of heteromyid and murid rodents by recording their diagnostic signs, such as burrows of banner-tailed kangaroo rats (*D. spectabilis*), houses of woodrats (*Neotoma*), and runways of cotton rats (*Sigmodon hispidus*).

TABLE 4. Number of trap nights used in calculations of capture rates of heteromyid and murid rodents in 12 habitats on the reef and 14 habitats on the seabed.

Habitat	Trap nights
<i>On reef</i>	
A. Face of escarpment	
1. Exposed slopes	226
2. Gullies and ravines	182
B. Summits	
1. Juniper peneplain	198
2. Grassy-oak areas	191
3. Pine-juniper woodland	133
C. Canyonsides	
1. Exposed slopes	132
2. Gullies and ravines	239
3. Rock outcrops	185
4. Cliffs	90
D. Canyon floors	
1. Desert-scrub areas	125
2. Grassy areas	296
E. Water holes	55
<i>On seabed along base of escarpment</i>	
A. Desert scrubland	
1. Open areas	323
2. Grassy areas	245
B. Arid grassland	115
C. Juniper plain	166
D. Alluvial fans	114
E. Drainage areas	
1. Arroyos	228
2. Wide draws	61
<i>On seabed at Rattlesnake Springs</i>	
A. Woodlots	71
B. Dense grass	95
C. Weedy areas	65
D. Shrubby areas	
1. Cropped grass	15
2. Exposed soil	30
3. Desert scrub	27
4. Mesquite	25
TOTAL	3,632

We used different techniques to determine the distribution of squirrels, pocket gophers, and porcupines. Because only two squirrels were captured in traplines, we used sightings to gather most information on sciurid rodents. Occasionally after seeing an individual, we attempted to capture it by placing traps near burrows. In addition, a few individuals were collected with firearms, and others were salvaged from road kills.

Although presence of pocket gophers is easily detected because they deposit characteristic mounds of soil on the surface of the ground, individuals must be captured to verify the species. To capture pocket gophers, we placed homemade live-traps (Baker and Williams 1972) and Macabee kill traps in their tunnels.

Similar to squirrels, sightings were the primary method we obtained information on porcupines. In addition, we recorded localities where we observed diagnostic signs, such as stripped bark on trees with fecal pellets of porcupines on the ground below.

In addition to conducting surveys in natural habitats in the park, we set traps to capture rodents in places associated with humans such as buildings, the underground lunchroom of Carlsbad Cavern, and areas around the Sewage Disposal Ponds. In these cases, we used Sherman live-traps and snap traps (Museum Specials).

Other mammals. We recorded all sightings of lagomorphs, carnivores, and ungulates during our visits to the park from 1973 to 2000. Most observations of carnivores were obtained while we drove along roads at night, and during those times we used a hand-held spotlight to help observe mammals. Because many sightings of carnivores occurred on the paved road between Whites City and the Visitor Center, we conducted a study along this road to gather information on seasonal activity. While driving this road at night in 1991, we recorded all carnivores and other mammals seen during midwinter, late winter/early spring, mid-spring, and midsummer. Occasionally we attempted to capture carnivores by setting Havahart traps along canyon floors on the reef and along the stream at Rattlesnake Springs. Some additional infor-

mation was gathered on carnivores by salvaging road kills.

Museum Specimens

Our voucher specimens from the park are housed in the Museum of Southwestern Biology at the University of New Mexico, Albuquerque (MSB). We deposited 558 specimens into the collection, plus ca. 9,000 additional specimens of young Brazilian free-tailed bats (*Tadarida brasiliensis*) from Carlsbad Cavern. The young bats represent nonvolant individuals that had fallen from the maternity roost; they were collected from 1973 to 1976. At MSB, there are 14 additional specimens from the park that were collected by other investigators.

Locality descriptions. For each collection site, we recorded distance and direction of the site from permanent features on quadrangle maps. Distances were calculated to the nearest 0.01 mile and were measured from centers of symbols representing the Visitor Center, Sewage Disposal Ponds, cave entrances, springs, buildings, and the post office in Whites City (Fig. 4). For animals captured in traplines, localities were based on measurements taken near centers of traplines. For most localities, we also recorded the legal land description and elevation. Elevations were recorded in feet, converted to the nearest 5 meters, and reported throughout the text in metric and English units. For determination of localities, we used the following quadrangle maps of the United States Geological Survey (7.5 minute series, topographic): Rattlesnake Spring 1978, Grapevine Draw 1978, Gunsight Canyon 1979, Serpentine Bends 1979, Queen 1979, Carlsbad Caverns 1979, and Black River Village 1979. Locality information for sightings was determined in the same manner as those described for museum specimens.

Voucher specimens collected by others. Before our investigations, numerous specimens of mammals from the park already had been deposited in various museums in the United States. To verify identification of these specimens and to collect information from specimen tags and notes of previous investigators, we visited the following museums or re-

TABLE 5. Museum specimens of mammals from Carlsbad Caverns National Park. Acronyms of museums follow Hafner *et al.* (1997; see *Museum Specimens* in *Methods and Materials*).

Museum	Number of specimens
AMNH	7
CACA	225
KU	253
LACM	9
MSB	572 ^a
TCWC	6
TTU	55
USNM	70
UTEP	1

^aThe Museum of Southwestern Biology (MSB) also has ca. 9,000 fluid-preserved young of *Tadarida brasiliensis* from Carlsbad Cavern.

ceived their specimens via loans: Museum of Southwestern Biology (MSB), Natural History Collection at Carlsbad Caverns National Park (CACA), United States National Museum of Natural History (USNM), University of Kansas Museum of Natural History (KU), Museum of Texas Tech University (TTU), Texas Cooperative Wildlife Collection at Texas A & M University (TCWC), and American Museum of Natural History (AMNH). The only specimens from these museums that we did not examine were several *Tadarida brasiliensis* (three from TCWC and one from AMNH).

The Natural History Museum of Los Angeles County (LACM) and Centennial Museum at the University of Texas at El Paso (UTEP) also contained specimens from the park. Although we were unable to visit these museums or examine specimens (nine *T. brasiliensis* and one *Bassariscus astutus*, respectively), we did obtain necessary information for each specimen. Number of voucher specimens housed at each museum is shown in Table 5.

Comments on obtaining reproductive information. For pregnant females kept as voucher specimens, we recorded number of embryos or fetuses present and measured

crown-to-rump length of the largest one. For females with tiny embryos, we measured only the largest uterine swelling; this measurement was either a diameter or length, depending on whether the swelling was round or oblong. In *Accounts of Species*, we state if each measurement refers to a crown-to-rump length or size of a uterine swelling. For males kept as voucher specimens, we measured the length of one testis to the nearest 0.5 mm.

Although most information on reproduction and age was recorded while preparing study skins, additional information was obtained from individuals that were released at capture sites (e.g., females in lactation, males with scrotal testes, young bats with cartilaginous plates present in their finger joints, individuals having small body size, *Peromyscus* in juvenal gray pelage, and *Peromyscus* in postjuvenal molt).

Format of *Accounts of Species*

Accounts of Species include 63 contemporary species, five extirpated species, and 11 species with uncertain status with respect to their occurrence in the park. Each account is headed by the scientific name of the species and followed by its common name. Generic, specific, and common names are based on Baker *et al.* (2003b).

For all contemporary species, each account begins with information about the distribution of the species in New Mexico. These introductory remarks are followed by a description of the distribution of the species in the park. Accounts also include information on reproduction and other aspects of natural history. Unless otherwise stated, all reproductive data are based on animals collected in the park and are presented under subheadings titled *Reproduction*. Next, under subheadings titled *Taxonomic remarks*, we give subspecific designations of contemporary species, and here we also include other comments concerning nomenclature and comments on identification.

Distribution maps are provided for 55 of the 63 contemporary species and are based on localities listed under *Museum specimens* and *Additional records*. For extirpated species, we

present evidence that confirms or supports the conclusion that each species did inhabit the park in the past, and for species with uncertain status, we describe where each species is likely to be discovered in the park.

Museum specimens. Mammals that have been collected in the park, preserved as specimens, and stored in museums are listed at the end of each account. Localities are given as they appear on specimen tags; however, we occasionally inserted additional information in brackets to clarify certain locations. For example, during Bailey's early survey of mammals in and around Carlsbad Cavern, each of his specimens was labeled "Carlsbad Cave," whether the individual was collected inside, outside, or away from the cavern. Only in a few instances did the specimen tag provide specific details on where the animal was obtained; however, specific localities almost always were noted in his personal catalog. Using brackets, we included this additional information from his catalog in localities given herein.

For each locality, the number of museum specimens is shown in parentheses, along with the institutional abbreviation of where specimens are housed (abbreviations follow Hafner *et al.* 1997). In accounts of rodents, there is an additional number after the parentheses. These numbers are italicized and correspond to bold-faced numbers in Appendix 4. Numbers can be used to determine the precise location of symbols on distribution maps.

Distribution maps for bats are based only on surface records. Maps do not show records from caves because the National Park Service requested that we do not show the location of caves, except Carlsbad Cavern and Slaughter Canyon Cave. Although records from caves are not plotted on maps, each record is listed in the account.

Localities are listed in the following order. Specimens from the reef are listed first, followed by those from the seabed. Within the seabed, specimens obtained along the base of the escarpment are listed before those from Rattlesnake Springs. In general, localities are listed from east to west within an area or region. The only exception to this scheme is in

accounts of bats where records from caves are placed together before other records.

Additional records. Below localities given for museum specimens, we list records of occurrence documented by means other than museum specimens. These records include localities where animals were captured alive and released or where animals were observed at a distance. Also included here are (1) records reported in scientific literature, (2) those based on interviews with park employees and other persons associated with the park, (3) those based on field notes of previous investigators, and (4) records reported in park documents. Park documents include *Wildlife Reports* on file at the park. Most of these reports dealt with larger mammals,

and we included them only if we believed that the information was accurate.

With few exceptions, localities of additional records are listed only if no museum specimen is known from that location. For each locality, the type of record is indicated in parentheses, including dates and people involved. In accounts of most carnivores, there is an italicized letter after the parentheses; these letters correspond to letters contained in symbols on distribution maps. In accounts of ungulates, dates on distribution maps correspond to dates in *Additional records*. In accounts of rodents, italicized numbers after parentheses correspond to bold-faced numbers in Appendix 4. Additional records are listed in the same order as those described for museum specimens.

RESULTS OF SURVEYS

In this section we summarize our overall success in conducting surveys of mammals in Carlsbad Caverns National Park. However, further interpretation of these results and other specific information not included below are presented in *Accounts of Species*. Below we also indicate whether each species is documented from both major regions of the park (seabed and reef) or is known only from one. For those only found in one region, we briefly discuss the likelihood of the species being discovered in the other region.

Shrews. We captured only one species of shrew in the park—*Notiosorex crawfordi*. A single individual was captured in a pitfall trap on the reef. None was captured in pitfall traps on the seabed at Rattlesnake Springs or in Sherman live-traps throughout the park. Two other records of *N. crawfordi* are known from the park, and both also are from the reef.

Bats. Of 15 species of bats known to occur in the park, we captured 13 from 1973 to

2000. *Nyctinomops femorosaccus* and *N. macrotis* were the two species we did not capture. The most recent record for both species is 1956. Based on previous records, *N. macrotis* is known from both regions of the park, and *N. femorosaccus* is known only from the reef.

We documented 13 species by capturing 743 individuals over water holes (Tables 6-8), 99 individuals among trees (Table 6), and nine individuals on buildings (Table 9). Of the 13 species, ten were captured in both regions of the park and three in only one region (*Lasionycteris noctivagans*, *Lasiurus borealis*, and *Myotis ciliolabrum*). Although *L. noctivagans* and *L. borealis* were captured only on the seabed during our study, each is known from the other region based on previous records. In summary, all species of bats have been documented from habitats on the seabed and reef except *N. femorosaccus* and *M. ciliolabrum* (Table 10). Thus far, both of these species are known only from the reef.

TABLE 6. Captures of bats on the seabed at Sewer Lagoon Tank and Rattlesnake Springs. At Rattlesnake Springs, nets were set over the rock-lined storage pond (= Rattlesnake Spring), over the small pond in the adjacent woodlot, beneath the canopy of trees in front yard of ranger station, and under and next to canopies of trees in the orchard. Numbers indicate total number of individuals captured at each netting site during the study. Numbers in parentheses represent number of nights each site was netted.

Species	Sewer Lagoon Tank (4)	Rattlesnake Springs			
		Storage pond (14)	Woodlot pond (1)	Front yard (15)	Orchard (5)
<i>Myotis velifer</i>	15	21	—	15	2
<i>Myotis thysanodes</i>	—	2	2	11	2
<i>Myotis californicus</i>	—	4	—	17	—
<i>Pipistrellus hesperus</i>	22	11	—	—	—
<i>Eptesicus fuscus</i>	1	16	—	1	—
<i>Lasiurus cinereus</i>	2	11	—	4	—
<i>Lasiurus borealis</i>	—	3	—	1	—
<i>Corynorhinus townsendii</i>	—	1	—	7	3
<i>Antrozous pallidus</i>	5	10	—	18	15
<i>Tadarida brasiliensis</i>	294	122	—	3	—

TABLE 7. Captures of *Myotis* over water holes on the reef. Numbers indicate total number of individuals captured at each water hole during the study. Numbers in parentheses represent number of nights each site was netted.

Water holes	<i>Myotis velifer</i>	<i>Myotis thysanodes</i>	<i>Myotis californicus</i>	<i>Myotis ciliolabrum</i>	<i>Myotis volans</i>
Indian Shelter Exhibit (2)	1	—	1	—	—
Grammer Pool (2)	1	3	1	—	—
Oak Spring (3)	—	—	—	—	—
Spider Cave Seep (2)	—	—	2	—	—
Exhibit 13 (1)	—	—	—	—	—
Lowe Spring (1)	—	—	—	—	—
Upper Lowe Spring (3)	—	—	—	1	—
Slaughter Pothole (1)	—	1	—	—	—
Dog Pen Seep (2)	—	—	—	—	—
Dog Pen Pool (1)	—	—	—	1	—
Longview Spring (3)	—	3	—	2	1
Putman Tank (1)	—	—	—	—	—
Putman Pool (1)	—	1	—	1	—

TABLE 8. Captures of *Pipistrellus*, *Eptesicus*, *Lasiurus*, *Corynorhinus*, *Antrozous*, and *Tadarida* over water holes on the reef. Numbers indicate total number of individuals captured at each water hole during the study. Numbers in parentheses represent number of nights each site was netted.

Water holes	<i>Pipistrellus hesperus</i>	<i>Eptesicus fuscus</i>	<i>Lasiurus cinereus</i>	<i>Corynorhinus townsendii</i>	<i>Antrozous pallidus</i>	<i>Tadarida brasiliensis</i>
Indian Shelter Exhibit (2)	1	—	1	—	3	14
Grammer Pool (2)	12	1	—	1	5	—
Oak Spring (3)	—	—	—	—	—	4
Spider Cave Seep (2)	13	—	—	—	1	—
Exhibit 13 (1)	1	2	—	—	5	4
Lowe Spring (1)	—	—	—	—	—	—
Upper Lowe Spring (3)	1	—	—	—	—	—
Slaughter Pothole (1)	4	—	—	1	—	—
Dog Pen Seep (2)	—	—	—	—	—	—
Dog Pen Pool (1)	3	—	—	—	—	—
Longview Spring (3)	54	15	—	1	13	—
Putman Tank (1)	—	—	—	—	—	—
Putman Pool (1)	10	9	—	2	—	—

TABLE 9. Dates that bats were documented using human-made structures at Rattlesnake Springs.

Species	Pump house	Ranger station	Tool shed	Adobe garage
<i>Myotis velifer</i>	—	7 April 2000	13 March 1991	24 April 1951
<i>Myotis thysanodes</i>	30 May 1984 17 June 1986	23 May 1992 —	— —	10 October 1951 —
<i>Myotis volans</i>	13 August 1991	—	—	—
<i>Lasionycteris noctivagans</i>	20 May 1951 4 December 1959 13 March 1991	— — —	— — —	— — —
<i>Eptesicus fuscus</i>	16 August 1990	—	—	—
<i>Corynorhinus townsendii</i>	—	10 December 2000	—	—
<i>Antrozous pallidus</i>	August 1978	—	—	19 May 1951
<i>Nyctinomops macrotis</i>	27 May 1955	—	—	—

TABLE 10. Distribution of bats in the two major regions of Carlsbad Caverns National Park, the seabed and reef.

Species known from seabed and reef	Species known only from reef
<i>Myotis velifer</i>	<i>Myotis ciliolabrum</i>
<i>Myotis thysanodes</i>	<i>Nyctinomops femorosaccus</i>
<i>Myotis californicus</i>	
<i>Myotis volans</i>	
<i>Lasionycteris noctivagans</i>	
<i>Pipistrellus hesperus</i>	
<i>Eptesicus fuscus</i>	
<i>Lasiurus cinereus</i>	
<i>Lasiurus borealis</i>	
<i>Corynorhinus townsendii</i>	
<i>Antrozous pallidus</i>	
<i>Tadarida brasiliensis</i>	
<i>Nyctinomops macrotis</i>	
TOTAL = 13	TOTAL = 2

TABLE 11. Distribution of rodents in the two major regions of Carlsbad Caverns National Park, the seabed and reef. For species inhabiting the seabed, information in parentheses indicates if a species occurs along the base of the escarpment (B), at Rattlesnake Springs (RS), or in both areas.

Species known from seabed and reef	Species known only from seabed	Species known only from reef
<i>Spermophilus variegatus</i> (B & RS)	<i>Spermophilus mexicanus</i> (B & RS)	<i>Neotamias canipes</i>
<i>Thomomys bottae</i> (B & RS)	<i>Spermophilus spilosoma</i> (B only)	<i>Ammospermophilus interpres</i>
<i>Perognathus flavus</i> (B & RS)	<i>Cratogeomys castanops</i> (B & RS)	<i>Chaetodipus nelsoni</i>
<i>Chaetodipus hispidus</i> (B & RS)	<i>Dipodomys spectabilis</i> (B & RS) ^a	<i>Peromyscus nasutus</i>
<i>Reithrodontomys megalotis</i> (B & RS)	<i>Dipodomys merriami</i> (B & RS) ^a	<i>Neotoma mexicana</i>
<i>Peromyscus pectoralis</i> (B only)	<i>Reithrodontomys montanus</i> (B & RS)	<i>Mus musculus</i>
<i>Peromyscus boylii</i> (B only)	<i>Peromyscus eremicus</i> (B only)	
<i>Onychomys arenicola</i> (B & RS)	<i>Peromyscus leucopus</i> (B & RS) ^a	
<i>Sigmodon hispidus</i> (B & RS)	<i>Peromyscus maniculatus</i> (B only)	
<i>Neotoma leucodon</i> (B & RS)	<i>Neotoma micropus</i> (B & RS) ^a	
<i>Erethizon dorsatum</i> (B & RS)		
TOTAL = 11	TOTAL = 10	TOTAL = 6

^aEarly records from the reef (1924 for *D. spectabilis*, 1924 and 1959 for *D. merriami*, 1924 for *P. leucopus*, and 1924 and 1930 for *N. micropus*) are not included, see *Accounts of Species and Discussion*.

Five species of bats (*Myotis velifer*, *M. thysanodes*, *M. californicus*, *Corynorhinus townsendii*, and *Antrozous pallidus*) were captured regularly under canopies of trees at Rattlesnake Springs (Table 6). These data suggest that some individuals forage under tree canopies. Because little is known about foraging habits of New Mexican bats, Rattlesnake Springs would provide an informative site to study this aspect of bat behavior.

Many species of bats use buildings for daytime shelters and as places to temporarily rest at night. By searching inside and outside human-made structures at Rattlesnake Springs, we discovered bats roosting on the pump house, ranger station, and tool shed. In the 1950s, bats also roosted in an adobe garage at the west end of the picnic area. Thus far, eight species have been documented using buildings at Rattlesnake Springs (Table 9). Locations of these buildings are shown in Fig. 23.

Caves also are used by bats for shelter. In fact, evidence exists that all 15 species of bats in the park have either entered Carlsbad Cavern or have been discovered in its large natural opening. For 13 species, individuals have been captured alive in the cavern or its entrance, but for *M. volans* and *M. ciliolabrum*, evidence of past use is based solely on skulls of unknown age. Species of bats that have been documented in caves other than Carlsbad Cavern include *M. thysanodes*, *M. ciliolabrum*, *P. hesperus*, *E. fuscus*, *L. cinereus*, *L. borealis*, *C. townsendii*, and *A. pallidus*.

In the past, *M. yumanensis* has been considered part of the mammalian fauna of the park (Baker 1962). However, we did not include *M. yumanensis* as a contemporary species in this volume (see *Species with Uncertain Status*).

Lagomorphs. Thus far, only two species of lagomorphs have been confirmed in the park—*Sylvilagus audubonii* and *Lepus californicus*.

TABLE 12. Rates of capture of *Chaetodipus nelsoni*, *Reithrodontomys megalotis*, *Peromyscus pectoralis*, and *Peromyscus boylii* in eight habitats on the reef. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Chaetodipus nelsoni</i> (2)	<i>Reithrodontomys megalotis</i> (1)	<i>Peromyscus pectoralis</i> (137)	<i>Peromyscus boylii</i> (17)
<i>Face of escarpment</i>					
1. Exposed slopes	B	—	—	28.0	—
	C	0.6	—	11.0	—
	D	2.2	—	4.3	—
2. Gullies and ravines	C	—	—	7.9	—
	D	—	—	5.9	—
<i>Summits</i>					
1. Juniper peneplain	A	—	—	27.6	—
	B	—	—	28.0	—
	D	—	—	6.7	—
2. Grassy-oak areas	C	—	—	2.1	0.5
3. Pine-juniper woodland	A	—	—	—	17.0
	C	—	—	—	23.3
	D	—	—	—	—
<i>Canyon floors</i>					
1. Desert-scrub areas	A	—	—	28.0	—
	C	—	—	12.0	—
	D	—	—	2.0	—
2. Grassy areas	A	—	—	22.0	—
	B	—	2.0	34.0	—
	C	—	—	9.6	—
	D	—	—	4.2	—
<i>Water holes</i>	C	—	—	2.5	—
	D	—	—	—	—

Both species occur on the seabed and reef, and through the years, we observed many individuals of each species in both regions of the park.

Rodents. Of 27 species of rodents inhabiting the park, only *Mus musculus* has not

been documented in recent years (most recent record = 1949). Records of the remaining species (5 sciurids, 2 geomyids, 5 heteromyids, 13 murids, and 1 erethizontid) are available from the 1990s. Based on records from 1991 to 2000 and those of *M. musculus* from 1949, 11 species

TABLE 13. Rates of capture of *Onychomys arenicola*, *Sigmodon hispidus*, and *Neotoma leucodon* in eight habitats on the reef. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Onychomys arenicola</i> (2)	<i>Sigmodon hispidus</i> (3)	<i>Neotoma leucodon</i> (8)
<i>Face of escarpment</i>				
1. Exposed slopes	B	—	—	—
	C	—	—	0.6
	D	—	—	—
2. Gullies and ravines	C	—	—	0.9
	D	—	—	—
<i>Summits</i>				
1. Juniper peneplain	A	3.4	—	—
	B	—	—	—
	D	—	—	—
2. Grassy-oak areas	C	—	—	—
3. Pine-juniper woodland	A	—	—	—
	C	—	—	—
	D	—	—	—
<i>Canyon floors</i>				
1. Desert-scrub areas	A	—	—	8.0
	C	—	—	—
	D	—	—	2.0
2. Grassy areas	A	—	—	—
	B	—	—	—
	C	—	2.4	1.6
	D	—	—	—
<i>Water holes</i>				
	C	—	—	—
	D	—	—	6.7

live in both regions of the park, ten are known only from the seabed, and six only from the reef (Table 11). Localities where rodents have been collected or sighted in the park are listed in Appendix 4.

Of the park's five species of squirrels, *Spermophilus variegatus* is the only species

inhabiting both regions. *Spermophilus mexicanus* and *S. pilosoma* have been confirmed only on the seabed, and *Ammospermophilus interpres* and *Neotamias canipes* only on the reef.

Only two species of pocket gophers occur in the park—*Cratogeomys castanops* and

TABLE 14. Rates of capture of *Peromyscus* and *Neotoma* on canyonsides at various elevations. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer). Elevations of habitats are given in meters and feet.

Habitat meters (feet)		<i>Peromyscus</i> <i>pectoralis</i> (55)	<i>Peromyscus</i> <i>boylii</i> (20)	<i>Peromyscus</i> <i>nasutus</i> (10)	<i>Neotoma</i> <i>leucodon</i> (4)	<i>Neotoma</i> <i>mexicana</i> (2)
<i>Canyonsides</i>						
1. Exposed slopes						
1,220-1,370 (4,000-4,500)	A	10.0	—	—	—	—
	B	8.0	—	—	4.0	—
	C	14.0	—	—	—	—
2. Gullies and ravines						
1,310-1,370 (4,300-4,500)	A	18.0	—	—	2.0	—
1,525-1,615 (5,000-5,300)	C	9.4	—	—	—	—
1,755-1,905 (5,750-6,250)	A	—	—	—	—	2.1
	D	0.9	6.4	—	0.9	—
3. Rock outcrops						
1,310 (4,300)	B	36.0	—	—	—	—
	C	12.0	—	—	—	—
1,705-1,735 (5,600-5,700)	C	8.0	—	—	1.3	—
1,800-1,950 (5,900-6,400)	A	4.0	8.0	4.0	—	2.0
	C	—	10.0	—	—	—
4. Cliffs						
1,280 (4,200)	A	24.0	—	—	—	—
1,645 (5,400)	C	4.0	—	—	—	—
1,920 (6,300)	A	—	20.0	20.0	—	—

Thomomys bottae. All records of *C. castanops* are from the seabed, while *T. bottae* has been trapped in both regions.

In the early 1990s, rats and mice of the families Heteromyidae and Muridae were the most commonly trapped rodents in the park, and their abundance in 26 habitats is shown in Tables 12-19. These tables are based on a total of 685 animals captured in 3,632 trap nights (overall 19% trapping success). Because trapping success was noticeably higher in winter than summer, rates of capture are reported by season. Important supplementary information on distribution was obtained by salvaging road kills of *Perognathus flavus* and *Chaetodipus hispidus* on the reef.

Based on data from the 1990s, two heteromyids (*P. flavus* and *C. hispidus*) and six mu-

rids (*Reithrodontomys megalotis*, *Peromyscus pectoralis*, *P. boylii*, *Onychomys arenicola*, *Sigmodon hispidus*, and *Neotoma leucodon*) inhabit both regions of the park; two heteromyids (*Dipodomys spectabilis* and *D. merriami*) and five murids (*R. montanus*, *P. eremicus*, *P. leucopus*, *P. maniculatus*, and *N. micropus*) occur only on the seabed; and one heteromyid (*C. nelsoni*) and two murids (*P. nasutus* and *N. mexicana*) occur only on the reef (Table 11).

Erethizon dorsatum occurs on the seabed and reef. We observed this large rodent 13 times on the reef and many times on the seabed at Rattlesnake Springs. We only observed one individual on the seabed that was not at Rattlesnake Springs.

Carnivores. Of 13 species of carnivores inhabiting the park, we observed seven from

TABLE 15. Rates of capture of heteromyid rodents on the seabed along base of escarpment. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Perognathus flavus</i> (24)	<i>Chaetodipus hispidus</i> (4)	<i>Dipodomys spectabilis</i> (11)	<i>Dipodomys merriami</i> (31)
<i>Desert scrubland</i>					
1. Open areas	A	0.8	—	1.6	8.9
	B	2.8	—	—	2.8
	C	—	—	—	—
	D	1.1	—	1.1	8.0
2. Grassy areas	A	—	—	—	1.2
	B	3.1	—	—	3.1
	C	—	2.0	—	—
	D	8.0	—	—	—
<i>Arid grassland</i>	A	6.0	—	—	6.0
	B	9.2	—	4.6	1.5
<i>Juniper plain</i>	B	—	—	7.7	7.7
	C	—	1.6	—	—
	D	2.0	—	2.0	2.0
<i>Alluvial fans</i>	C	2.6	1.8	—	—
<i>Drainage areas</i>					
1. Arroyos	A	—	—	—	—
	B	—	—	—	—
	C	—	—	—	—
	D	4.0	—	—	—
2. Wide draws	A	—	—	—	—
	B	—	—	—	—
	C	—	—	—	—

1973 to 2000 (*Procyon lotor*, *Bassariscus astutus*, *Urocyon cinereoargenteus*, *Mephitis mephitis*, *Conepatus leuconotus*, *Mustela frenata*, and *Canis latrans*). Although we never observed the other six (*Vulpes macrotis*, *Ursus americanus*, *Taxidea taxus*, *Spilogale gracilis*, *Puma concolor*, and *Lynx rufus*), each was documented in the park in the 1990s, except *S. gracilis* (most recent record = 1985). Each species of carnivore has been observed in both regions of the park, except *V. macrotis*, *U. americanus*, *C. leuconotus*, and *S. gracilis*.

Thus far, these four have been reported only from the reef.

Of our 508 sightings in the park (204 *P. lotor*, 157 *B. astutus*, 82 *U. cinereoargenteus*, 40 *M. mephitis*, 22 *C. leuconotus*, 2 *C. latrans*, and 1 *M. frenata*), most occurred while we drove between Whites City and the Visitor Center (93%; 474 out of 508). At least some individuals, and perhaps many, were observed more than once. Seasonal activity (midwinter-midsummer) of three species is shown in Fig. 41. In 1991, most observations of *U. cinereoar-*

TABLE 16. Rates of capture of *Reithrodontomys*, *Onychomys*, *Sigmodon*, and *Neotoma* on the seabed along base of escarpment. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Reithrodontomys megalotis</i> (3)	<i>Reithrodontomys montanus</i> (6)	<i>Onychomys arenicola</i> (32)	<i>Sigmodon hispidus</i> (15)	<i>Neotoma leucodon</i> (11)	<i>Neotoma micropus</i> (11)
<i>Desert scrubland</i>							
1. Open areas	A	—	—	5.6	—	—	—
	B	—	—	2.8	—	—	—
	C	—	—	—	—	—	1.3
	D	—	—	—	—	—	—
2. Grassy areas	A	—	—	13.6	2.5	—	3.7
	B	—	4.7	4.7	—	—	3.1
	C	—	2.0	—	—	—	—
	D	—	—	—	—	—	—
<i>Arid grassland</i>	A	6.0	—	10.0	22.0	—	2.0
	B	—	3.1	3.1	3.1	—	—
<i>Juniper plain</i>	B	—	—	—	—	3.8	5.8
	C	—	—	—	—	—	1.6
	D	—	—	2.0	—	8.0	—
<i>Alluvial fans</i>	C	—	—	0.9	—	0.9	—
<i>Drainage areas</i>							
1. Arroyos	A	—	—	4.0	—	—	—
	B	—	—	—	—	—	—
	C	—	—	—	—	1.6	—
	D	—	—	—	—	—	—
2. Wide draws	A	—	—	—	—	—	—
	B	—	—	—	—	8.0	—
	C	—	—	—	—	—	—

genteus occurred in mid-spring, and most observations of *B. astutus* and *P. lotor* occurred in late winter/early spring. Fewest individuals of each species were observed either in midwinter or midsummer. No information on seasonal activity was collected in autumn.

Ungulates. Five species of ungulates occur in the park today, and we observed four of them during our visits from 1973 to 2000—

Pecari tajacu, *Odocoileus hemionus*, *Cervus canadensis*, and *Ammotragus lervia*. Although we did not observe *Antilocapra americana* in or near the park, individuals were reported near the park's boundary in the early 1990s. The most recent sighting of this species in the park was in 1965. *Pecari tajacu* and *O. hemionus* occur in both regions of the park, *C. canadensis* and *A. lervia* are known only from

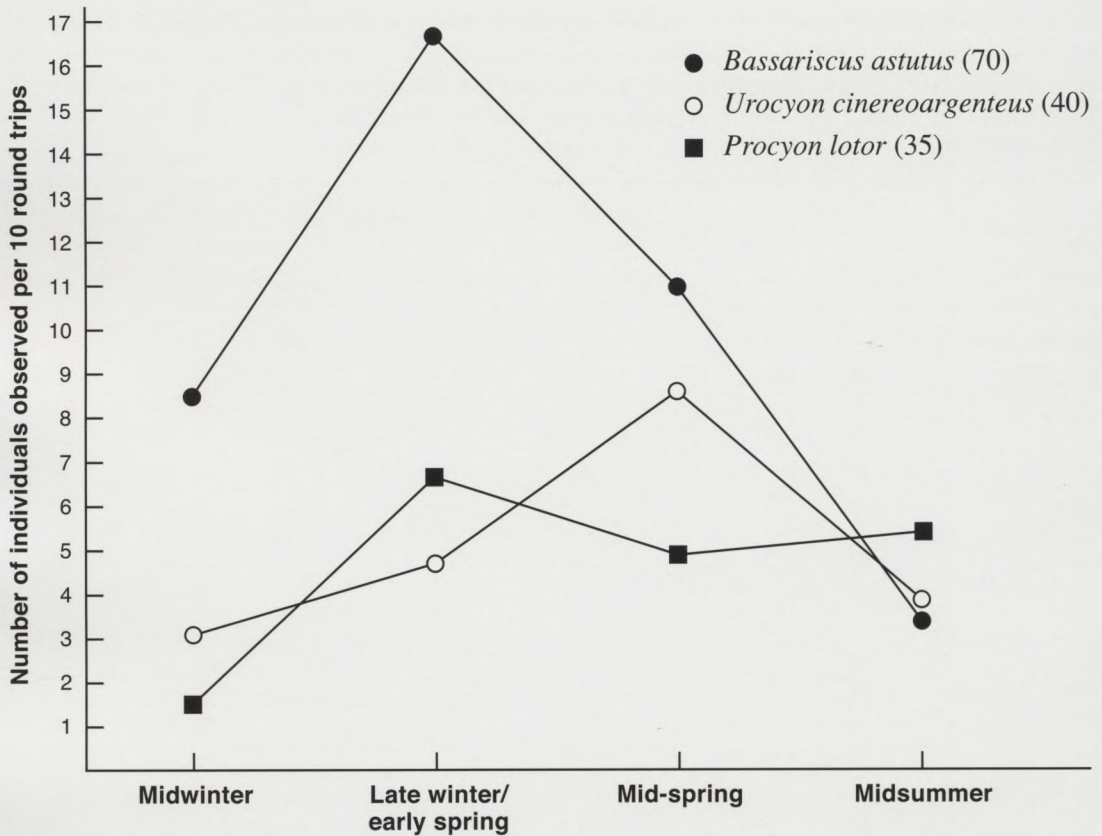


Fig. 41. Seasonal activity of carnivores at Carlsbad Caverns National Park from midwinter to midsummer in 1991. Activity is based on sightings made at night while we drove from the park's east entrance by Whites City to residences near the large natural opening to Carlsbad Cavern (one round trip equals 19.9 km or 12.4 mi). Total number of animals observed is shown in parentheses. Observations are based on 13 round trips in midwinter (16 January-13 February), 15 in late winter/early spring (8-28 March), 24.5 in mid-spring (21 April-27 May), and 20.5 in midsummer (18 July-14 August).

the reef, and *A. americana* is known only from the seabed.

Likelihood of a species being discovered in the other region. Of the 63 contemporary species of mammals in the park, 37 (59%) are known from both major regions of the park, 11 (17%) are known only from the seabed, and 15 (24%) are known only from the reef (Table 20). With additional surveys, we believe that additional species will be documented from both regions.

For 11 species known only from the seabed (10 species of rodents and *A. americana*), the possibility exists for each to enter the reef, especially at mouths of canyons. At these locations, habitats of the seabed are continuous or in proximity to those along canyon floors.

Thus, some of these species may eventually be discovered on canyon floors, especially near mouths of major canyons. Interestingly, four species of rodents that seem restricted to the seabed today once occurred in habitats of the reef (*D. spectabilis*, *D. merriami*, *P. leucopus*, and *N. micropus*; see *Accounts of Species and Discussion*).

Of 15 species known only from the reef, the possibility of them inhabiting the seabed varies greatly from species to species. Those species least likely to occur on the seabed include ones most confined to high elevations on the reef, such as *N. canipes*, *P. nasutus*, and *N. mexicana*. However, isolated populations of these species still may be discovered on the seabed. For example, *P. boylii* also was com-

TABLE 17. Rates of capture of *Peromyscus* on the seabed along base of escarpment. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Peromyscus</i> <i>eremicus</i> (3)	<i>Peromyscus</i> <i>leucopus</i> (45)	<i>Peromyscus</i> <i>maniculatus</i> (12)	<i>Peromyscus</i> <i>pectoralis</i> (56)	<i>Peromyscus</i> <i>boylii</i> (4)
<i>Desert scrubland</i>						
1. Open areas	A	0.8	0.8	2.4	4.8	—
	B	—	—	5.6	2.8	—
	C	—	—	—	—	—
	D	—	—	—	—	—
2. Grassy areas	A	—	9.9	1.2	2.5	—
	B	—	15.6	1.6	—	—
	C	—	2.0	—	—	—
	D	—	—	—	—	—
<i>Arid grassland</i>	A	—	16.0	6.0	—	—
	B	—	3.1	—	3.1	—
<i>Juniper plain</i>	B	1.9	17.3	3.8	9.6	1.9
	C	—	—	—	3.1	—
	D	—	4.0	—	—	—
<i>Alluvial fans</i>	C	—	2.6	—	1.8	—
<i>Drainage areas</i>						
1. Arroyos	A	—	—	—	20.0	—
	B	—	—	—	3.6	10.7
	C	—	—	—	12.8	—
	D	—	—	—	—	—
2. Wide draws	A	5.0	5.0	—	20.0	—
	B	—	—	—	32.0	—
	C	—	—	—	12.5	—

mon only in wooded areas at high elevations in the park, but in 1991 we discovered an isolated population in a rocky arroyo crossing the seabed. Although *N. canipes*, *P. nasutus*, and *N. mexicana* are most common in mountainous situations in New Mexico, each also lives at lower elevations in habitats not associated with mountains (Findley *et al.* 1975).

At the other extreme, five species likely will be discovered on the seabed in the future

—*N. crawfordi*, *A. interpres*, *V. macrotis*, *C. leuconotus*, and *S. gracilis*. *Notiosorex crawfordi* probably will be captured in several habitats on the seabed with use of pitfall traps. *Ammospermophilus interpres* is known from seabed habitats south of the park in Guadalupe Mountains National Park (Genoways *et al.* 1979), and it should be looked for on the juniper plain, in rocky arroyos, and wide draws in Carlsbad Caverns National

TABLE 18. Rates of capture of heteromyid rodents on the seabed at Rattlesnake Springs. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Perognathus flavus</i> (4)	<i>Chaetodipus hispidus</i> (2)	<i>Dipodomys merriami</i> (7)
Woodlots	A	—	—	—
	B	—	—	—
	C	—	—	—
	D	—	—	—
Dense grass	A	—	—	—
	B	—	—	—
	C	—	—	—
Weedy areas	B	—	2.0	—
	C	—	—	—
<i>Shrubby areas</i>				
1. Cropped grass	A	—	—	—
2. Exposed soil	C	10.0	—	13.3
3. Desert scrub	C	3.7	—	11.1
4. Mesquite	C	—	4.0	—

Park. *Vulpes macrotis* normally occupies grasslands and deserts; thus, it is a matter of time before one will be documented from the seabed. *Conepatus leuconotus* has been observed on the seabed near the park by KNG, and with time this species will be observed on the seabed in the park. Besides habitats of the reef, *S. gracilis* probably also inhabits brushy, rocky arroyos and washes that cross the seabed.

The possibility of discovering the remaining species (*U. americanus*, *C. canadensis*, *A. lervia*, *M. ciliolabrum*, *N. femorosaccus*, *M. musculus*, and *C. nelsoni*) on the seabed is less certain. The first three species are large bodied and capable of travelling long distances. Each has been observed along canyon floors at mid-elevations in the park, and seeing an occasional wanderer on the seabed is certainly a possibility. Although *M. ciliolabrum* appears to be most abundant at high elevations in the park, a record of this species exists from the

seabed at Guadalupe Mountains National Park (Genoways *et al.* 1979). Thus, *M. ciliolabrum* may occasionally feed and drink over Rattlesnake Spring or Sewer Lagoon Tank, and all small *Myotis* from the seabed should be carefully examined. *Nyctinomops femorosaccus* is rare in New Mexico, and the capture of one on the reef most likely represents a wandering or lost individual. If this species is documented again in the park, it is just as likely to be captured on the seabed at Rattlesnake Springs or over Sewer Lagoon Tank. *Mus musculus* was last captured in 1949 in a building near the large opening of Carlsbad Cavern. Because this mouse commonly is associated with humans, it is just as likely to be captured in buildings at Rattlesnake Springs. Recent records of *C. nelsoni* are from slopes of the eastern escarpment just above the seabed. Possibly, some individuals also live on moderate slopes of alluvial fans below the escarpment.

TABLE 19. Rates of capture of murid rodents on the seabed at Rattlesnake Springs. Rates are given as number of individuals captured per 100 trap nights. Numbers in parentheses indicate total number of animals captured. Letters indicate trapping periods (A = midwinter, B = late winter/early spring, C = mid-spring, and D = midsummer).

Habitat		<i>Reithrodontomys megalotis</i> (3)	<i>Reithrodontomys montanus</i> (1)	<i>Peromyscus leucopus</i> (62)	<i>Onychomys arenicola</i> (2)	<i>Sigmodon hispidus</i> (62)	<i>Neotoma leucodon</i> (5)	<i>Neotoma micropus</i> (8)
<i>Woodlots</i>	A	—	—	53.3	—	26.7	—	—
	B	—	—	17.4	—	30.4	—	8.7
	C	—	—	28.6	—	42.9	—	—
	D	—	—	11.5	—	11.5	—	11.5
<i>Dense grass</i>	A	—	—	25.0	—	27.5	—	5.0
	B	4.4	—	11.1	—	17.8	—	—
	C	—	—	10.0	—	20.0	—	—
<i>Weedy areas</i>	B	2.0	—	34.0	—	40.0	—	—
	C	—	—	6.7	—	—	—	—
<i>Shrubby areas</i>								
1. Cropped grass	A	—	—	26.7	—	13.3	—	—
2. Exposed soil	C	—	—	10.0	3.3	—	6.7	3.3
3. Desert scrub	C	—	—	—	3.7	—	11.1	—
4. Mesquite	C	—	4.0	16.0	—	8.0	—	—

TABLE 20. Distribution of mammals in the two major regions of Carlsbad Caverns National Park, the seabed and reef.

Group	Seabed and reef	Seabed only	Reef only	TOTAL
Shrews	0	0	1	1
Bats	13	0	2	15
Lagomorphs	2	0	0	2
Rodents ^a	11	10	6	27
Carnivores	9	0	4	13
Ungulates	2	1	2	5
TOTAL	37	11	15	63

^aEarly records of *Dipodomys spectabilis* (1924), *D. merriami* (1924 and 1959), *Peromyscus leucopus* (1924), and *Neotoma micropus* (1924 and 1930) from the reef are not included, see *Accounts of Species*, *Discussion*, and Table 11.

DISCUSSION: COMPARISON OF SURVEYS OF 1924 AND 2000

Five months after Carlsbad Cavern was declared a national monument, Vernon Bailey conducted a survey of animals in the cavern and surrounding area. The survey lasted three months (March to May 1924), and results were published four years later in a monograph titled *Animal Life of the Carlsbad Cavern*. Bailey did not compile a complete list of mammals during his brief survey, but he managed to confirm many species that occur in the park today. On the reef, most of Bailey's collecting was conducted inside Carlsbad Cavern, on "limestone ridges" near Carlsbad Cavern, around Oak Spring, and along Walnut Canyon. On the seabed, information about mammals was gathered while he traveled to and from Washington Ranch and Slaughter Canyon. In addition, he obtained information by talking with local residents.

Based on Bailey's survey, a total of 39 species of mammals was confirmed within the modern boundaries of Carlsbad Caverns National Park. Those species are listed in Table 21, along with other mammals documented in the park since 1924. After comparing results of Bailey's survey to ours, we noted a significant change in population size or a shift in distribution for 12 species (in order of presentation: *Cynomys ludovicianus*, *Ovis canadensis*, *Ammotragus lervia*, *Mus musculus*, *Cervus canadensis*, *Pecari tajacu*, *Antilocapra americana*, *Peromyscus leucopus*, *Neotoma micropus*, *Dipodomys spectabilis*, *D. merriami*, and *Tadarida brasiliensis*).

By the time Bailey conducted his survey in 1924, elk (*Cervus canadensis*), bison (*Bos bison*), and grizzly bears (*Ursus arctos*) had already been eradicated from the Carlsbad region, and gray wolves (*Canis lupus*) were nearly gone. Since 1924 two additional species, the black-tailed prairie dog (*Cynomys ludovicianus*) and bighorn sheep (*Ovis canadensis*), have been extirpated from the park.

According to Bailey (1928), prairie dogs were common in lowlands below Carlsbad Cavern in 1924, but prairie dogs do not exist there today. The last known individuals near the park were observed in the early 1980s. Unfortunately, this extirpation is not surpris-

ing because prairie dogs have been deliberately eliminated over much of western North America due to the perception that they degrade rangelands (Wuerthner 1997). Today, as in the past, prairie dogs commonly are eradicated by scattering poisoned grain around burrows (Bailey 1928; Wuerthner 1997). Poisoning of *C. ludovicianus* has resulted in fragmentation of populations into small, isolated colonies which, in turn, are susceptible to extirpation through disease and loss of genetic variability (Miller *et al.* 1994; Wuerthner 1997).

In the 1920s, bighorn sheep struggled for existence in the Guadalupe Mountains (Bailey 1928, 1931), and during that time the herd was estimated to be comprised of 100-200 individuals (Gross 1960). The most recent sighting of bighorn sheep in the Guadalupe Mountains occurred in 1979. Some suggest that the initial decline of bighorn sheep in the region was due to competition for food with domestic goats (*Capra hircus*) and sheep (*Ovis aries*), introduction of diseases by domestic sheep, and hunting pressures by humans (Davis and Taylor 1939). More recently an additional strain was placed on bighorn sheep when aoudads (*Ammotragus lervia*) colonized the Guadalupe Mountains in the 1950s. Because of overlap in diet, overlap in habitat preference, and the relatively high reproductive rate of aoudads, several investigators concluded that a sympatric existence of aoudads and bighorn sheep probably would lead to the decline of bighorn sheep (Barrett 1967; Simpson *et al.* 1978; Seegmiller and Simpson 1979). Hence, before bighorn sheep can be reestablished in the park, aoudads may have to be eliminated from the Guadalupe Mountains.

Excluding domestic animals, five species of mammals documented in the park are the result of introductions by humans. Two involved unintentional introductions of individuals (aoudads and house mice), while the other three (Rocky Mountain elk, collared peccaries, and pronghorns) were intentionally introduced.

In 1943 several aoudads escaped from a ranch 135 km north-northwest of the park. Since then, their descendants have spread south, and a free-ranging population is now

TABLE 21. Mammals of Carlsbad Caverns National Park. Results of surveys completed in 1924 (Bailey 1928) and 2000 (this volume). A check mark indicates that the species was documented within the park's boundary during Bailey's survey. Dates listed in the last column indicate the most recent record of each species in the park since 1924. Species that have been extirpated from the park and species with uncertain status in the park also are indicated in the table.

Species	1924	2000
<i>Didelphis virginiana</i>	not reported in park	status uncertain
<i>Notiosorex crawfordi</i>	not reported in park	1997
<i>Cryptotis parva</i>	not reported in park	status uncertain
<i>Myotis velifer</i>	✓ ^a	2000
<i>Myotis thysanodes</i>	✓	2000
<i>Myotis californicus</i>	✓ ^a	1995
<i>Myotis ciliolabrum</i>	not reported in park	1996
<i>Myotis volans</i>	not reported in park	1991
<i>Myotis yumanensis</i>	not reported in park	status uncertain
<i>Lasionycteris noctivagans</i>	✓	1991
<i>Pipistrellus hesperus</i>	✓	1998
<i>Eptesicus fuscus</i>	✓	2000
<i>Lasiurus cinereus</i>	✓	1992
<i>Lasiurus borealis</i>	✓ ^a	1997
<i>Euderma maculatum</i>	not reported in park	status uncertain
<i>Corynorhinus townsendii</i>	not reported in park	2000
<i>Antrozous pallidus</i>	✓	2000
<i>Tadarida brasiliensis</i>	✓	2000
<i>Nyctinomops femorosaccus</i>	not reported in park	1956
<i>Nyctinomops macrotis</i>	not reported in park	1956
<i>Sylvilagus audubonii</i>	✓	1998
<i>Sylvilagus robustus</i>	not reported in park	status uncertain
<i>Lepus californicus</i>	✓	1999
<i>Neotamias canipes</i>	not reported in park	1991
<i>Ammospermophilus interpres</i>	not reported in park	2000
<i>Spermophilus variegatus</i>	✓	2000
<i>Spermophilus mexicanus</i>	not reported in park	2000
<i>Spermophilus spilosoma</i>	not reported in park	1991
<i>Cynomys ludovicianus</i>	not reported in park ^b	extirpated
<i>Thomomys bottae</i>	✓	1992
<i>Cratogeomys castanops</i>	✓ ^c	1992
<i>Perognathus flavus</i>	✓ ^c	1991
<i>Chaetodipus hispidus</i>	✓ ^c	1991
<i>Chaetodipus nelsoni</i>	not reported in park	1991
<i>Chaetodipus intermedius</i>	not reported in park	status uncertain
<i>Chaetodipus eremicus</i>	not reported in park	status uncertain
<i>Dipodomys spectabilis</i>	✓	1992
<i>Dipodomys merriami</i>	✓	1992
<i>Castor canadensis</i>	not reported in park	status uncertain
<i>Reithrodontomys megalotis</i>	not reported in park	1991
<i>Reithrodontomys montanus</i>	not reported in park	1992
<i>Peromyscus eremicus</i>	not reported in park	1991
<i>Peromyscus leucopus</i>	✓	1992

TABLE 21 continued

Species	1924	2000
<i>Peromyscus maniculatus</i>	not reported in park	1991
<i>Peromyscus pectoralis</i>	✓ ^d	1993
<i>Peromyscus boylii</i>	not reported in park ^d	1991
<i>Peromyscus nasutus</i>	not reported in park	1991
<i>Peromyscus truei</i>	not reported in park	status uncertain
<i>Onychomys arenicola</i>	✓ ^c	1991
<i>Sigmodon hispidus</i>	✓ ^c	1992
<i>Neotoma leucodon</i>	✓	1992
<i>Neotoma micropus</i>	✓	1992
<i>Neotoma mexicana</i>	not reported in park	1991
<i>Microtus mogollonensis</i>	not reported in park	status uncertain
<i>Ondatra zibethicus</i>	not reported in park	status uncertain
<i>Mus musculus</i>	not reported in park	1949
<i>Erethizon dorsatum</i>	not reported in park	2000
<i>Canis latrans</i>	✓	2000
<i>Canis lupus</i>	nearly extirpated	extirpated
<i>Vulpes macrotis</i>	not reported in park	1998
<i>Urocyon cinereoargenteus</i>	✓	2000
<i>Ursus americanus</i>	✓	1999
<i>Ursus arctos</i>	extirpated	extirpated
<i>Bassariscus astutus</i>	✓	2000
<i>Procyon lotor</i>	✓	2000
<i>Mustela frenata</i>	✓	1995
<i>Taxidea taxus</i>	✓	1992
<i>Conepatus leuconotus</i>	✓	2000
<i>Mephitis mephitis</i>	✓	2000
<i>Spilogale gracilis</i>	✓	1985
<i>Puma concolor</i>	✓	2000
<i>Lynx rufus</i>	✓	1999
<i>Pecari tajacu</i>	not reported in park	2000
<i>Odocoileus hemionus</i>	✓	2000
<i>Cervus canadensis</i>	extirpated ^e	1999 ^e
<i>Antilocapra americana</i>	not reported in park	1965 ^f
<i>Bos bison</i>	extirpated	extirpated
<i>Ovis canadensis</i>	✓	extirpated
<i>Ammotragus lervia</i>	not present in park	2000

^aBased on skulls discovered inside Carlsbad Cavern (one *M. velifer*, one *M. californicus*, and two *L. borealis*).

^bBailey reported prairie dogs 1.3 km from the present-day boundary of the park.

^cBased on skeletal material discovered in pellets of great horned owls (*Bubo virginianus*). Pellets were located below nests in the large opening of Carlsbad Cavern.

^dSpecies account of *P. boylii* in Bailey actually refers to *P. pectoralis*.

^eWhen Bailey conducted his survey in 1924, elk (*C. c. merriami*) already had been eradicated from the park. Elk observed during our survey represent the introduced subspecies *C. c. nelsoni*.

^fRepresents the most recent sighting in the park. However, pronghorns have been sighted near the park's boundary in the early 1990s.

established in the Guadalupe Mountains. Today aoudads are commonly observed in the park. The other unintentional introduction involves the ubiquitous house mouse (*Mus musculus*). In the 1930s, house mice were captured in Carlsbad Cavern, and in 1949 one was caught in a building near the cavern. Most likely, these mice were inadvertently transported to the park in shipments of supplies such as lumber, machinery, clothing, and sacks of food. House mice have been spread by this manner for centuries (Nowak and Paradiso 1983). In the 1990s, we failed to capture house mice in the park. We suspect that *M. musculus* may be transported into the park in the future or may colonize parts of the park, such as Rattlesnake Springs or lower portions of Walnut Canyon, due to proximity to other human habitations.

Merriam's elk (*Cervus canadensis merriami*) once roamed the Guadalupe Mountains in large numbers but were extirpated by the time Bailey surveyed the region in 1924. Year-round hunting by humans, including commercial market hunters, probably contributed to their extermination (Gates 1967). In the late 1920s, a different subspecies of elk (*C. c. nelsoni*) was released in the Texas portion of the Guadalupe Mountains and eventually spread into New Mexico. The current number of elk inhabiting Carlsbad Caverns National Park is unknown, but based on infrequent sightings, numbers are probably few.

Today collared peccaries (*Pecari tajacu*) are common residents of the park, occurring on the seabed and reef, but no record was known before 1986. Bailey (1931) mentioned that peccaries once were abundant in sandy habitats along the eastern edge of the Pecos River valley in southeastern New Mexico, but he never mentioned them inhabiting areas west of the river, including the Guadalupe Mountains. Peccaries were reported in the park only after 36 were released west of the park in the 1960s. However, the sighting of a peccary west of the park in 1954 suggests that a population might have inhabited the region before the introductions (Donaldson 1967). One can only speculate on the number of individuals in the region before the 1960s and the influence those individuals have had on the number of peccaries we see today.

According to Bailey (1928), pronghorns (*Antilocapra americana*) were fairly common within sight of Carlsbad Cavern. But, his examples of "within sight" included two animals seen 35 km northeast of the cavern and small herds observed in Texas at least 19.5 km south of the cavern. This suggests that pronghorns were not common or even present on park property during Bailey's survey. Only after individuals were released near Rattlesnake Springs in 1948 and 1952 were pronghorns clearly documented in the park. In recent years, however, the number of pronghorns has declined near the park, and individuals have not been seen since the early 1990s. The reason for this local decline is uncertain.

Besides changes in populations due to extirpations and introductions by humans, trapping of small mammals in the 1920s, 1950s, and 1990s also indicates that the distribution of four rodents has changed since Bailey's survey. In 1924, Bailey captured white-footed mice (*Peromyscus leucopus*), southern plains woodrats (*Neotoma micropus*), banner-tailed kangaroo rats (*Dipodomys spectabilis*), and Merriam's kangaroo rats (*D. merriami*) on the reef in and around Carlsbad Cavern. In the 1990s, however, we found no evidence of those species on the reef.

In 1924, Bailey discovered a population of *P. leucopus* living deep inside Carlsbad Cavern, but on the surface, he captured only one individual. In contrast, he found *P. pectoralis* abundant on the surface, but inside the cave, it occurred only in rooms near the natural openings. By the late 1950s, *P. pectoralis* had replaced *P. leucopus* in the cavern, and by the 1990s, we found no evidence that *P. leucopus* occurred anywhere on the reef. Today *P. leucopus* is common only in lowlands of the seabed where it is especially numerous at Rattlesnake Springs. The population of *P. leucopus* from the cavern in 1924 might represent individuals inadvertently introduced during the early 1900s when numerous supplies were constantly brought into the cavern from the lowlands.

In New Mexico, *N. micropus* is a grassland species and typically is found far away from rocks (Findley *et al.* 1975). However, in other parts of the country, it inhabits rocky

situations (Braun and Mares 1989). In 1924, Bailey caught two *N. micropus* in rocky areas near Carlsbad Cavern, and six years later, another one was obtained in the same area. Although Bailey caught those individuals on the reef, it was *N. leucodon* that he found common in that region of the park. In the 1990s, we also found *N. leucodon* common on the reef, and we caught *N. micropus* only in habitats of the seabed. In the past, *N. micropus* might have occurred naturally on the reef in small numbers, or its presence around the cavern might have been the result of individuals inadvertently introduced in shipments of supplies from the seabed.

According to Bailey (1928), *D. spectabilis* and *D. merriami* were "abundant" and "common" on high limestone ridges around Carlsbad Cavern in 1924. He captured both species on a ridge north of Carlsbad Cavern, collected *D. merriami* in Walnut Canyon, and obtained a young *D. spectabilis* from a mound near the cavern. In 1959 another investigator also captured *D. merriami* on the reef. In sharp contrast to these distributional records, we found no evidence of either species on the reef in the 1990s. We did not capture any individuals, see any crossing roads at night, or observe the conspicuous mounds of *D. spectabilis* in any habitats on the reef. In fact, we made a special effort to capture *D. merriami* at the mouth of Walnut Canyon and were unsuccessful. We trapped there because it represented the only area on the reef containing desert scrub, a habitat on the seabed where we regularly captured and observed *D. merriami*. In addition, we attempted to locate mounds constructed by *D. spectabilis* in areas around the cavern's main entrance where Bailey observed them in 1924. We did not observe any mounds in that area, and the area was rocky and contained much lechuguilla. On the seabed, we noticed that *D. spectabilis* usually avoids building mounds in areas with rocks and lechuguilla. We are not sure why *D. spectabilis* and *D. merriami* are absent from areas around the cavern today but were common there in 1924. Because changes in distribution of mammals are often associated with changes in habitat, climate, or both (e.g., Frey 1992; Hafner and Shuster 1996; Benedict *et*

al. 2000; Geluso 2004b), examination of habitats on the reef in the 1920s may lead to an understanding of why kangaroo rats have disappeared from the reef over the years (see Waser and Ayers 2003).

The last documented change in a mammalian population inhabiting the park involves the Brazilian free-tailed bat (*Tadarida brasiliensis*) in Carlsbad Cavern. Bailey never encountered large numbers of this species because most bats had not arrived from their southern wintering areas. On 5 May 1924, he estimated a population size of 12,000. The first published estimate of this population was made by Allison (1937) on 16 June 1936; he reported 8,700,000 individuals. Even if Allison's estimate was off by millions, the relatively few free-tailed bats reported in 1973 (218,000) indicate a significant decline from the 1930s (Altenbach *et al.* 1979). Studies in the 1970s showed that the pesticide DDT probably was involved in the decline (Geluso *et al.* 1976, 1981). In addition, guano mining operations in the early 1900s initially may have affected the size of the colony. Since 1973 several significant changes have occurred that hopefully will allow this species to eventually attain its former size. These changes include the ban of DDT in the United States for agricultural purposes, decreased use of DDT in Mexico, and plugging of guano shafts in Carlsbad Cavern. In 1996 the summer colony of Brazilian free-tailed bats in Carlsbad Cavern was estimated at 353,000 (Route *et al.* 1998).

Since Vernon Bailey's survey in 1924, 25 additional species of mammals have been confirmed in the park. These species include 1 shrew, 5 bats, 14 rodents, 1 carnivore, and 4 ungulates (Table 21). The importance of understanding the distribution, abundance, and types of plants and animals on public lands cannot be overstated. Results of biological surveys provide basic ecological data for making sound management decisions and for designing accurate interpretive programs for education of the general public. Carlsbad Caverns National Park is one of the most ecologically diverse parks in our national system, and we hope that information provided in this volume will stimulate additional research on mammals and other organisms in the park.

ACCOUNTS OF SPECIES

Order Insectivora

Family Soricidae

Notiosorex crawfordi (Coues, 1877)

Crawford's Desert Shrew

Most New Mexican specimens of *N. crawfordi* come from arid and semiarid regions of the state, although records are also available from other ecological situations (Findley *et al.* 1975; Findley 1987). Thus far, three records of *N. crawfordi* exist from the park; all are from dry areas on the reef.

The first record of *N. crawfordi* was obtained in the early 1940s. Although the specimen tag states August 1942, park documents indicate that the shrew might have been collected in January 1943. This individual was captured in the large opening of Carlsbad Cavern, prepared as a fluid-preserved specimen, and deposited in the United States National Museum of Natural History.

The most recent record of *N. crawfordi* also is from the large opening of Carlsbad Cavern. On 6 October 1997, a park ranger discovered a dead individual on the paved switchback trail leading into the cavern. The animal was salvaged and prepared as a museum specimen.

The third record of this species was obtained in 1991. On 19 May, we captured an adult female alive in a pitfall trap near the large natural opening of Carlsbad Cavern. The trap was located at the base of a limestone ledge on the south-facing slope of Bat Cave Draw. At an elevation of 1,335 m (4,380 ft), the trap site was surrounded by small junipers, catclaw, mescal bean, sotol, prickly pear, Spanish dagger, netleaf hackberry, oreganillo, and skeletonleaf golden-eye.

Reproduction. All three shrews from the park were females. The individual from the early 1940s had no noticeable wear on her teeth and was probably <90 days old

(Armstrong and Jones 1972). The individual collected on 6 October was older (teeth slightly worn) and showed no sign of being reproductively active. The female from 19 May had conspicuously worn teeth and was lactating; we were able to obtain milk from all six nipples located in the groin area. Presence of lateral skin glands (one on each flank) also indicated that this individual was mature (Armstrong and Jones 1972). Glands were evident as bumps between the forelimbs and hind limbs, and when touched, the surrounding area became moist and gave off a mild, skunk-like odor.

Taxonomic remarks. Prior to 2000, *Notiosorex crawfordi* was considered polytypic with two subspecies—*N. c. crawfordi* (Coues, 1877) and *N. c. evotis* (Coues, 1877). However, Carraway and Timm (2000) concluded that these subspecies actually comprised three monotypic species—*N. crawfordi*, *N. evotis*, and *N. villai*. Their conclusions were based on differences in cranial and mandibular characteristics. Recently, Baker *et al.* (2003a) concluded that *N. crawfordi* (as defined by Carraway and Timm 2000) represents at least two species based on molecular data (*N. crawfordi* and *N. cockrumi*). These species occur sympatrically in southeastern Arizona, but thus far, the only species of *Notiosorex* known in New Mexico is *N. crawfordi*.

Museum specimens (total 3); not mapped:

- 0.03 mi. E Large Natural Opening of Carlsbad Cavern, T24S, R25E, NW ¼ Sec. 31 (MSB 1);
- Large Natural Opening of Carlsbad Cavern, T24S, R25E, NW ¼ Sec. 31 (MSB 1);
- Carlsbad Caverns [in large natural opening of Carlsbad Cavern] (USNM 1).

Order Chiroptera
Family Vespertilionidae
Myotis velifer (J. A. Allen, 1890)
Cave Myotis

Cave myotis are common inhabitants of New Mexican deserts and grasslands, especially in areas containing open bodies of water (Findley 1987). In the park, they were numerous in lowlands around large water holes (i.e., Sewer Lagoon Tank and Rattlesnake Spring) and under canopies of trees near Rattlesnake Spring (Table 6).

At Rattlesnake Springs, cave myotis also have been reported in buildings—pregnant females in the adobe garage at the west end of the picnic area on 24 April 1951, an adult male in the wooden shed near the pump house on 13 March 1991, and an adult male inside the ranger station on 7 April 2000 (Table 9). Occasional use of buildings by this species has been reported by others (Fitch *et al.* 1981).

In contrast to the seabed, *M. velifer* was uncommon on the reef and occurred only at low elevations; we captured one individual each at Indian Shelter Exhibit and Grammer Pool (Table 7; Fig. 42). The only other records of *M. velifer* on the reef are from Carlsbad Cavern. Males were captured in Left Hand Tunnel on 24 June 1952 (Baker 1962), and five young and an adult male were netted in the tunnel on 6 July 2000. During the late 1990s, a pregnant female (3 July), lactating female (17 July), and an adult male (9 July) were captured in the large opening of the cavern, and adult males (15 July, $n = 1$; 29 July, $n = 3$) were netted in the small opening. Skulls of *M. velifer* also have been retrieved from the Guadalupe Room.

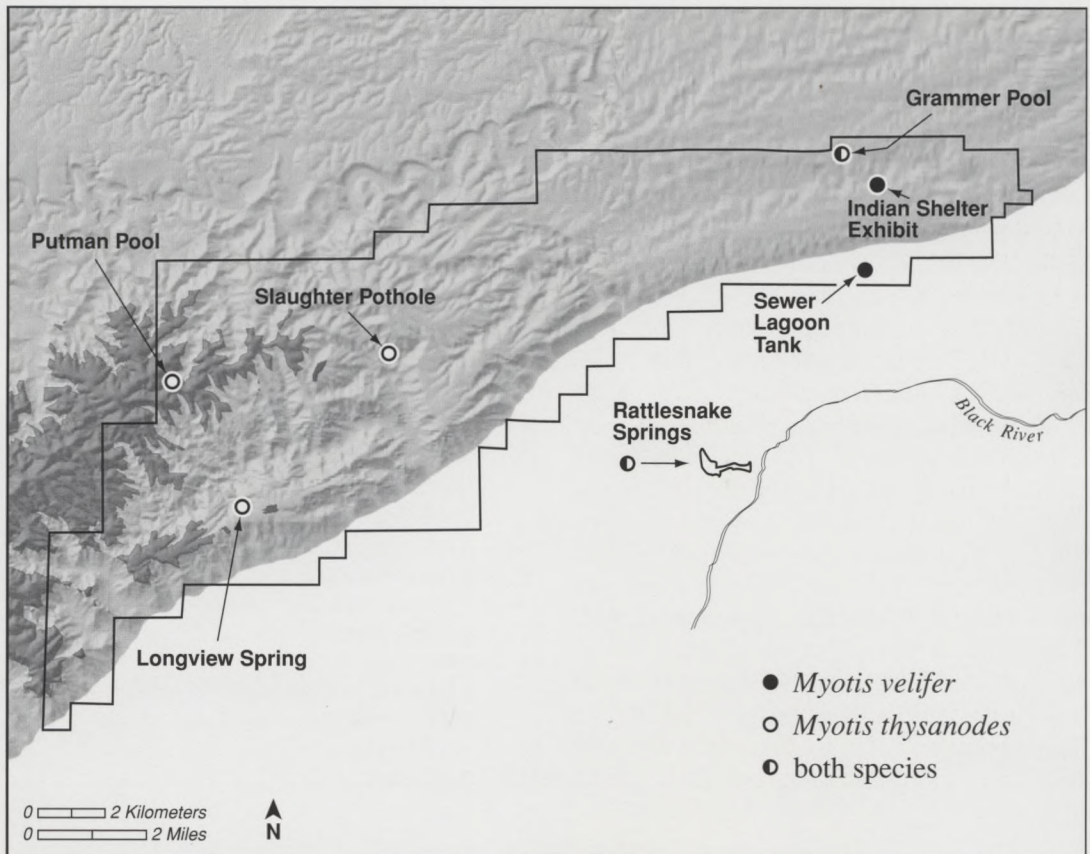


Fig. 42. Distribution of the cave myotis (*Myotis velifer*) and fringed myotis (*M. thysanodes*) in Carlsbad Caverns National Park, excluding records from caves.

Positive documentation of *M. velifer* raising its young in the cavern is lacking. For example, presence of volant young in Left Hand Tunnel in 2000 does not necessarily mean the bats were born and raised in the cavern. Perhaps young changed roosts after learning to fly. For pregnant and lactating females captured in the large opening, these individuals may have been using the cavern as a night roost. Although no conclusive evidence is available, we suspect that *M. velifer* uses Carlsbad Cavern to raise its young.

Populations of *M. velifer* in southeastern New Mexico probably spend winter in nearby caves (Findley *et al.* 1975), but winter records of this species are not known from this corner of the state. In southeastern New Mexico, *M. velifer* is present from at least 7 March to 28 October (Findley *et al.* 1975), and all records from the park occur within this time span (13 March to 16 August). We suspect that some *M. velifer* hibernate during winter in gypsum caves east of the park.

Reproduction. Although we collected two females at Rattlesnake Springs that contained no discernible embryos (24 April and 1 May 1991), all females collected on this parcel of land in the early 1950s were pregnant (four on 24 April 1951; three on 30 April 1952). On 24 April, two females contained one embryo each, and two females carried twins. On 30 April, each female contained a single embryo. At the park, we recorded lactating females from 9 July to 8 August and volant young from 6 July to 10 August (Appendix 5). Adult males were taken 13 March-8 August.

Taxonomic remarks. Except for one aberrant individual (MSB 123814), we assigned specimens of *Myotis velifer* in the park to the subspecies *M. v. incautus* (J. A. Allen, 1896) based on the distribution reported in Hall (1981:196, map 153). Due to color of dorsal pelage and length of hair, the appearance of MSB 123814 closely resembled specimens of *M. v. velifer* (J. A. Allen, 1890) from southwestern New Mexico and eastern Arizona rather than other specimens of *M. v. incautus* from the park.

Myotis v. velifer from southwestern New Mexico and eastern Arizona was formerly regarded as *M. v. brevis* Vaughan, 1954 (Hayward 1970).

Museum specimens (total 15); Fig. 42:

- Guadalupe Room, Carlsbad Cavern [skull collected in 1992] (CACA 1) *not plotted*;
- Indian Shelter Exhibit, T24S, R25E, SW ¼ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE ¼ Sec. 30 (MSB 1);
- Sewer Lagoon Tank near Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1);
- Adobe Garage, Rattlesnake Springs [24 April 1951] (CACA 4);
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 2);
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [discovered inside building on 7 April 2000] (MSB 1);
- Storage Shed at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [discovered in wooden tool shed on 13 March 1991] (MSB 1);
- Rattlesnake Springs [30 April 1952] (CACA 3).

Additional records (Fig. 42):

- vicinity of Bell Cord Room near end of Left Hand Tunnel of Carlsbad Cavern (Baker 1962) *not plotted*;
- small natural opening of Carlsbad Cavern (captured and released by KNG on 29 July 1996 and 15 July 1997) *not plotted*;
- large natural opening of Carlsbad Cavern (captured and released by L. A. McWilliams on 17 July 1997 and KNG on 3 and 9 July 1999) *not plotted*;
- in Left Hand Tunnel of Carlsbad Cavern, 169 m E of wooden gate that separates underground lunchroom from entrance to Left Hand Tunnel (captured and released by KNG and KG on 6 July 2000) *not plotted*;
- orchard near ranger station at Rattlesnake Springs (captured and released by KNG on 9 July 1997);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (most recent capture and release by KNG and KG was on 7 July 2000).

***Myotis thysanodes* Miller, 1897**
Fringed Myotis

In New Mexico, the fringed myotis lives in a wide variety of habitats, including deserts, grasslands, woodlands, and forests (Findley *et al.* 1975; Geluso 2002). Thus, it is not surprising that we documented this species throughout the park from low elevations on the seabed to high elevations on the reef (Fig. 42). *Myotis thysanodes* is known to roost in buildings and caves (O'Farrell 1999), and both types of occurrences have been recorded at the park.

At Rattlesnake Springs, we captured *M. thysanodes* over Rattlesnake Spring, over the small pond in the adjacent woodlot, and beneath canopies of trees (Table 6). In addition, we discovered them using buildings as daytime shelters (Table 9). For example, a small colony was roosting on the front porch

of the pump house on 17 June 1986, and at least one was a pregnant female. Bats were roosting between a wooden beam and plank beneath the roof of the porch. On 23 May 1992, we found a female roosting on the front porch of the ranger station. A specimen from the park's museum indicates that *M. thysanodes* also roosted in the adobe garage at the west end of the picnic area in the early 1950s.

On the reef, we captured *M. thysanodes* at four water holes (Table 7; Fig. 42), and these sites span a wide range of elevations (Table 3). Additional surveys in the park likely will show that *M. thysanodes* uses most water holes on the reef.

Through the years, *M. thysanodes* has used at least three caves in the park to raise

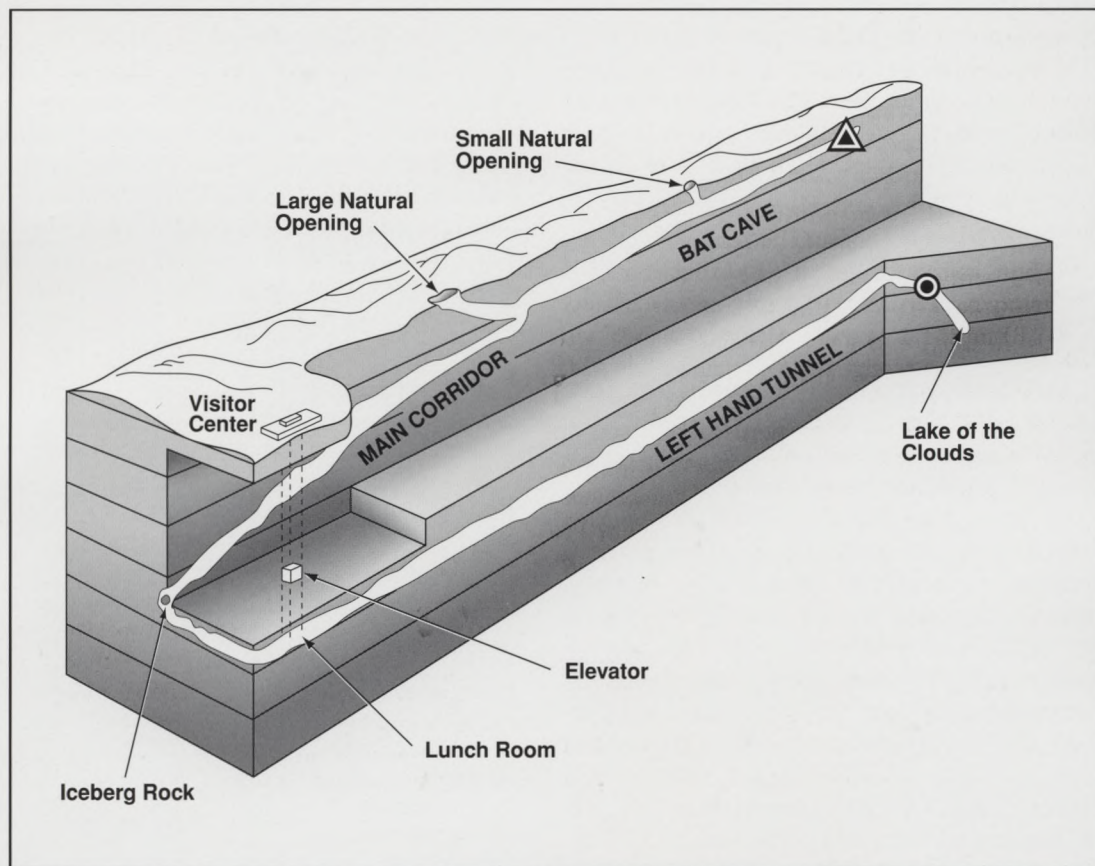


Fig. 43. Three-dimensional view of part of Carlsbad Cavern. The circle marks the maternity roost of fringed myotis (*Myotis thysanodes*) and the triangle marks the location of the maternity roost of Brazilian free-tailed bats (*Tadarida brasiliensis*).

its young—Lake Cave, Midnight Goat Cave, and Carlsbad Cavern. Lake Cave usually contains a few hundred individuals (Baker 1962), and Midnight Goat Cave had about 100 in June 1990 (D. A. Ek *pers. comm.*). In Carlsbad Cavern, colonies also have numbered ca. 100 (Baker 1962; KING and T. L. Best *pers. observ.*).

The nursery colony of *M. thysanodes* in Carlsbad Cavern is located near the end of Left Hand Tunnel in a room 213 m underground when measured from the surface of ground directly above (Fig. 43). Fringed myotis have consistently used this portion of the cave for at least the last 48 years. For example, an adult female banded near the end of the tunnel in 1952 was discovered in the same area six years later (Baker 1962), and we confirmed *M. thysanodes* there in 1995 and 1997. Through the years, *M. thysanodes* also has been documented in the large natural opening of the cavern (1956 and 1998), the small natural opening (1996 and 1997), and the guano shaft at the end of Bat Cave (1970s). Additional records from the cavern include specimens from the Mystery Room, Main Corridor, and Bat Cave.

To reach an opening of the cavern from their underground roost, fringed myotis travel down Left Hand Tunnel, proceed through the lunchroom, head toward Iceberg Rock, fly along the Main Corridor, and exit from one of the two natural openings (Fig. 43; KING and T. L. Best *unpub. data*). Rooms near the end of Left Hand Tunnel are the warmest in the cavern (Hill 1987), and this may be the primary characteristic that females are using to select this remote area of the cavern to raise their young (see Williams and Brittingham 1997). Other benefits at this location include constant temperatures, high relative humidity, and low risk of predation on fallen young.

Winter habits of *M. thysanodes* are poorly known (O'Farrell and Studier 1980), and we have no winter record of this species from the park. At the park, *M. thysanodes* was present from 11 April to 6 November. Findley *et al.* (1975) also did not report any winter-taken *M. thysanodes* from New Mexico. Lack of winter records from New Mexico and Texas supports the belief that this species is migratory (O'Farrell and Studier 1980; Schmidly 1991;

Yancey 1997). However, magnitude of movements, final destinations, and extent of dormancy at winter sites are unknown.

Reproduction. We captured three pregnant females in the park—one each on 24 May, 17 June, and 9 July. The female from May contained one embryo in a uterine swelling measuring 9 mm. The female from June gave birth to a single pup while being held overnight. The newborn weighed 2 g and had a forearm length of 14 mm. The third female was captured leaving the nursery roost in Left Hand Tunnel on 9 July 1995. This female was captured with ten lactating females, indicating that the colony in the cavern was near the end of its birthing period in early July of that year. We recorded other lactating females as early as 17 June and as late as 10 August (Appendix 5). Volant young were captured 15 July–20 August (Appendix 5).

At Carlsbad Cavern, adult males have been captured in the large natural opening (11 and 25 April 1998), in the small natural opening (15 July 1997 and 29 July 1996), and in Left Hand Tunnel (9 July 1995 in entrance to room containing the maternity colony of *M. thysanodes*, 16 July 1997 in the maternity room of *M. thysanodes*, and 6 July 2000 near the underground lunchroom). Captures of adult males outside the cavern occurred at Putman Pool on 2 August 1996.

Taxonomic remarks. The subspecies of *Myotis thysanodes* in the park is *M. t. thysanodes* Miller, 1897 based on the distribution reported in Hall (1981:204, map 161).

Museum specimens (total 24); Fig. 42:

- Bat Cave [in Carlsbad Cavern] (CACA 3) *not plotted*;
- Auditorium [flat area just before reaching Devil's Spring from main entrance to Carlsbad Cavern; Devil's Spring is in the Main Corridor] (CACA 2) *not plotted*;
- Lake of the Clouds Room, Carlsbad Cavern [end of Left Hand Tunnel; Baker 1962] (CACA 5) *not plotted*;
- Mystery Room [in Carlsbad Cavern] (CACA 1) *not plotted*;
- Carlsbad Cave [dead in rain barrel near small natural opening of Carlsbad Cavern] (USNM 1) *not plotted*;
- Carlsbad Cavern (KU 1) *not plotted*;

- East Entrance, Carlsbad Cavern (KU 1) *not plotted*;
- Vandalize Cave [Vandalized Cave is presently known as Lake Cave; Lake Cave is in a side canyon of North Slaughter Canyon] (KU 3) *not plotted*;
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE ¼ Sec. 30 (MSB, 1);
- Rattlesnake Springs, adobe garage [10 October 1951] (CACA 1);
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 2);
- Rattlesnake Springs [front porch of pump house; 17 June 1986] (TTU 2);
- Rattlesnake Springs (MSB 1).
- large natural opening of Carlsbad Cavern (captured in bat trap in 1956, Constantine 1958b; captured and released by L. A. McWilliams in April, June, and August 1998) *not plotted*;
- in Left Hand Tunnel of Carlsbad Cavern, 169 m E of wooden gate that separates underground lunchroom from entrance to Left Hand Tunnel (captured and released by KNG and KG on 6 July 2000) *not plotted*;
- Midnight Goat Cave in Midnight Canyon (observation by D. A. Ek in June 1990) *not plotted*;
- Slaughter Pothole, 0.08 mi. N, 0.34 mi. W Goat Cave, T25S, R23E, SW ¼ Sec. 11 (captured and released by KNG on 21 June 1986);
- Longview Spring, T25S, R23E, E ½ Sec. 29 (captured and released by KNG on 25 July 1974);
- Putman Pool, 0.24 mi. N, 0.08 mi. E Putman Cabin, T25S, R23E, NW ¼ Sec. 18 (captured and released by KNG on 2 August 1996);
- orchard near the ranger station at Rattlesnake Springs (captured and released by KNG on 9 August 1988 and 9 July 1997);
- front porch of ranger station at Rattlesnake Springs (captured and released by KNG and KG on 23 May 1992);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (captured and released by KNG on 30 and 31 May 1984);
- earthen pond by Rattlesnake Spring (captured and released by KNG on 17 June 1986).

Additional records (Fig. 42):

- room containing maternity colony of *M. thysanodes*, see Fig. 43 [room is located between entrances to Bell Cord Room and Lake of the Clouds in Left Hand Tunnel of Carlsbad Cavern] (presence of radiotagged individuals; radiosignals detected by T. L. Best and KNG in July 1995 and 1997) *not plotted*;
- east guano shaft of Carlsbad Cavern (captured and released by R. C. Kerbo in 1970s) *not plotted*;
- entrance to room containing maternity colony of *M. thysanodes* (captured and released by T. L. Best and KNG on 9 July 1995) *not plotted*;
- small natural opening of Carlsbad Cavern (captured and released by KNG on 29 July 1996 and 15 July 1997) *not plotted*;

Myotis californicus (Audubon and Bachman, 1842) California Myotis

Although *M. californicus* occurs from desert lowlands through ponderosa pine forests in New Mexico (Findley *et al.* 1975), this species is most common in habitats below the ponderosa pine zone (Bogan 1975). In the park, all records of *M. californicus* are from the seabed or low elevations on the reef (Fig. 44).

California myotis were common at Rattlesnake Springs. Many individuals were captured under the canopy of trees next to the

ranger station, while others were netted over the nearby storage pond (Table 6). Although *M. californicus* is known to roost in human-made structures (Barbour and Davis 1969; Bogan 1999), we have no record of *M. californicus* in buildings in the park.

On the reef, we captured *M. californicus* at Indian Shelter Exhibit, Grammer Pool, and Spider Cave Seep (Table 7). The only other records on the reef are those from Carlsbad Cavern. A skull was located in the "deepest

room of the cave" in 1924 (Bailey 1928). More recently an individual was observed alive and later found dead in the underground lunchroom in October 1989.

Although winter records are not known from the park, *M. californicus* has been reported in other mountain ranges of New Mexico in winter (Findley *et al.* 1975). We suspect that *M. californicus* also overwinters in the Guadalupe Mountains. In the park, earliest and latest dates of capture on the surface were 15 March and 7 October.

Reproduction. We captured two pregnant females at Rattlesnake Springs on 1 May, and each contained a single embryo; uterine swellings measured 7 and 9 mm. We captured lactating females on 12 and 17 June, volant young on 25 July and 16 August, and adult males 15 March-16 August (Appendix 5).

Taxonomic remarks. The subspecies of *Myotis californicus* in the park is *M. c. californicus* (Audubon and Bachman, 1842)

based on the distribution reported in Hall (1981:186, map 146).

Museum specimens (total 29); Fig. 44:

- Lunchroom of Carlsbad Cavern [18 October 1989] (MSB 1) *not plotted*;
- Carlsbad Cave, deepest room in cave [in Carlsbad Cavern; skull] (USNM 1) *not plotted*;
- Indian Shelter Exhibit, T24S, R25E, SW ¼ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE ¼ Sec. 30 (MSB 1);
- Spider Cave Seep, T24S, R24E, NE ¼ Sec. 35 [0.12 mi. N, 1.14 mi. W Visitor Center] (MSB 2);
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 17);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 4);
- Rattlesnake Springs (CACA 2).

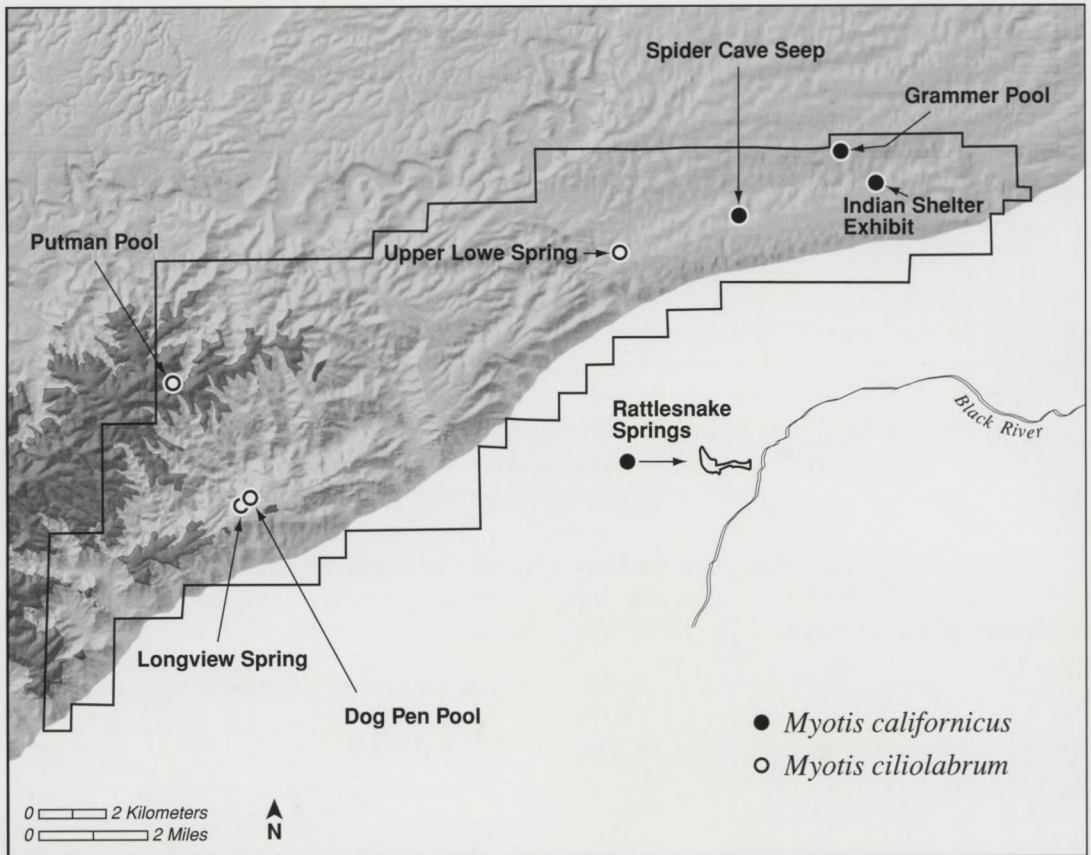


Fig. 44. Distribution of the California myotis (*Myotis californicus*) and western small-footed myotis (*M. ciliolabrum*) in Carlsbad Caverns National Park, excluding records from caves.

***Myotis ciliolabrum* (Merriam, 1886)**
Western Small-footed Myotis

Although *Myotis ciliolabrum* and *M. californicus* have been captured over the same water hole at several localities in New Mexico (Findley *et al.* 1975), *M. ciliolabrum* tends to be more common at higher elevations. For example, its center of distribution appears to be ponderosa pine forests, whereas *M. californicus* generally is more common in habitats below ponderosa pine (Findley *et al.* 1975; Bogan 1975). The tendency for *M. ciliolabrum* to be captured at higher elevations was evident in the park (Fig. 44). We caught five *M. ciliolabrum* in the park, and all were from the reef. Four were captured at high elevations where isolated patches of conifers exist (one at Dog Pen Pool, two at Longview Spring, and one at Putman Pool), and one was captured at mid-elevation in the juniper penepain (Upper Lowe Spring; Table 7). In contrast, all *M. californicus* were captured on the seabed or at low elevations on the reef (Fig. 44).

The only other records of *M. ciliolabrum* in the park are those based on skeletal remains from Carlsbad Cavern and Lechuguilla Cave. Baker (1962) stated that *Myotis subulatus* (= *M. ciliolabrum*) is known from Carlsbad Cavern through skeletal evidence, but he provided no other information. More recently, skulls of *M. ciliolabrum* have been removed from the Guadalupe Room of the cavern and deposited in the park's museum. Numerous skulls discovered in Lechuguilla Cave suggest that *M. ciliolabrum* may have been

more abundant in the park in the past (P. L. Jablonsky *pers. comm.*). The age of these skulls is not known.

Dates of capture in the park were 25 July and 2, 11, and 14 August. Although *M. ciliolabrum* hibernates throughout most of its summer range (Holloway and Barclay 2001), published records of wintering individuals are not available from the park or from other parts of New Mexico (Findley *et al.* 1975).

Reproduction. We captured females on 25 July ($n = 2$) and 14 August ($n = 1$); none was pregnant or lactating. A young male was captured on 11 August and an adult male on 2 August (Appendix 5).

Taxonomic remarks. The subspecies of *Myotis ciliolabrum* in the park is *M. c. melanorhinus* (Merriam, 1890) based on the distribution reported in Hall (1981:188, map 147).

Museum specimens (total 10); Fig. 44:

- Guadalupe Room, Carlsbad Cavern [skulls collected in 1992] (CACA 3) *not plotted*;
- Lechuguilla Cave [in Lechuguilla Canyon; skulls collected in 1992 and 1995] (CACA 2) *not plotted*;
- Upper Lowe Spring, 0.33 mi. S, 0.02 mi. W Lowe Spring, T24S, R24E, S $\frac{1}{2}$ Sec. 33 (MSB 1);
- Dog Pen Pool, 0.07 mi. N, 0.03 mi. E Longview Spring, T25S, R23E, NE $\frac{1}{4}$ Sec. 29 (MSB 1);
- Longview Spring, T25S, R23E, E $\frac{1}{2}$ Sec. 29 (MSB 2);
- Putman Pool, 0.24 mi. N, 0.08 mi. E Putman Cabin, T25S, R23E, NW $\frac{1}{4}$ Sec. 18 (MSB 1).

***Myotis volans* (H. Allen, 1866)**
Long-legged Myotis

Based on >700 specimens collected in New Mexico, most long-legged myotis have been captured in ponderosa pine forests or in communities at higher elevations; about 2% were taken in grassland habitats (Findley *et al.* 1975). At the park, we obtained only two *M. volans*—a female captured on the reef at

an elevation of 1,760 m (5,770 ft) and a male on the seabed at 1,105 m (3,630 ft).

The female was netted at Longview Spring on 2 June 1984 (Table 7; Fig. 45). The spring was situated below a summit dominated by alligator juniper, pinyon pine, and ponderosa pine. The male was captured at

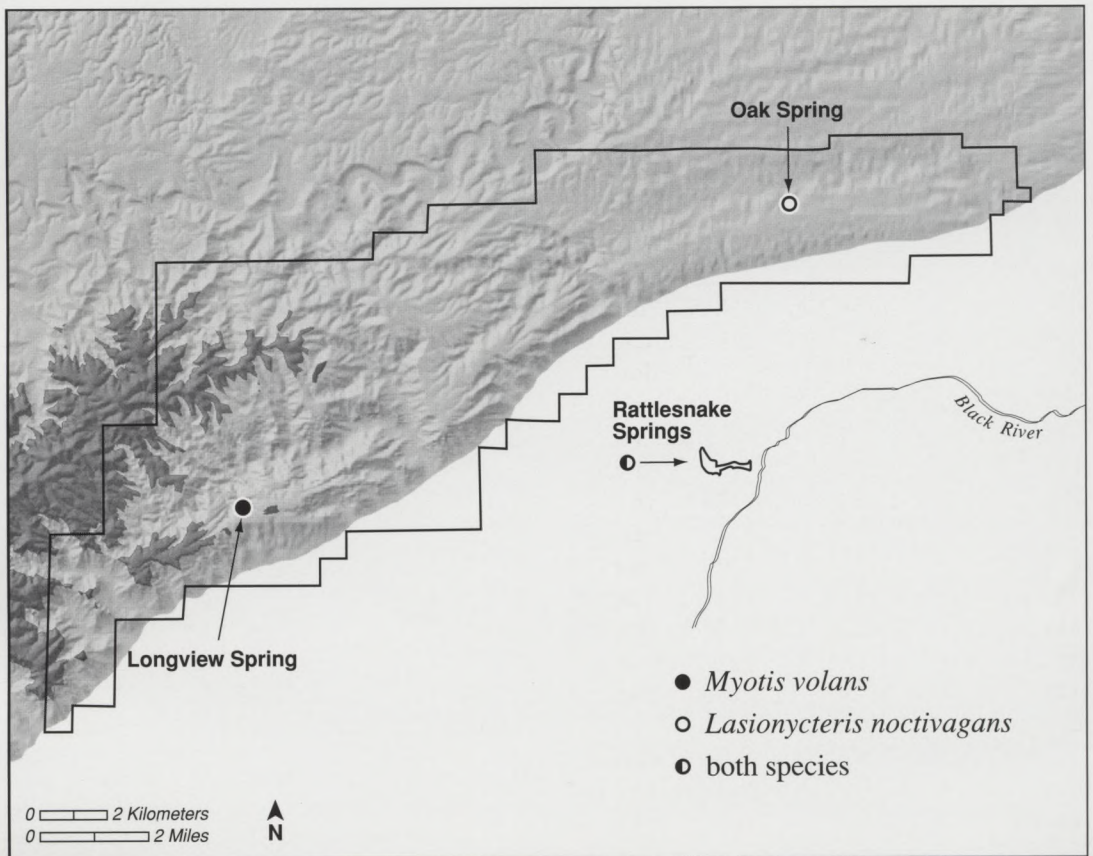


Fig. 45. Distribution of the long-legged myotis (*Myotis volans*) and silver-haired bat (*Lasionycteris noctivagans*) in Carlsbad Caverns National Park, excluding records from caves.

Rattlesnake Springs on 13 August 1991 (Table 9). This individual flew slowly over the storage pond in daylight (1945 h), took a drink, landed on the outside wall of the pump house, and was captured by hand by KG. At this low elevation on the seabed, the male may represent a migrant, sick, or wandering individual. The only other record of *M. volans* in the park is a skull from Carlsbad Cavern.

Myotis volans is a hibernating species (Czaplewski 1999), but nothing is known about its winter habits in New Mexico. Thus far, earliest and latest dates of capture in New Mexico are 10 May and 28 September (Findley *et al.* 1975). Captures in the park occurred on 2 June and 13 August.

Reproduction. The female from Longview Spring contained no discernible embryos and was not lactating. The male from Rattlesnake Springs was an adult with testes measuring 4.5 mm in length.

Taxonomic remarks. The subspecies of *Myotis volans* in the park is *M. v. interior* Miller, 1914 based on the distribution reported in Hall (1981:198, map 154).

Museum specimens (total 3); Fig. 45:

- below Devil's Den bridge [in Carlsbad Cavern; skull collected in 1951] (CACA 1) *not plotted*;
- Longview Spring, T25S, R23E, E ½ Sec. 29 (MSB 1);
- Pump House at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [13 August 1991] (MSB 1).

***Lasionycteris noctivagans* (LeConte, 1831)**
Silver-haired Bat

Silver-haired bats are known to migrate and hibernate (Jones *et al.* 1983). In New Mexico, adults of both sexes are present during migratory movements in spring and autumn (Findley *et al.* 1975; Findley 1987), and recent evidence indicates that both sexes are also present in winter (Cryan 2003). When silver-haired bats appear in spring, it is not known what proportion of the population represents individuals that have recently emerged from nearby hibernacula versus those that have recently arrived from other wintering grounds (Cryan 2003). In New Mexico, silver-haired bats are most abundant in summer when populations are comprised almost entirely of adult males living in mountainous areas (Findley 1987). Most females are absent at this time because they moved out of the state to bear and raise young at more northerly locations.

At the park, three silver-haired bats have been obtained during spring migration, but records do not exist from autumn. On 13 March 1991, KG discovered a male roosting on the pump house at Rattlesnake Springs. The bat was hanging from a wooden beam on the front porch and was captured by hand at 1045 h; it had not been at that location the previous day. Another male had been collected from the same building on 20 May 1951 (Table 9). Bailey (1928) reported a male being shot "at the spring" on 12 April 1924, and according to his catalog, he is referring to Oak Spring (Fig. 45).

Two additional records of *L. noctivagans* provide evidence that some individuals overwinter in the Guadalupe Mountains. A female was discovered in Carlsbad Cavern on 30 January 1977. According to the skin tag, this bat was found dead in the Queen's Chamber but was seen in Lower Cave the previous week. Another silver-haired bat (sex unknown) was discovered alive inside the pump house at Rattlesnake Springs on 4 December 1959 (Table 9).

Reproduction. The male captured on 13 March had testes measuring 3.5 mm in length.

Taxonomic remarks. *Lasionycteris noctivagans* is a monotypic species with no subspecies recognized (Hall 1981:210, map 166).

Museum specimens (total 4); Fig. 45:

- Queens Chamber, Carlsbad Cavern (CACA 1) not plotted;
- Carlsbad Cave [at Oak Spring] (USNM 1);
- Pump House at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [on front porch; 13 March 1991] (MSB 1);
- Pump House, Rattlesnake Springs [20 May 1951] (CACA 1).

Additional records (Fig. 45):

- in Pump House at Rattlesnake Springs (observation by C. A. McLemore on 4 December 1959; a black and white photograph of this individual is in the park's museum; photograph taken on 6 December 1959).

***Pipistrellus hesperus* (H. Allen, 1864)**
Western Pipistrelle

Western pipistrelles are common in deserts, arid grasslands, and adjacent woodlands of the Southwest (Sidner 1999). In the park, they were captured at more water holes than any other species of bat. On the seabed, we regularly netted them at Sewer Lagoon Tank and Rattlesnake Spring (Table 6), and on the reef we captured them at nine of the 13 water holes (Table 8). In addition, Vernon

Bailey collected five at Oak Spring in 1924, and other researchers collected eight in Rattlesnake Canyon in 1930 (Fig. 46).

Bailey (1928) noted that *P. hesperus* was probably the small bat that he observed flying in the mouth of Carlsbad Cavern in 1924. In 1956 and 1957, a *P. hesperus* was captured in a bat trap placed in the large opening of the cavern, and in 1998 one was discovered alive

lying on the ground in the large opening. Thus far, however, no confirmed record of this species exists inside Carlsbad Cavern.

Western pipistrelles are year-round residents in Nevada, Texas, and Arizona (O'Farrell and Bradley 1970; Hayward and Cross 1979; Yancey 1997), and certainly the same is true for New Mexico. Nevertheless, winter residents were not reported in New Mexico by Findley *et al.* (1975), and we know of only one winter record from the park (26 January 1959). The winter-taken specimen was collected in Small Cave in West Slaughter Canyon. Because *P. hesperus* is known to be active on warm winter nights (O'Farrell and Bradley 1970; Yancey 1997), winter surveys undoubtedly will show this species to be more numerous in winter than present data indicate. Excluding the specimen from January, records of *P. hesperus* in the park extend from 8 April to 14 August.

Reproduction. Pregnant females were captured on 30 May ($n = 3$) and 12 June ($n = 1$); these females were released. We recorded lactating individuals from 12 June to 11 August and volant young from 23 July to 13 August (Appendix 5). Adult males were collected 21 May-11 August.

Taxonomic remarks. The subspecies of *Pipistrellus hesperus* in the park is *P. h. maximus* Hatfield, 1936 based on the distribution reported in Hall (1981:211, map 167).

Museum specimens (total 27); Fig. 46:

- entrance Carlsbad Cavern, bat trap [in large natural opening; 16 June 1957; also see Constantine 1958b for another individual captured in bat trap in 1956] (CACA 1) *not plotted*;
- Small Cave, West Slaughter Canyon (CACA 1) *not plotted*;
- Walnut Canyon (CACA 2) *not plotted*;
- Walnut Canyon Road (CACA 1) *not plotted*;

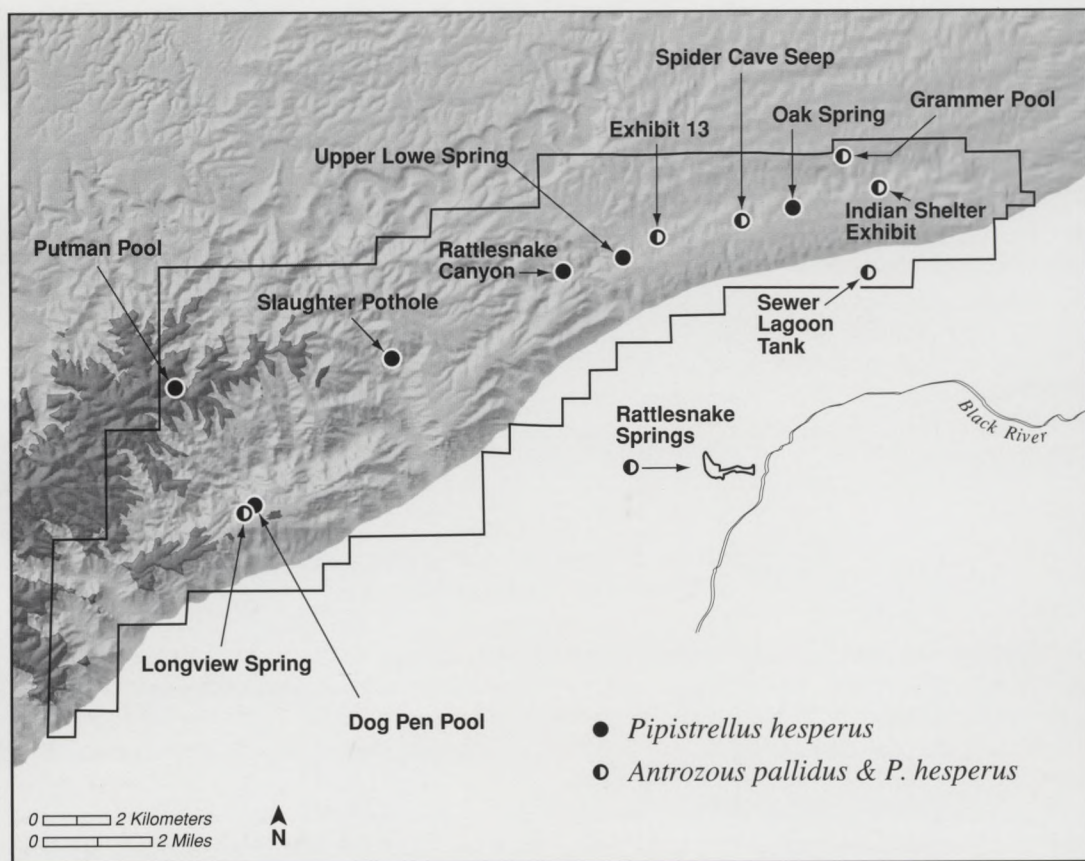


Fig. 46. Distribution of the western pipistrelle (*Pipistrellus hesperus*) and pallid bat (*Antrozous pallidus*) in Carlsbad Caverns National Park, excluding records from caves.

- Indian Shelter Exhibit, T24S, R25E, SW $\frac{1}{4}$ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE $\frac{1}{4}$ Sec. 30 (MSB 1);
- Carlsbad Cave [at Oak Spring] (USNM 5);
- Exhibit #13 along Scenic Loop Road [0.17 mi. N, 0.70 mi. E Lowe Spring, T24S, R24E, W $\frac{1}{2}$ Sec. 34] (TTU 1);
- 1.5 mi. up Rattlesnake Canyon [collected 22-24 July 1930] (KU 8);
- Dog Pen Pool, 0.07 mi. N, 0.03 mi. E Longview Spring, T25S, R23E, NE $\frac{1}{4}$ Sec. 29 (MSB 1);
- Longview Spring, T25S, R23E, E $\frac{1}{2}$ Sec. 29 (MSB 1);
- Sewer Lagoon Tank near Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (MSB 1);
- Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 2);
- Carlsbad Caverns National Park (CACA 1) *not plotted*.

Additional records (Fig. 46):

- Spider Cave Seep, 0.12 mi. N, 1.14 mi. W Visitor Center, T24S, R24E, NE $\frac{1}{4}$ Sec. 35 (captured and released by KNG on 22 June 1976 and 12 June 1986);
- Upper Lowe Spring, 0.33 mi. S, 0.02 mi. W Lowe Spring, T24S, R24E, S $\frac{1}{2}$ Sec. 33 (captured and released by KNG on 14 August 1992);
- Slaughter Pothole, 0.08 mi. N, 0.34 mi. W Goat Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 11 (captured and released by KNG on 21 June 1986);
- Putman Pool, 0.24 mi. N, 0.08 mi. E Putman Cabin, T25S, R23E, NW $\frac{1}{4}$ Sec. 18 (captured and released by KNG on 2 and 3 August 1996).

Eptesicus fuscus (Palisot de Beauvois, 1796) Big Brown Bat

In New Mexico, big brown bats are most abundant in ponderosa pine forests (Findley *et al.* 1975), and in the park they were common at high elevations on the reef where coniferous woodlands exist. However, *E. fuscus* also inhabited lowlands of the seabed and dry canyons in lower portions of the reef (Fig. 47). On the seabed, we captured *E. fuscus* at Rattlesnake Springs (1,105 m or 3,630 ft) and over Sewer Lagoon Tank (1,120 m or 3,680 ft). At Rattlesnake Springs, bats were netted regularly over the storage pond, and one individual was captured under the tree canopy in the front yard of the ranger station (Table 6). In addition, one was discovered roosting on the front porch of the pump house (Table 9).

On the reef, big brown bats were captured across a wide range of elevations (1,280-1,825 m or 4,200-5,980 ft; Table 8). These locations include Walnut, West Slaughter, and Putman canyons. In addition, specimens from the early 1900s were collected in Slaughter and Rattlesnake canyons. Records of *E. fuscus* associated with caves include an individual ex-

iting the small opening of Carlsbad Cavern, individuals resting in the large opening of the cavern, and skulls discovered inside the cavern and Lechuguilla Cave.

Because *E. fuscus* hibernates and typically moves short distances (<80 km) to wintering grounds (Kurta 1999), this species should be widely distributed in New Mexico during winter, similar to its distribution in summer. However, 28 February is the only published date of a winter-taken specimen in New Mexico (Findley *et al.* 1975), and winter records are lacking from the park. At the park, *E. fuscus* was present from 27 March to 16 August, but Findley *et al.* (1975) reported this species in New Mexico as late as 30 October.

Reproduction. In temperate North America, number of young born to *E. fuscus* varies geographically. Females from eastern parts of the United States usually produce twins, while those in western parts of the country normally have one (Kurta 1999). At the park, we collected three adult females

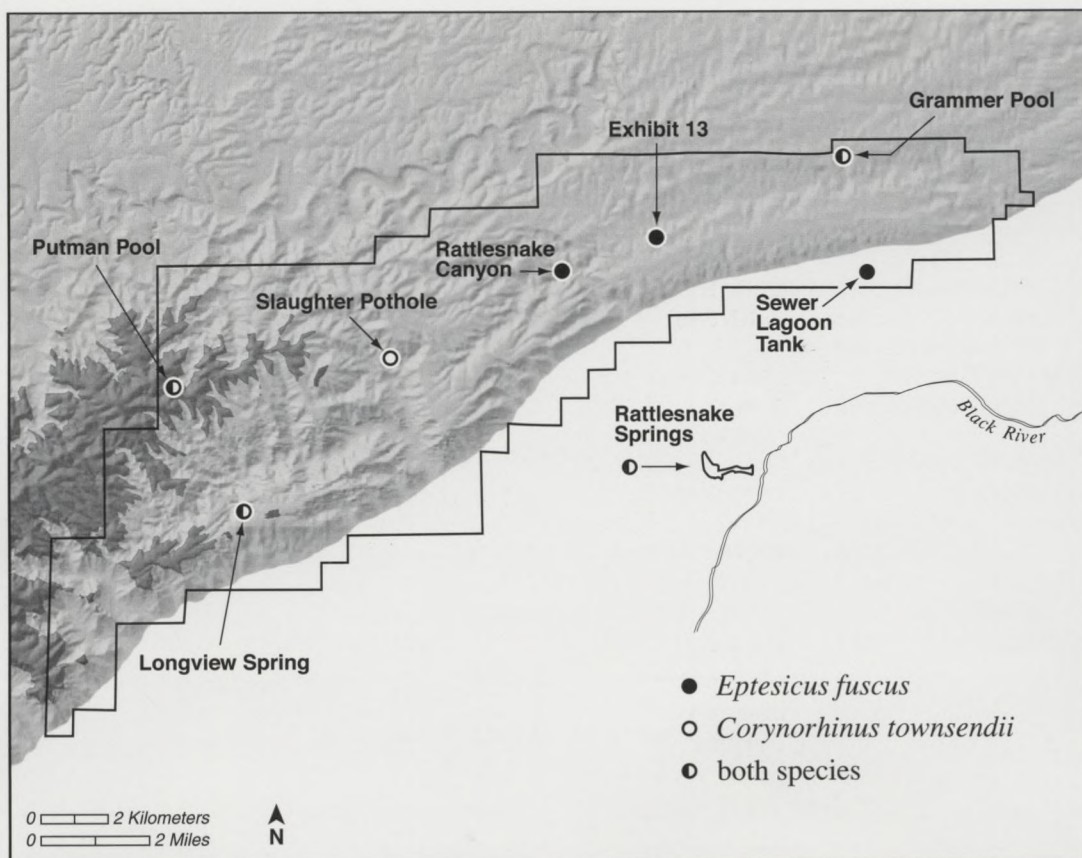


Fig. 47. Distribution of the big brown bat (*Eptesicus fuscus*) and Townsend's big-eared bat (*Corynorhinus townsendii*) in Carlsbad Caverns National Park, excluding records from caves.

from Rattlesnake Springs. Two collected on 31 May each contained one embryo (uterine swellings measured 9 mm in both), and one collected on 1 May contained no discernible embryos. Pregnant females collected in the Texas portion of the Guadalupe Mountains also contained single embryos ($n = 6$; Genoways *et al.* 1979). Thus, females from the Guadalupe Mountains are similar to other females from western parts of the United States. At the park, we recorded lactating females from 7 July to 13 August and volant young 2-16 August (Appendix 5). Adult males were collected 31 May-3 August.

Taxonomic remarks. The subspecies of *Eptesicus fuscus* in the park is *E. f. pallidus* Young, 1908 based on the distribution reported in Hall (1981:216, map 169).

Museum specimens (total 13); Fig. 47:

- New Mexico Room, Carlsbad Cavern [skulls collected in 1992] (CACA 2) *not plotted*;
- Lechuguilla Cave [in Lechuguilla Canyon; skull collected in 1995] (CACA 1) *not plotted*;
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE $\frac{1}{4}$ Sec. 30 (MSB 1);
- Exhibit #13 along Scenic Loop Road [0.17 mi. N, 0.70 mi. E Lowe Spring, T24S, R24E, W $\frac{1}{2}$ Sec. 34] (TTU 1);
- 1.5 mi. up Rattlesnake Canyon [22 July 1930] (KU 2);
- Slaughter Canyon [29 April 1924] (USNM 2) *not plotted*;
- Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 4).

Additional records (Fig. 47):

- small natural opening of Carlsbad Cavern (captured and released by R. C. Kerbo and J. W. Grace in July 1977) *not plotted*;
- large natural opening of Carlsbad Cavern (observation by J. M. Richards on 27 March 1998) *not plotted*;
- south end of lowest room in Carlsbad Cavern [skulls] (Bailey 1928:122) *not plotted*;
- Longview Spring, T25S, R23E, E ½ Sec. 29 (captured and released by KNG on 25 July 1974 and 2 June 1984);
- Putman Pool, 0.24 mi. N, 0.08 mi. E Putman Cabin, T25S, R23E, NW ¼ Sec. 18 (captured and released by KNG on 2 and 3 August 1996);
- Sewer Lagoon Tank near Sewage Disposal Ponds (captured and released by KNG on 10 July 1997);
- front yard of ranger station at Rattlesnake Springs (captured and released by KNG and KG on 13 August 1991);
- front porch of pump house at Rattlesnake Springs (captured and released by KG on 16 August 1990);
- Rattlesnake Spring (most recent capture and release by KNG and KG was on 7 July 2000).

Lasiurus cinereus (Palisot de Beauvois, 1796) Hoary Bat

The hoary bat is a migratory species, and each spring males and females probably arrive in New Mexico from distant wintering areas (Findley *et al.* 1975; Cryan 2003). Females continue through New Mexico and head for locations north of the state to raise their young, while some males remain in mountainous areas of the state during summer. In autumn, males and females also are present in New Mexico (Findley *et al.* 1975).

At the park, hoary bats were captured only during seasonal movements in spring and autumn. In spring, females were netted over Rattlesnake Spring on 24 April ($n = 2$) and 1 May 1991 ($n = 2$), and males were captured there on 30 May 1984 ($n = 1$) and 31 May 1990 ($n = 1$; Table 6). We also captured a male at Sewer Lagoon Tank on 16 June 1986.

According to Findley and Jones (1964), autumn migration of *L. cinereus* in New Mexico begins in August. We captured eleven individuals in a five-day period (6-10 August 1988), and this group might have been part of a migratory wave (Findley and Jones 1964). These bats were captured on the seabed at Sewer Lagoon Tank (a male) and Rattlesnake Springs (over storage pond and under tree canopies; total = 6 females and 3 males) and on the reef at Indian Shelter Exhibit (a female; Tables 6 and 8; Fig. 48). Although cartilaginous epiphyseal plates were not visible

in finger joints of these 11 individuals, most were probably young based on lack of tooth wear and lack of nipple development. Another autumn migrant was captured in the large opening of Carlsbad Cavern on 10 September 1992. The only other records of hoary bats in the park include mummies and bones discovered inside Carlsbad Cavern and skeletal remains from Lechuguilla Cave.

Reproduction. Northbound females kept as museum specimens were pregnant. One taken on 24 April contained three embryos (uterine swellings measured 5, 5, and 4 mm), and two captured on 1 May both carried twins (uterine swellings measured 8 and 9 mm; 11 and 11 mm).

Taxonomic remarks. The subspecies of *Lasiurus cinereus* in the park is *L. c. cinereus* (Palisot de Beauvois, 1796) based on the distribution reported in Hall (1981:226, map 176).

Museum specimens (total 22); Fig. 48:

- below Devil's Den [in Carlsbad Cavern; mummy] (CACA 1) *not plotted*;
- Lower Cave, Carlsbad Cavern [mummy] (CACA 1) *not plotted*;
- Carlsbad Cave, deepest room in cave [in Carlsbad Cavern; wing bones] (USNM 1) *not plotted*;
- New Mexico Room, Carlsbad Cavern [skulls collected in 1992] (CACA 2) *not plotted*;

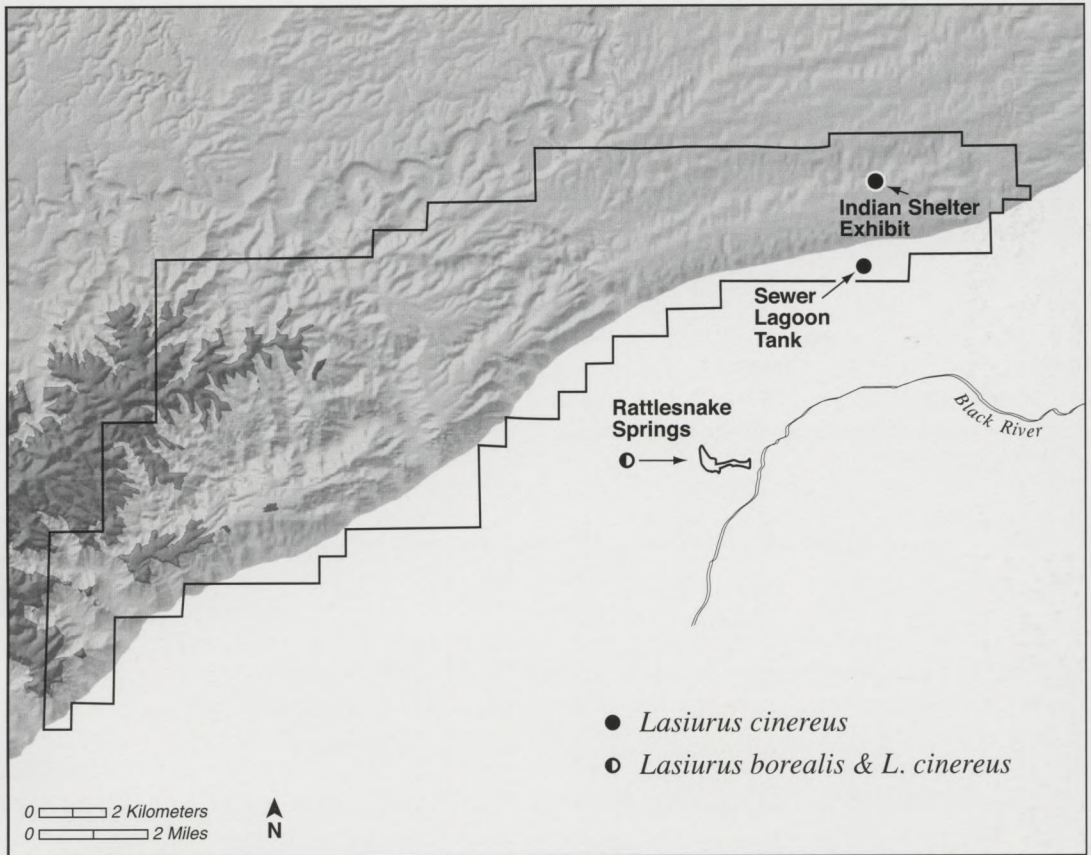


Fig. 48. Distribution of the hoary bat (*Lasiurus cinereus*) and eastern red bat (*L. borealis*) in Carlsbad Caverns National Park, excluding records from caves.

- Lechuguilla Cave [in Lechuguilla Canyon; skull collected in 1991] (CACA 1) *not plotted*;
 - Indian Shelter Exhibit, T24S, R25E, SW ¼ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
 - Sewer Lagoon Tank near Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 2);
 - Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 4);
 - Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 7);
 - Rattlesnake Springs (MSB 1);
 - Carlsbad Caverns National Park (CACA 1) *not plotted*.
- Additional records (not plotted in Fig. 48):*
- large natural opening of Carlsbad Cavern (captured and released by P. S. West on 10 September 1992).

***Lasiurus borealis* (Müller, 1776)**
Eastern Red Bat

The eastern red bat is known only from three localities in New Mexico—Bosque del Apache National Wildlife Refuge in the central part of the state (one individual; Valdez *et al.* 1999), the city of Portales in east-central New Mexico (one individual; Choate 1997), and Carlsbad Caverns National Park (seven individuals excluding mummies and skulls). Except for individuals reported in caves in the park, all *L. borealis* from the state have been captured in areas containing large deciduous trees.

In New Mexico, female eastern red bats appear to be migratory (Cryan 2003); they probably arrive in spring from wintering areas and leave in late summer and autumn. During summer, females are known to bear and raise young in the state, but to date, no record of an adult male has been confirmed in New Mexico. The earliest record of *L. borealis* in the state is 25 June, and the latest record is 7 October; both these dates are based on records from Carlsbad Caverns National Park.

At the park, all surface records of *L. borealis* are from Rattlesnake Springs (Fig. 48). On 7 October 1956, a male (age not specified) was found hanging among leaves of a pear tree (Constantine 1961). The bat was roosting on the south side of the tree 3.7 m above the ground; it was photographed, banded, and released. In recent years, we captured additional individuals on this parcel of land—a juvenile male under the canopy of trees in the front yard of the ranger station (25 July 1993) and a lactating female and two volant young over the storage pond (9 July 1997; Table 6). The female and young (both females) were captured in the same net from 2048 to 2210 h (Mountain Daylight Saving Time) and probably represented a family group.

Although eastern red bats primarily roost in foliage of trees and other vegetation, they occasionally enter caves (Barbour and Davis 1969). The occurrence of *L. borealis* in caves has been reported in the park on several occasions. A pregnant female was captured alive in the underground lunchroom of Carlsbad Cavern on 25 June 1953, and another red bat (sex not reported) was discovered alive in the King's

Palace on 25 September 1951 (Constantine 1961). In addition, several mummies and skulls have been removed from various rooms in Carlsbad Cavern (Bailey 1928; Constantine 1961). Besides the cavern, eastern red bats also have entered Deep Cave. Barbour and Davis (1969) noted that many red bats found in caves may represent lost individuals.

Reproduction. The pregnant female from 25 June contained two fetuses (Constantine 1961). As noted above, we captured a lactating female on 9 July and volant young on 9 and 25 July (Appendix 5). The eastern red bat from central New Mexico (Socorro Co.) was an adult female (E. W. Valdez *pers. comm.*); she was captured on 13 July 1994 and was neither pregnant nor lactating (Valdez *et al.* 1999). The eastern red bat from Portales (Roosevelt Co.) was captured on 30 August 1968. No reproductive information was recorded on the skin tag of this female (L. L. Choate *pers. comm.*).

Taxonomic remarks. *Lasiurus borealis* is a monotypic species with no subspecies recognized (Baker *et al.* 1988).

Museum specimens (total 9); Fig. 48:

- Mystery Room [in Carlsbad Cavern; mummies] (CACA 4) *not plotted*;
- Lower Cave [in Carlsbad Cavern; mummy] (CACA 1) *not plotted*;
- Carlsbad Cavern National Park [underground lunchroom in Carlsbad Cavern] (CACA 1) *not plotted*;
- Carlsbad Cave, bottom of deepest room [in Carlsbad Cavern; skulls] (USNM 2) *not plotted*;
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 1).

Additional records (Fig. 48):

- King's Palace in Carlsbad Cavern (Constantine 1961) *not plotted*;
- Deep Cave in side canyon of South Double Canyon (observation of a dead red bat by R. C. Kerbo on 27 January 1978) *not plotted*;
- orchard at Rattlesnake Springs (Constantine 1961);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (captured and released by KNG on 9 July 1997).

Corynorhinus townsendii (Cooper, 1837) Townsend's Big-eared Bat

This year-round resident of New Mexico occurs in habitats ranging from desert scrubland to montane forests (Findley *et al.* 1975). Not surprisingly, we captured this species from lowlands of the seabed to mesic canyons at high elevations on the reef (Fig. 47). At Rattlesnake Springs, individuals were netted over the storage pond, in the orchard, and under the canopy of trees by the ranger station (Table 6). On the reef, they were captured at Grammer Pool, Slaughter Pothole, Longview Spring, and Putman Pool (Table 8).

In the park, *C. townsendii* uses caves as shelters in warm months and as hibernacula in cold months. Through the years, this species has been confirmed in the following caves: Carlsbad Cavern (July), Chimney (October), Cueva de León (17 May), Deep (27 January), Lake (27 April), Lechuguilla (18 March and 13 January), Lost Spider (21 March), Ogle (winter), Rainbow (16 March), Recluse (30 May), Rock Rattler (October and 5 February), and Rockslide (15 July). Bats were observed alive in each case except in Rockslide Cave. In addition, museum specimens are available from Goat Cave and Lechuguilla Cave. Elevations at entrances of caves used by *C. townsendii* ranged from 1,300 to 1,800 m (4,300-5,900 ft; Appendix 3).

The most recent record of *C. townsendii* in the park is from Rattlesnake Springs. A male was discovered roosting on the front porch of the ranger station on 10 December 2000 (Table 9). The bat was in torpor, and the ambient temperature was 8°C. Excluding this December record, early and late dates of capture show *C. townsendii* active (= volant individuals captured on the surface) in the park from 1 May to 8 October.

Reproduction. Pregnant females captured in spring each contained a single fetus with the following crown-to-rump length: 11 mm (1 May), 21 mm (24 May), and 20 mm (31 May). We captured lactating females on 21 June, 7 July, and 2 August and adult males 1 May-9 August (Appendix 5). All reproductive records are from individuals captured in flight on the surface.

Taxonomic remarks. The subspecies of *Corynorhinus townsendii* in the park is *C. t. pallescens* Miller, 1897 based on the distribution reported in Hall (1981:235, map 184). This species was formerly placed in the genus *Plecotus*.

Museum specimens (total 14); Fig. 47:

- Guadalupe Room, Carlsbad Cavern [skull collected in 1992] (CACA 1) *not plotted*;
- Bat Cave [in Carlsbad Cavern; two collected on 6 November 1949 and one on 10 April 1950; unknown if dead or alive] (CACA 3) *not plotted*;
- Lechuguilla Cave [in Lechuguilla Canyon; skull collected in 1995] (CACA 1) *not plotted*;
- Goat Cave [in side canyon of North Slaughter Canyon, T25S, R23E, SE ¼ Sec. 11; one in hibernation; both collected in December 1953] (CACA 2) *not plotted*;
- Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE ¼ Sec. 30 (MSB 1);
- Slaughter Pothole, T25S, R23E, SW ¼ Sec. 11 [0.08 mi. N, 0.34 mi. W Goat Cave] (MSB 1);
- Longview Spring, T25S, R23E, E ½ Sec. 29 (MSB 1);
- Orchard near Ranger Station at Rattlesnake Springs [T25S, R24E, SW ¼ Sec. 23] (MSB 1);
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 [in front yard] (MSB 3).

Additional records (Fig. 47):

- small natural opening of Carlsbad Cavern (captured and released by R. C. Kerbo and J. W. Grace in July 1977) *not plotted*;
- Chimney Cave (observation by D. A. Ek in October 1990) *not plotted*;
- Cueva de León (observation by D. A. Ek on 17 May 1990) *not plotted*;
- Deep Cave (observation by R. C. Kerbo on 27 January 1978) *not plotted*;
- Lake Cave (observation by D. A. Ek on 27 April 1990) *not plotted*;
- Lechuguilla Cave in Lechuguilla Canyon (observation by D. A. Ek on 18 March 1990 and J. M. Richards on 13 January 2000) *not plotted*;
- Lost Spider Cave (observation by D. A. Ek on 21 March 1990) *not plotted*;

- Ogle Cave (observation by D. A. Ek in winter 1988/1989) *not plotted*;
- Rainbow Cave (observation by J. K. Baker on 16 March 1959) *not plotted*;
- Recluse Cave (observation by D. A. Ek on 30 May 1990) *not plotted*;
- Rock Rattler Cave (observation by D. A. Ek in October 1990 and D. A. Ek, J. J. Krupa, and KNG on 5 February 1991) *not plotted*;
- Rockslide Cave (observation by D. A. Ek on 15 July 1992) *not plotted*;
- Putman Pool, 0.24 mi. N, 0.08 mi. E Putman Cabin, T25S, R23E, NW ¼ Sec. 18 (captured and released by KNG on 2 August 1996);
- front porch of ranger station at Rattlesnake Springs (observation by D. M. Roemer on 10 December 2000);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (captured and released by KNG on 1 May 1991).

Antrozous pallidus (LeConte, 1856) Pallid Bat

Similar to western pipistrelles, pallid bats are common inhabitants of arid and semiarid regions of New Mexico (Findley *et al.* 1975; Findley 1987), and in the park both species were captured at many of the same water holes (Fig. 46). On the seabed, pallid bats were netted over Sewer Lagoon Tank and Rattlesnake Spring (Table 6). At Rattlesnake Springs, we also captured them regularly under canopies of trees at the ranger station and in the orchard. In the 1950s, pallid bats were captured in the adobe garage in the picnic area, and in 1978 they were observed on the front porch of the pump house (Table 9).

On the reef, the distribution of pallid bats is known primarily from netting them over water holes. They were captured at Indian Shelter Exhibit, Grammer Pool, Spider Cave Seep, Exhibit 13, and Longview Spring (Table 8). In addition, Bailey (1928) reported finding "several dozen" drowned in a water tank in Slaughter Canyon.

The only records of pallid bats associated with caves are those from a cave in Slaughter Canyon ($n = 2$; sex not reported; April 1924) and those from the large natural opening of Carlsbad Cavern (a male captured in a bat trap on 22 September 1957, a male discovered hanging in a side tunnel of the twilight area in January 1979, and a female captured in a mist net on 18 June 1998).

The male discovered in the large opening in January was alive and not in deep torpor. This bat represents the only winter record for the park and New Mexico (Findley *et al.* 1975), and it provides evidence that *A.*

pallidus overwinters in the Guadalupe Mountains. Based on park records, pallid bats are active from at least April (bats found dead in a water tank) to 8 October (netted at Rattlesnake Springs).

Reproduction. We recorded lactating females 7-18 July and volant young 27 July-16 August (Appendix 5). Adult males were captured 1 May-16 August.

Taxonomic remarks. The subspecies of *Antrozous pallidus* in the park is *A. p. pallidus* (LeConte, 1856) based on the distribution reported in Hall (1981:237, map 185).

Museum specimens (total 16); Fig. 46:

- entrance of Carlsbad Cavern, in bat trap [large natural opening; 22 September 1957] (CACA 1) *not plotted*;
- Cave in Slaughter Canyon [April 1924] (USNM 2) *not plotted*;
- Indian Shelter Exhibit, T24S, R25E, SW ¼ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
- Exhibit #13 along Scenic Loop Road [0.17 mi. N, 0.70 mi. E Lowe Spring, T24S, R24E, W ½ Sec. 34] (TTU 2);
- Goat Ranch in Slaughter Canyon, dead in water tank in April 1924 [perhaps referring to Clemond Ranch in Slaughter Canyon, T25S, R23E, E ½ Sec. 14; ranch is 0.65 mi. S Goat Cave] (USNM 1) *not plotted*;
- Slaughter Canyon [April 1924] (USNM 2) *not plotted*;
- Longview Spring, T25S, R23E, E ½ Sec. 29 (MSB 1);
- Sewer Lagoon Tank near Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1);

- Rattlesnake Springs, adobe garage [one collected on 19 May 1951; other in 1951] (CACA 2);
 - Ranger Station at Rattlesnake Springs, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 [in front yard] (MSB 1);
 - Rattlesnake Spring (CACA 1);
 - Carlsbad Cavern National Park (MSB 1) *not plotted*.
- Additional records (Fig. 46):*
- large natural opening of Carlsbad Cavern (captured and released by L. A. McWilliams on 18 June 1998) *not plotted*;
 - iron gate in large natural opening of Carlsbad Cavern [in twilight area] (observation by R. C. Kerbo in January 1979) *not plotted*;
 - farthest and deepest room in Carlsbad Cavern (based on wing bones, Bailey 1928:121) *not plotted*;
 - Grammer Pool, 1.33 mi. N, 0.66 mi. E Visitor Center, T24S, R25E, NE $\frac{1}{4}$ Sec. 30 (captured and released by KNG on 29 and 30 May 1984 and by KNG and KG on 23 July 1993);
 - Spider Cave Seep, 0.12 mi. N, 1.14 mi. W Visitor Center, T24S, R24E, NE $\frac{1}{4}$ Sec. 35 (captured and released by KNG on 12 June 1986);
 - orchard near ranger station at Rattlesnake Springs (captured and released by KNG and KG on 9 August 1988 and 7 July 2000 and by KNG on 9 July 1997);
 - front porch of pump house at Rattlesnake Springs (observation by P. E. Brown and R. C. Kerbo in August 1978).

Family Molossidae

Tadarida brasiliensis (L. Geoffroy Saint-Hilaire, 1824) Brazilian Free-tailed Bat

In New Mexico, Brazilian free-tailed bats occur statewide and are most common in lowland habitats such as deserts, grasslands, and pinyon-juniper woodland (Findley *et al.* 1975). The best known, and perhaps most studied, population of this species resides at Carlsbad Caverns National Park. The population inhabiting the park is migratory. Each spring hundreds of thousands of individuals arrive from places farther south and form a nursery colony at the end of a long tunnel in Carlsbad Cavern known as Bat Cave (Fig. 43). At this roost, females bear and raise their single young. The young are born in early summer and begin to fly by late July. With onset of cold weather in autumn, young and adults migrate south. One *T. brasiliensis* banded at Carlsbad Cavern flew at least "800 miles" (1,287 km) during autumn migration (Villa-R. and Cockrum 1962). Other studies documenting shorter movements from the cavern are presented by Constantine (1967) and Glass (1959).

Relatively small groups of *T. brasiliensis* remain in Carlsbad Cavern in winter, but it is not known whether these individuals are

part of the park's summer colony or if they are ones that have migrated from more northerly locales. Netting the cavern's large opening on 10 February 1991 revealed that winter residents include both males and females. Christensen (1947) also reported that a small number of *T. brasiliensis* were present in Carlsbad Cavern in February 1942.

Distribution in the park. Currently, Carlsbad Cavern is the only cave in the park that *T. brasiliensis* is known to occupy. All other records of this species are from individuals netted at various water holes on the seabed and reef and from individuals captured under canopies of trees at Rattlesnake Springs (Tables 6 and 8; Fig. 49). Most Brazilian free-tailed bats were netted over Sewer Lagoon Tank on the floor of the seabed. This earthen pond is the closest source of water to the cavern where free-tailed bats can drink from a large and unobstructed surface (Fig. 35). Another important water source for free-tailed bats is Rattlesnake Spring (Fig. 24). Radiotracking studies confirmed that free-tailed bats living in Carlsbad Cavern use both water holes (Best and Geluso 2003).

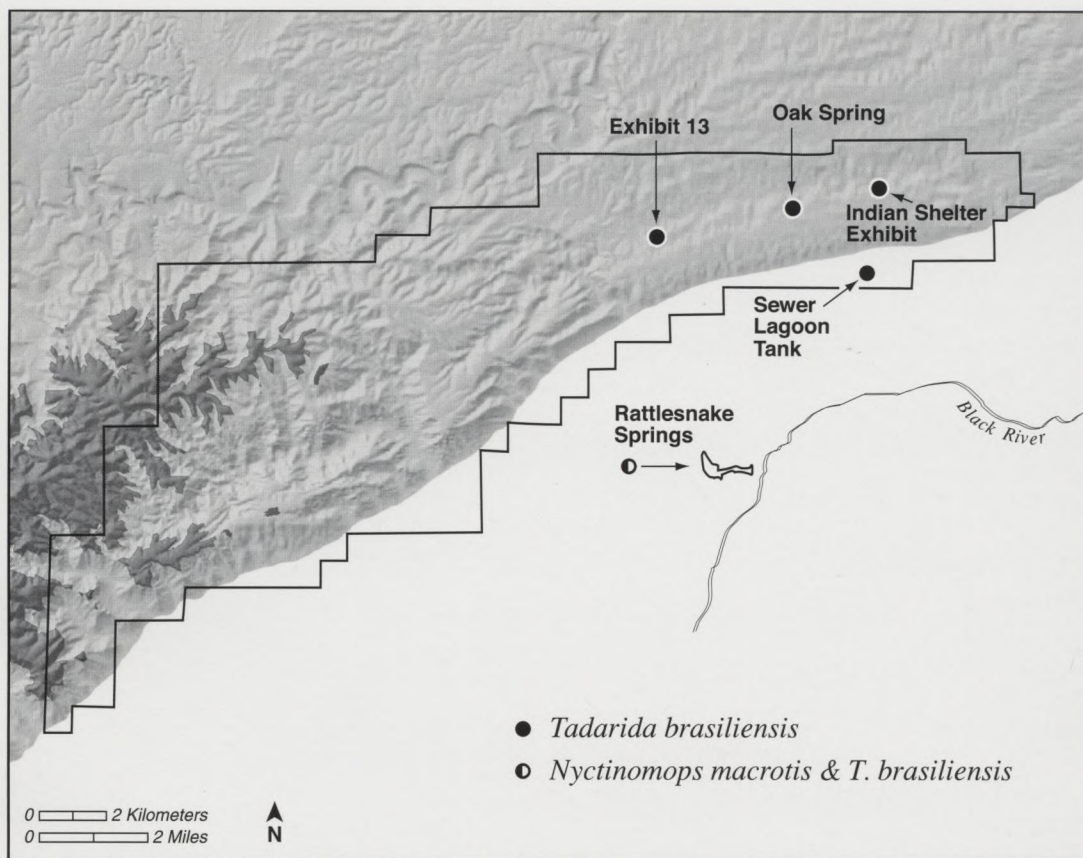


Fig. 49. Distribution of the Brazilian free-tailed bat (*Tadarida brasiliensis*) and big free-tailed bat (*Nyctinomops macrotis*) in Carlsbad Caverns National Park, excluding records from caves.

Reproduction. At Carlsbad Cavern, parturition in *T. brasiliensis* begins around mid-June and ends by mid-July. During that period, most births take place in a 15-day time span. For example, >90% of births occurred from 22 June to 6 July in 1973 (Altenbach *et al.* 1979). Young begin to appear in outflights in late July; at that time, they are about 40 days old. In 1973, at least some females were still lactating on 21 August.

Throughout summer, substantial numbers of adult males are present in the maternity roost at Carlsbad Cavern. We have netted the outflight of *T. brasiliensis* at the large natural opening many times since 1973, and we have always captured large numbers of adult males. For example, numerous adult males were captured on two nights in the 1970s and one night in 1997 (Table 22). During those nights, nearly all females were lac-

tating, volant young were not captured, and at least four samples of bats were collected during the outflight.

In the cavern, adult males are known to roost with pregnant and lactating females. Aida Parkinson (*pers. comm.*) marked heads of adult males and females with different colors of reflective tape, and from June to August 1981, she consistently observed both sexes occupying the same domes on the ceiling of Bat Cave.

Bat flight programs for park visitors.

Brazilian free-tailed bats were involved in the discovery of Carlsbad Cavern and since have become a major attraction of the park. Each night from spring to autumn, visitors may attend a bat flight program sponsored by the park and watch free-tailed bats exit the cavern. Visitors observe outflights from a large stone amphitheater in front of the cavern's

TABLE 22. Number of adult Brazilian free-tailed bats (*Tadarida brasiliensis*) captured during three exit flights from the large natural opening of Carlsbad Cavern. Samples of bats were taken throughout the flight with a large scoop net measuring 71 cm in diameter.

Time interval of netting ^a	Adult males	Reproductive females ^b	Nonreproductive females
<i>13 July 1975</i>			
2021-2026	10	52	1
2030-2035	25	23	1
2041-2045	30	4	1
2053-2100	37	2	0
2105-2111	38	2	0
2117-2125	22	1	1
2135-2150	13	1	1
<i>16 July 1976</i>			
2008-2014	23	28	2
2017-2023	24	34	2
2025-2029	25	17	4
2033-2039	20	5	3
2043-2055	34	2	4
<i>14 July 1997</i>			
2016-2029	52	27	0
2029-2032	62	17	0
2042-2048	83	9	0
2105-2113	31	0	2

^aMountain Daylight Saving Time.

^bAll females were lactating, except two pregnant females in 1997.

large opening (Figs. 38 and 39). The view of the outflight below the amphitheater is shown in Fig. 50. Although most bats leave the cavern through its large opening, some *T. brasiliensis* exit through the small opening of the cavern (Fig. 40). Free-tailed bats leaving the cavern on summer evenings usually head in a southeasterly direction, but the colony eventually disperses in every direction to forage for insects and to drink (Fig. 51; Best and Geluso 2003).

Food habits. Bailey (1928) first reported on the diet of *T. brasiliensis* living in Carlsbad Cavern. He discovered that the bats primarily ate insects of the orders Lepidoptera and Coleoptera. More recently, diet of this population was examined from April to September

(McWilliams 2002). In 1998, >1,300 *T. brasiliensis* were captured in the large natural opening of the cavern. Examination of fecal material revealed remains of 11 orders of Insecta (including 38 families) and two orders of Arachnida. Similar to Bailey's findings, lepidopterans and coleopterans were consumed most often by this population (39.2 and 24.6%, respectively by volume).

McWilliams (2002) also discovered that prey items of adult males and females were not different throughout the season except in late June. During late June, which coincided with late pregnancy and early lactation, females consumed more coleopterans, and males consumed more lepidopterans and insects of the order Neuroptera. McWilliams

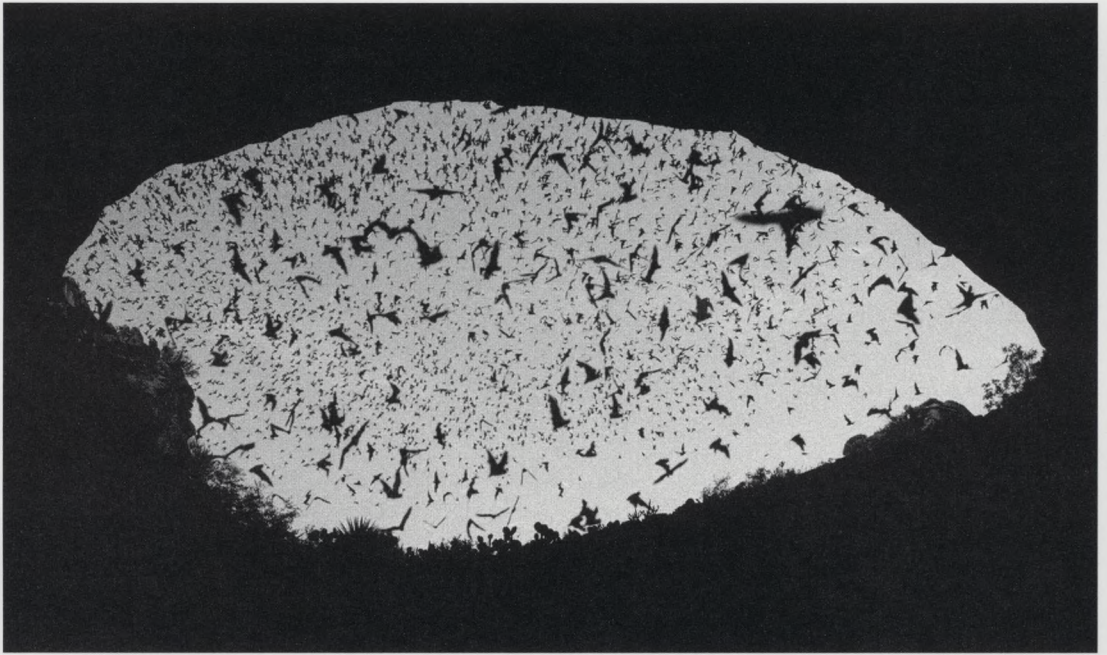


Fig. 50. View of the evening outflight of Brazilian free-tailed bats (*Tadarida brasiliensis*) when standing inside the mouth of the large natural opening to Carlsbad Cavern.

reported only slight differences in diet between pregnant, lactating, and non-reproductive females; however, she noted significant differences in diets between adults and volant young. In general, adults consumed greater quantities of lepidopterans, and young consumed greater quantities of coleopterans and insects of the orders Hymenoptera, Diptera, Homoptera, and Isoptera.

Population size. The summer colony at Carlsbad Cavern has been estimated as high as 8,700,000 in 1936 (Allison 1937) and as low as 218,000 in 1973 (Altenbach *et al.* 1979). Both estimates were based on counting bats during evening outflights. The estimate in 1936 was determined by direct observation, while the latter one used photographic methods. Even if the 1936 estimate was off by 4 or 5 million, a significant decline in population size occurred after the 1930s. It is not known whether the decline was gradual or abrupt. In recent years, estimates have been based upon infrared photographs of roosting bats, and in 1996 the size of the summer colony was about 353,000 (Route *et al.* 1998).

In 1973, the National Park Service, World Wildlife Fund, and U.S. Fish and Wildlife Ser-

vice funded a study to investigate whether chemical pesticides were a possible cause for the decline of *T. brasiliensis* at Carlsbad Cavern. Results indicated that DDT, a commonly used agricultural insecticide, probably contributed to the decline (Geluso *et al.* 1976). Researchers discovered that as baby bats mature in the maternity roost, they continually accumulate pesticides (mostly DDE, a metabolite of DDT) in their bodies. Most pesticide is obtained from mother's milk, but some is received through the placenta (Clark *et al.* 1975). Mothers obtain most chemical residues by eating contaminated insects. Nonvolant young are protected from toxic effects of chemicals because they contain enough body fat for pesticide storage (Wilson *et al.* 1978); however, as body fat is mobilized during migration, pesticides may reach the brain in lethal amounts. Laboratory experiments demonstrated that pesticide levels in some young from the cavern in 1974 were high enough to cause death when pesticides were mobilized during a simulated migratory flight (Geluso *et al.* 1976). These data suggest that pesticides have contributed to the decline of *T. brasiliensis* at Carlsbad Cavern.

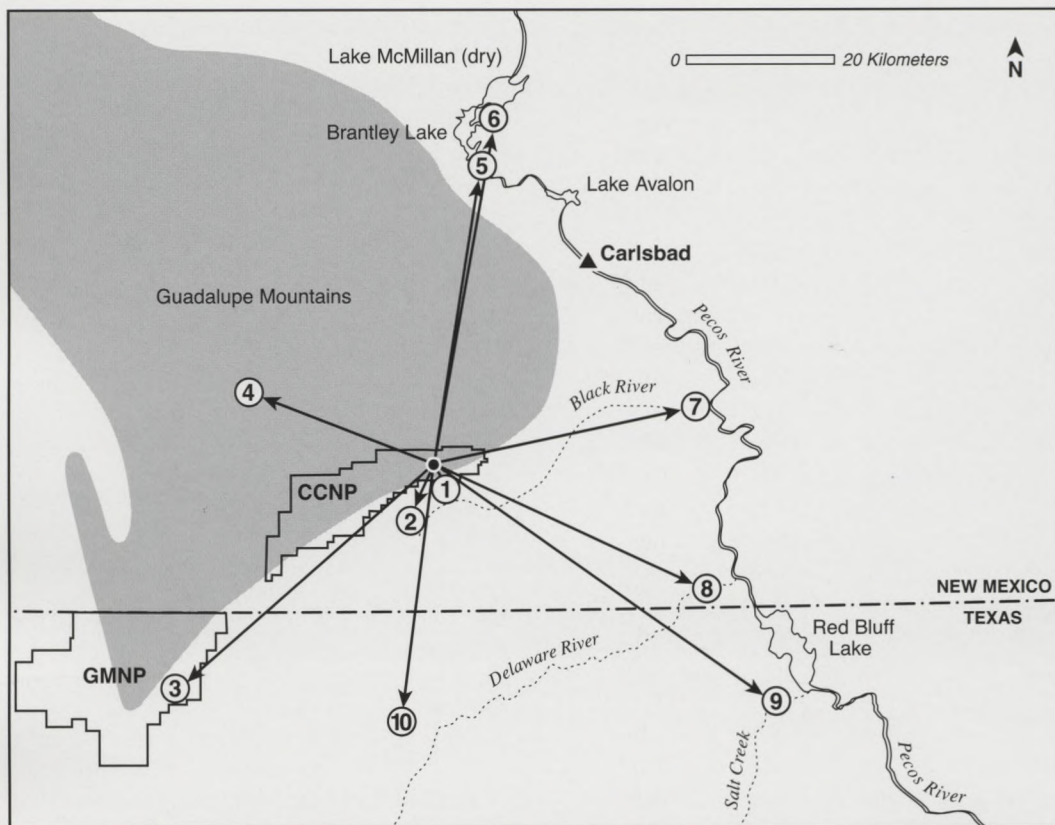


Fig. 51. On summer evenings, Brazilian free-tailed bats (*Tadarida brasiliensis*) living in Carlsbad Cavern disperse in every direction after leaving the cavern. The nightly foraging range is at least 56 km from the cavern. The black dot represents the large natural opening of the cavern. Circled numbers represent the following localities: 1 = Sewer Lagoon Tank in Carlsbad Caverns National Park (CCNP); 2 = Rattlesnake Spring in CCNP; 3 = Manzanita Spring in Guadalupe Mountains National Park (GMNP); 4 = Sitting Bull Falls; 5 = Pecos River; 6 = Lake McMillan Dam; 7 = Black River; 8 = Delaware River; 9 = Salt Creek; and 10 = a ranch-house pond (map modified from Best and Geluso 2003).

Comparative studies also showed that *T. brasiliensis* from Carlsbad Cavern contained higher body burdens of pesticides than those from Arizona, California, Oklahoma, and Texas (Geluso *et al.* 1981; White and Krynsky 1986; Thies *et al.* 1996). Clark (2001) recently concluded that lethal effects of DDT compounds on free-tailed bats from the cavern probably were substantially greater in the 1950s and 1960s than in the 1970s.

Guano mining in the early 1900s initially might have affected the population of *T. brasiliensis* in Carlsbad Cavern. Suitable nursery space was reduced in the cavern after a guano shaft was blasted through the ceiling where the main maternity colony was located. Brazilian free-tailed bats usually se-

lect spacious ceilings of large caves as sites for nursery roosts. By using body heat accumulated from huge numbers, they are able to raise temperatures of entire caves or large rooms within caves (Humphrey 1975). Warm roost temperatures promote rapid growth of young and assure readiness for autumn migration. Based on mining records in Carlsbad Cavern, *T. brasiliensis* occupied the large domed ceiling at the end of Bat Cave plus other huge expanses of ceiling. Climate of the dome was altered in 1906 when a shaft was blasted through the ceiling to facilitate removal of guano deposited by bats. The shaft probably acted as a chimney flue, allowing body heat to escape. Eventually, the large dome was not used as a nursery roost for

many years. It is not known exactly when this dome was abandoned and if some bats permanently left the cavern or just moved to other areas of Bat Cave. It is known, however, that in 1936 (30 years after construction of the shaft) large numbers of free-tailed bats were still living in the cavern.

From the 1950s to 1983, the relatively small population of *T. brasiliensis* in Bat Cave formed nursery colonies in four comparatively small domes approximately 230 m west of the large dome at the end of Bat Cave (information from 1950s, D. G. Constantine *pers. comm.*). In March 1981, the National Park Service plugged the guano shaft in the large dome in hopes of making it a suitable nursery site for future generations of bats. At the same time, they also plugged another guano shaft that was drilled near the small natural opening sometime before 1906. Free-tailed bats continued to use the smaller domes to raise their young during summers of 1981-1983 (Bat Cave was not checked in 1984), but in summers of 1985 and 1986, the nursery colony used a portion of the large dome plus a crevice in the ceiling adjacent to the dome. In the 1990s, the nursery colony sometimes was located almost entirely in the large dome, and in other years, it appeared to be located mostly in the crevice.

Besides Carlsbad Cavern, mining claims also allowed bat guano to be removed from Slaughter Canyon Cave, Ogle Cave, and Lechuguilla Cave. When Carlsbad Caverns National Monument was established in 1923, mining activities were halted in Carlsbad Cavern. Mining of guano ended in other caves by 1957. Skulls of bats removed from old guano in Slaughter Canyon Cave were different enough from other free-tailed bats to be described as a different species, *Tadarida constantinei* (Lawrence 1960).

Other common names. At the park, the Brazilian free-tailed bat is referred to as the Mexican free-tailed bat, which is the common name of the subspecies inhabiting the park.

Taxonomic remarks. The subspecies of *Tadarida brasiliensis* in the park is *T. b. mexicana* (Saussure, 1860) based on the distribution reported in Hall (1981:242, map 188).

Museum specimens (total 263, plus ca. 9,000 fallen young); Fig. 49:

- Large Natural Entrance of Carlsbad Cavern, T24S, R25E, NW ¼ Sec. 31 (MSB 4) *not plotted*;
- Entrance Carlsbad Cavern, in bat trap [in large natural opening] (MSB 1) *not plotted*;
- Carlsbad Cavern [large natural opening] (TTU 49) *not plotted*;
- Carlsbad Cavern entrance (CACA 2) *not plotted*;
- Carlsbad Cavern [fallen young from Bat Cave in Carlsbad Cavern] (MSB ca. 9,000; stored in lots; MSB 34634 [collected in 1973], 34635-34641 [1974], 34986 [1975], and 35378 [1976]) *not plotted*;
- Bat Cave, Carlsbad Cavern (KU 48, AMNH 1) *not plotted*;
- Bat Cave, 26 mi. SW Carlsbad [in Carlsbad Cavern] (MSB 1) *not plotted*;
- Bat Cave [in Carlsbad Cavern] (CACA 10) *not plotted*;
- near Shrine [in Big Room of Carlsbad Cavern] (CACA 1) *not plotted*;
- New Mexico Room, Carlsbad Cavern [skulls collected in 1991 and 1992] (CACA 8) *not plotted*;
- Mystery Room [in Carlsbad Cavern] (CACA 3) *not plotted*;
- Carlsbad Cavern (MSB 6, KU 98) *not plotted*;
- Carlsbad Cave [in Carlsbad Cavern] (USNM 2) *not plotted*;
- Carlsbad Cave (USNM 8) *not plotted*;
- Carlsbad Caverns (AMNH 2, LACM 9, TCWC 4) *not plotted*;
- Indian Shelter Exhibit, T24S, R25E, SW ¼ Sec. 29 [0.81 mi. N, 1.31 mi. E Visitor Center] (MSB 1);
- Exhibit #13 on Scenic Loop Road, T24S, R24E, W ½ Sec. 34 [0.17 mi. N, 0.70 mi. E Lowe Spring] (MSB 1);
- Sewer Lagoon Tank near Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1);
- Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 2);
- Carlsbad Caverns National Park (CACA 1).

Additional record (Fig. 49):

- small natural opening of Carlsbad Cavern (captured and released by KNG on 29 July 1996) *not plotted*;
- Oak Spring, T24S, R24E, NE ¼ Sec. 36 (captured and released by KNG on 20 June 1986);
- front yard of ranger station at Rattlesnake Springs (captured and released by KNG and KG on 1 May 1991 and 7 July 2000).

***Nyctinomops femorosaccus* (Merriam, 1889)**
Pocketed Free-tailed Bat

In the Southwest, the pocketed free-tailed bat occurs in desert habitats where it roosts in crevices on high cliffs and rocky outcrops (Barbour and Davis 1969). In New Mexico, it is known only from two localities—a canyon in the southwest corner of the state and Carlsbad Caverns National Park in the southeast (Findley *et al.* 1975). Southwestern records are based on ten individuals, including males and pregnant females (Easterla 1973a; Findley *et al.* 1975), while the park's record is based on one individual. A lactating female was captured in the large opening of Carlsbad Cavern on 8 September 1956 (Constantine 1958a).

Breeding populations of *N. femorosaccus* occur in southern Arizona (Hoffmeister 1986), thus, pregnant females captured on 30 June and 3–4 July in southwestern New Mexico might have been members of a local, reproducing population. However, it is unclear whether

the lactating female from Carlsbad Cavern was part of a breeding population or if she was a wandering or lost individual. The nearest published record of a breeding colony of *N. femorosaccus* to the park is 290 km south-southeast in Big Bend National Park (Easterla 1973b). Absence of established populations in the Guadalupe Mountains probably is not due to lack of appropriate habitat but may be related to seasonal temperatures being too cool (see Easterla 1973b).

Reproduction. The female from the park was lactating on 8 September (Constantine 1958a).

Taxonomic remarks. *Nyctinomops femorosaccus* is a monotypic species with no subspecies recognized (Hall 1981:244, map 190).

Museum specimens (total 1); not mapped:

- Carlsbad Cavern [caught in bat trap in large natural opening] (TCWC 1).

***Nyctinomops macrotis* (Gray, 1839)**
Big Free-tailed Bat

In southwestern United States, the big free-tailed bat typically inhabits rugged canyons containing rocky outcrops and tall cliffs (Milner *et al.* 1990). This species occurs in several areas throughout New Mexico, including the Guadalupe Mountains (Findley *et al.* 1975; Geluso 2002). Most records from this mountain range are from Texas ($n = 14$, Genoways *et al.* 1979; LaVal 1973), but two *N. macrotis* have been captured in the Guadalupe Mountains of New Mexico, both of which are from Carlsbad Caverns National Park.

The first record for the park was obtained at Rattlesnake Springs. A female was discovered roosting on the pump house next to Rattlesnake Spring on 27 May 1955 (Fig. 49 and Table 9). The specimen tag does not indicate whether the animal was roosting inside or outside the building. The second record is from Carlsbad Cavern. A female was captured

in the large opening on 10 October 1956 (Constantine 1958a). Although big free-tailed bats primarily roost in crevices and cracks on high canyon walls, other investigators also have captured them in buildings and caves (Milner *et al.* 1990).

In temperate North America, *N. macrotis* is migratory (Milner *et al.* 1990). Earliest and latest seasonal records for this molossid in New Mexico are 22 May and 22 October (Findley *et al.* 1975). Because capture dates of this species in the park are 27 May and 10 October, both records likely represent migratory individuals. However, a lactating female captured on 3 August in the Guadalupe Mountains of Texas suggests that resident populations occur in this mountain range from time to time (LaVal 1973).

Reproduction. The female captured on 27 May was an adult, and according to

Constantine (1958a), the female of 10 October was immature.

Taxonomic remarks. *Nyctinomops macrotis* is a monotypic species with no subspecies recognized (Hall 1981:246, map 191).

Museum specimens (total 2); Fig. 49:

- in bat trap in entrance of Carlsbad Cavern [in large natural opening] (TCWC 1) *not plotted*;
- Pumphouse, Rattlesnake Spring (CACA 1).

Order Lagomorpha
Family Leporidae
Sylvilagus audubonii (Baird, 1857)
Desert Cottontail

The desert cottontail occurs in a variety of habitats in the park, as it does throughout New Mexico (Findley 1987). In the park, we documented *S. audubonii* from lowlands of the seabed to the highest summits of the reef. Along the base of the escarpment, it was common in desert-scrub habitats, especially in disturbed areas around the Sewage Disposal Ponds. We occasionally observed this species in the grassland, juniper plain, and drainage areas. Desert cottontails were present at Rattlesnake Springs but were common only in the "pasture" at the west end.

On the reef, we observed *S. audubonii* on the face of the escarpment, in the juniper peneplain, on canyon floors, and in areas bordering the maintenance yard, residences, and Visitor Center. At 1,745 m (5,720 ft), KG observed an individual on a grassy-oak knoll along Guadalupe Ridge. At higher elevations, KNG saw several cottontails as they dashed through underbrush near Putman Cabin. Summits in this area reach 1,965 m (6,450 ft) and contain shrubs, grasses, scattered junipers, and pines. In the Texas portion of the Guadalupe Mountains, *S. audubonii* has been documented as high as 1,920 m (6,300 ft; Genoways *et al.* 1979).

Although we refer to cottontails on wooded summits of the park as *S. audubonii*, another species also might inhabit these areas. In the Guadalupe Mountains of Texas, the Davis Mountains cottontail (*Sylvilagus robustus*) inhabits dense stands of Douglas-fir and ponderosa pine at 2,375 m (7,800 ft; Genoways *et al.* 1979). The pine-juniper summits in Carlsbad Caverns National Park might provide marginal habitat for this species.

Reproduction. No information is available regarding reproductive biology of *S. audubonii* in the park.

Taxonomic remarks. The subspecies of *Sylvilagus audubonii* in the park is *S. a. neomexicanus* Nelson, 1907 based on the distribution reported in Hall (1981:309, map 225).

Museum specimens (total 6); *not mapped*:

- in pipe W of ticket office [near large opening of Carlsbad Cavern] (CACA 1);
- between mouths of Rattlesnake and Slaughter canyons (KU 4);
- 1 mi. below mouth of Slaughter Canyon (CACA 1).

Additional records (*not mapped*):

- floor of Walnut Canyon (most recent sighting by KNG and KG was on 13 July 1997);
- floor of Bat Cave Draw, T24S, R25E, N ½ Sec. 31 (sighting by KNG on 21 March 1995);
- around maintenance yard, residences, and Visitor Center (most recent sighting by KNG and KG was on 24 July 1996);
- juniper peneplain along Scenic Loop Drive (most recent sighting by KNG and KG was on 22 March 1995);
- summit along Guadalupe Ridge, T25S, R23E, near center of Sec. 3 (sighting by KG on 11 May 1991);
- near Putman Cabin, T25S, R23E, Sec. 18 (sightings by KNG in February 1991);
- face of eastern escarpment, 0.95 mi. S, 0.86 mi. W Red Cave, T26S, R23E, NW ¼ Sec. 6 (sighting by KNG on 30 April 1991);
- desert scrubland along gravel road between Sewage Disposal Ponds and park's entrance SW of Whites City (most recent sighting by KNG and KG was on 8 July 1997);

- next to Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 (most recent sighting by KNG and KG was on 18 March 1993);
- arid grassland, T25S, R23E, SW ¼ Sec. 25 (most recent sighting by KNG and KG was on 12 July 1998);
- arroyo, T25S, R23E, SE ¼ Sec. 33 (sighting by KNG on 23 July 1993);
- juniper plain, T25S, R23E, S ½ Sec. 33 (sighting by KNG on 30 December 1998);
- Rattlesnake Springs, T25S, R24E, S ½ Sec. 23 (most recent sighting by KNG and KG was on 15 July 1998).

Lepus californicus Gray, 1837 Black-tailed Jackrabbit

Black-tailed jackrabbits occur throughout New Mexico and are most common in deserts and grasslands (Findley *et al.* 1975; Findley 1987). In desert-scrub areas of the park, we observed them in open and grassy areas as well as disturbed areas around the Sewage Disposal Ponds and Sewer Lagoon Tank. In open areas, they occurred in places with and without lechuguilla. Although we did not observe jackrabbits in the grassland or juniper plain, they surely occur in those habitats. Black-tailed jackrabbits also inhabited Rattlesnake Springs. Besides observing them in weedy and shrubby habitats on this parcel of land, we saw individuals in the picnic area, mowed fields, and on the lawn next to the storage pond.

Although many black-tailed jackrabbits were observed on the seabed, most of our sightings occurred at night while driving roads on the reef. Greatest numbers were seen along roads in the juniper peneplain, especially those at the beginning of the Scenic Loop Drive and those near the residences, maintenance yard, and Visitor Center. Jackrabbits also were common in grassy areas along the floor of Walnut Canyon.

The highest elevational record of *L. californicus* in the park is based on a sighting near Guadalupe Ridge in the north-central section of the park (Fig. 10). At this elevation, an individual was flushed from its daytime shelter on a grassy-oak knoll at 1,735 m (5,700 ft). Higher records have been recorded in the Texas portion of the Guadalupe Mountains (1,920 m or 6,300 ft; Genoways *et al.* 1979) and in other parts of New Mexico (2,650 m or 8,700 ft; Findley *et al.* 1975).

Reproduction. No information is available regarding reproductive biology of *L. californicus* in the park.

Taxonomic remarks. The subspecies of *Lepus californicus* in the park is *L. c. texianus* Waterhouse, 1848 based on the distribution reported in Hall (1981:327, map 230).

Museum specimens (total 1); not mapped:

- Carlsbad Caverns (KU 1).

Additional records (not mapped):

- face of eastern escarpment, T24S, R25E, E ½ Sec. 33-W ½ Sec. 34 (sighting by KNG on 20 March 1995);
- floor of Walnut Canyon (most recent sighting by KNG and KG was on 8 July 1995);
- near residences, maintenance yard, and Visitor Center (most recent sighting by KNG and KG was on 24 July 1996);
- juniper peneplain along Scenic Loop Drive (most recent sighting by KNG and KG was on 5 July 1995);
- near Guadalupe Ridge, T25S, R23E, W ½ Sec. 2 (sighting by J. J. Krupa on 5 February 1991);
- desert scrubland along gravel road between Sewage Disposal Ponds and park's entrance SW of Whites City (most recent sighting by KNG and KG was on 23 October 1999);
- near Sewer Lagoon Tank, T25S, R25E, NW ¼ Sec. 5 (sighting by KNG on 5 August 1988);
- next to Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 (most recent sighting by KNG and KG was on 21 July 1993);
- Rattlesnake Springs, T25S, R24E, S ½ Sec. 23 (most recent sighting by KNG and KG was on 15 July 1998).

Order Rodentia
Family Sciuridae
Neotamias canipes (V. Bailey, 1902)
Gray-footed Chipmunk

The gray-footed chipmunk is primarily a forest-dwelling species and occurs only in southeastern New Mexico and western Texas (Best *et al.* 1992). Although this species can be found in a variety of habitats in New Mexico, including pinyon-juniper woodland and spruce-fir forests, its center of abundance seems to be ponderosa pine communities (Findley *et al.* 1975; Best *et al.* 1992).

Not surprisingly, most of our sightings and captures of *N. canipes* in the park occurred at high elevations on the reef in areas containing isolated patches of conifers and

deciduous trees ($\geq 1,770$ m or $\geq 5,800$ ft; Fig. 52). Here chipmunks were most common on rocky slopes. This habitat occurs most often in gullies, ravines, and narrow canyon heads in gullies, ravines, and narrow canyon heads with a northerly exposure. Near Yucca Cabin, we observed and captured chipmunks along ledges of rock outcrops on sides of a mesic ravine. This protected area contained a dense mixture of trees and shrubs consisting of alligator juniper, bigtooth maple, chinkapin oak, scrub oak, Texas madrone, and a few ponderosa pine. Other chipmunks were sighted in mesic habitats in and near Putman Canyon.

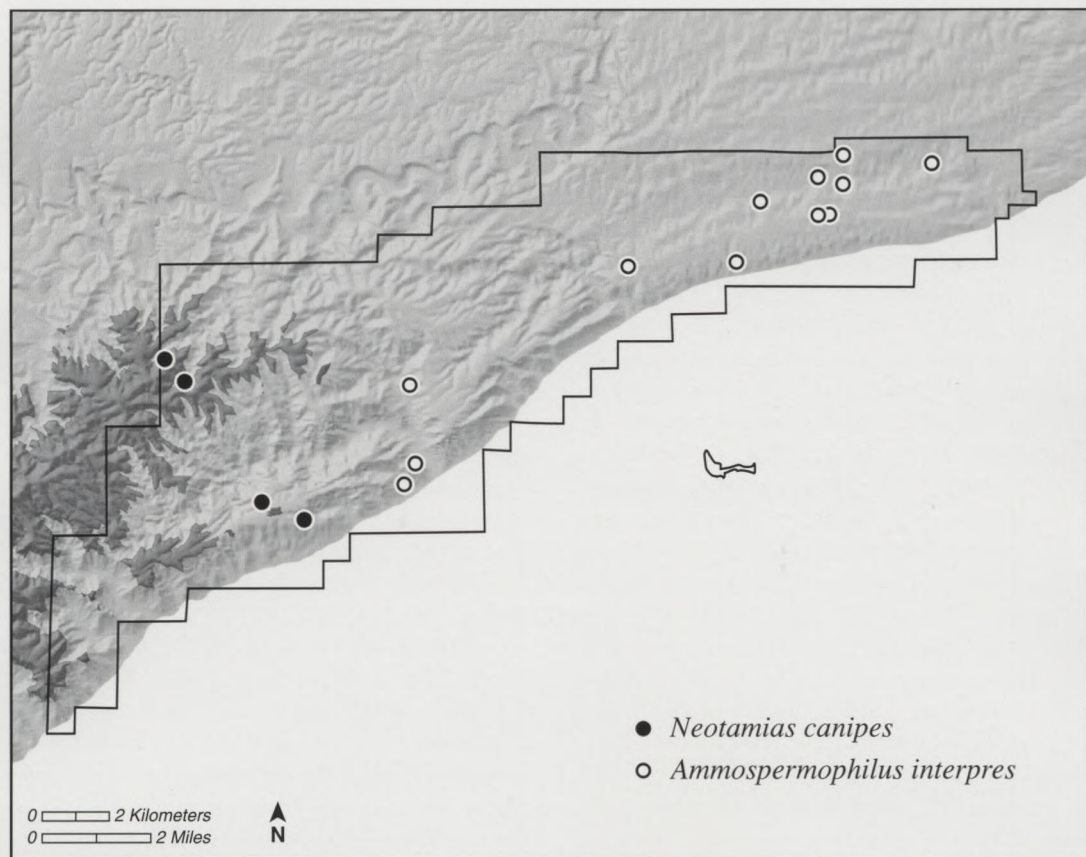


Fig. 52. Distribution of the gray-footed chipmunk (*Neotamias canipes*) and Texas antelope squirrel (*Ammospermophilus interpres*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

While working the high country, we observed chipmunks in spring and summer but not in winter.

Gray-footed chipmunks also inhabited drier habitats of the park. We observed an individual on a rocky slope in Yucca Canyon. The slope contained small oaks and bushes but no large trees. At 1,670 m (5,480 ft), this sighting represents one of the lowest elevational records of this species in the Guadalupe Mountains. Davis (1940) reported a *N. canipes* at 1,615 m (5,300 ft) in this mountain range in Texas.

Reproduction. Two females were pregnant with six young each on 24 July. In one female, the largest fetus measured 17 mm in crown-to-rump length, and in the other the largest uterine swelling measured 4 mm. Body masses of females were 70 and 60 g, respectively.

Taxonomic remarks. The subspecies of *Neotamias canipes* in the park is *N. c. canipes* (V. Bailey, 1902) based on the distribution reported in Hall (1981:360, map 244). This species was formerly placed in the genus *Tamias*.

Museum specimens (total 2); Fig. 52:

- 0.15 mi. N, 0.25 mi. E Longview Spring, T25S, R23E, NE ¼ Sec. 29 [ravine containing Dog Pen Seep] (MSB 2) reef 56.

Additional records (Fig. 52):

- 1.03 mi. E, 0.22 mi. S Longview Spring, T25S, R23E, SE ¼ Sec. 28 in Yucca Canyon (sighting by KNG, KG, and L. F. Lumsden on 24 July 1991) reef 53;
- Putman Canyon, T25S, R23E, NW ¼ Sec. 18 (sightings by KG on 31 July 1991) reef 65;
- 0.73 mi. N, 0.06 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 7 (sighting by KNG on 30 July 1991) reef 69.

Ammospermophilus interpres (Merriam, 1890) Texas Antelope Squirrel

In New Mexico, Texas antelope squirrels occur east of the Rio Grande from the Sandia Mountains south to the Sacramento and Guadalupe mountains (Findley *et al.* 1975; Findley 1987; Geluso 2004a). They live in rocky habitats and are most common below pinyon-juniper woodland. In the park, we captured or observed antelope squirrels only in habitats on the reef, including canyon floors, faces of steep cliffs, ledges of rock outcroppings, gullies of the eastern escarpment, and in the juniper penneplain (Fig. 52). Elevations of these occurrences ranged from 1,150 to 1,415 m (3,780-4,640 ft); however, in the Guadalupe Mountains of Texas, *A. interpres* has been reported as high as 1,920 m (6,300 ft; Genoways *et al.* 1979). In Texas, there also are records from the seabed at 1,510 m (4,960 ft) and 1,645 m (5,400 ft).

Most of our records of *A. interpres* were from the floor of Walnut Canyon. We observed individuals crossing rocky creek beds and sitting on boulders in the bottom of the creek. We also saw them chasing one another along grassy creek banks and captured them in traps

placed under shrubs along the bank. On several occasions, we found dead individuals on the paved road, and in each case a creek bed was located on one side and a cliff on the other.

We observed only one *A. interpres* in summer (29 July 1996); all other observations and captures occurred in January ($n = 8$), March (6), April (3), and May (1). A factor contributing to frequent sightings in winter is probably related to increased activity associated with reproduction. For example, we observed pairs of squirrels chasing each other in midwinter. One pair was a male with scrotal testes and a barren female. Findley *et al.* (1975) reported individuals on snow in midwinter in the Sandia Mountains of central New Mexico, and KG observed five individuals in November in the Sacramento Mountains (Otero Co.) and one individual in December in a northern part of the Guadalupe Mountains in Eddy Co. (Geluso 2004a; KG *pers. observ.*).

Reproduction. A female carried five embryos on 26 January; the largest uterine swelling measured 9 mm. Lactating females were noted on 20 March and 23 April. An

adult female showing no obvious sign of reproductive activity was captured on 26 January. We caught young females on 26 and 27 April; body masses were 36 and 37 g, respectively. Adult males captured on 26 January and 22 May had testes measuring 17.0 and 17.5 mm in length, respectively. Body masses of adults were as follows: males (115 and 135 g, respectively), lactating females (105 and 95 g, respectively), pregnant female (110 g), and nonreproductive female (105 g).

Taxonomic remarks. *Ammospermophilus interpres* is a monotypic species with no subspecies recognized (Hall 1981:380, map 255).

Museum specimens (total 9); Fig. 52:

- 1.18 mi. N, 1.57 mi. W Whites City, T24S, R25E, NW ¼ Sec. 28 (MSB 1) reef 6;
- 0.05 mi. N, 0.32 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N ½ Sec. 31 (MSB 3) reef 12;
- 0.67 mi. N, 0.76 mi. E Visitor Center, T24S, R25E, SE ¼ Sec. 30 (MSB 1) reef 18;
- 0.56 mi. W, 0.17 mi. N Oak Spring, T24S, R24E, SW ¼ Sec. 25 (MSB 2) reef 24;
- 0.13 mi. E, 0.46 mi. S Lowe Spring, T25S, R24E, NE ¼ Sec. 4 (MSB 1) reef 31;
- near Clement Ranch, Slaughter Canyon [=Clemond Ranch, T25S, R23E, E ½ Sec. 14; ranch is 0.65 mi. S Goat Cave] (CACA 1) reef 42.

Additional records (Fig. 52):

- 0.99 mi. N, 1.25 mi. W Whites City, T24S, R25E, NE ¼ Sec. 28 (sighting by KNG on 22 March 1992) reef 6;
- near large natural opening of Carlsbad Cavern (sighting by D. M. Roemer on 3 November 2000, 6 November 2000, and 6 December 2000) reef 13;
- near Grammer Pool, T24S, R25E, NE ¼ Sec. 30 (sighting by KNG on 29 July 1996) reef 19;
- 0.97 mi. N, 0.37 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 30 (sighting by KNG on 23 March 1991) reef 21;
- face of eastern escarpment, T25S, R24E, NE ¼ Sec. 2 (sighting by D. M. Roemer on 11 October 1996) reef 26;
- below New Cave [= Slaughter Canyon Cave] in Slaughter Canyon (sighting by J. K. Baker on 24 June 1959) reef 39;
- face of eastern escarpment, T25S, R23E, NE ¼ Sec. 26 (sighting by KNG on 20 March 1993) reef 41.

Spermophilus variegatus (Erxleben, 1777) Rock Squirrel

In New Mexico, rock squirrels are commonly associated with rocky terrain (Findley *et al.* 1975), and in the park they were particularly abundant on rocky outcrops along canyonsides. We observed countless rock squirrels in the park through the years.

At high elevations on the reef, we captured an *S. variegatus* on a rock ledge near Yucca Cabin at 1,770 m (5,800 ft; Fig. 53). The trap site was in a mesic ravine containing a dense stand of deciduous trees and conifers. At 1,765 m (5,790 ft), KG observed an individual on a grassy knoll containing many patches of gray oak growing among rocks, stones, and areas of exposed soil. In the Guadalupe Mountains of Texas, this squirrel has been reported as high as 2,135 m (7,000 ft; Davis 1940).

Although we never saw rock squirrels in open, flat areas along the base of the escarpment, we observed them in deep arroyos in the lowlands. In these situations, they lived along rocky ledges on walls of arroyos. Rock squirrels were common at Rattlesnake Springs where the only rock-like structures were cement aqueducts, the rock-lined storage pond, and a pile of rocks by the horse barn. Although squirrels took advantage of these rocky situations, they also burrowed in lawns around the ranger station and orchard. In this area, we noticed them climbing fruit trees and weeping willows. Rock squirrels also burrowed under buildings and lived in the picnic area. On the seabed, rock squirrels occurred at elevations of 1,105–1,320 m (3,625–4,330 ft).

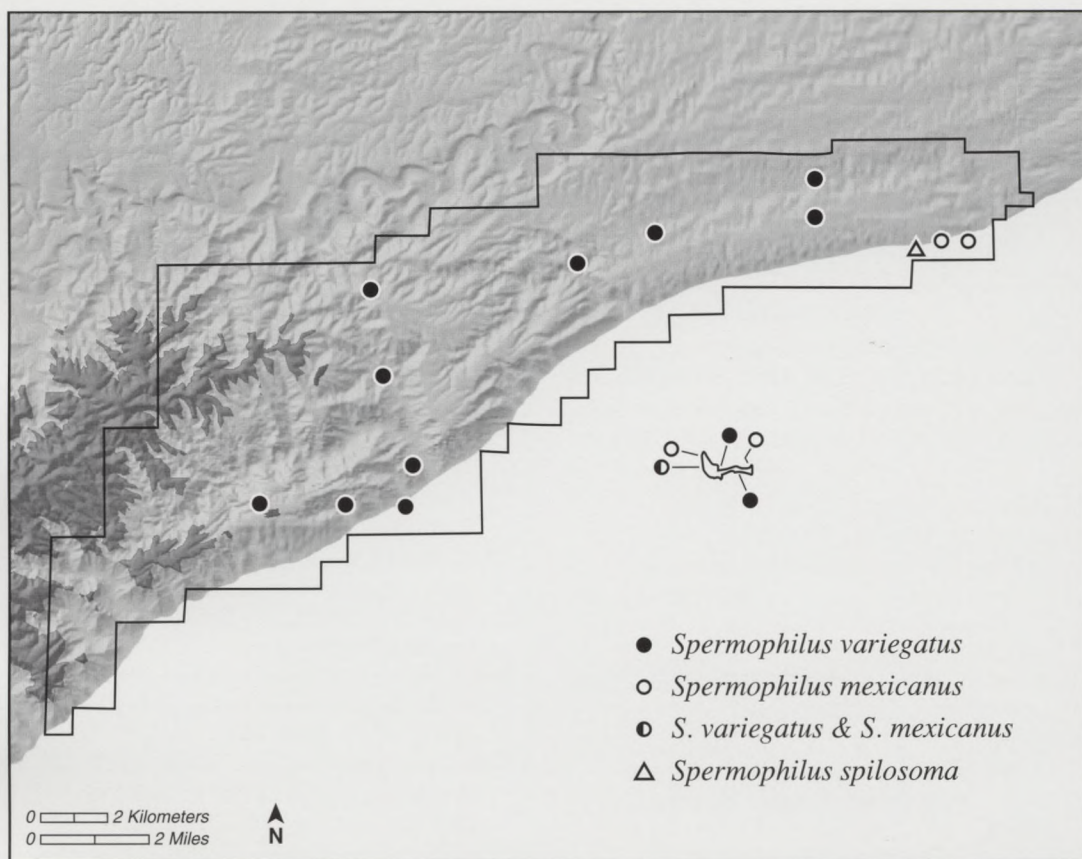


Fig. 53. Distribution of the rock squirrel (*Spermophilus variegatus*), Mexican ground squirrel (*S. mexicanus*), and spotted ground squirrel (*S. spilosoma*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

Although its activity may be curtailed on exceptionally cold days, *S. variegatus* apparently does not hibernate at the park. Throughout the year, individuals usually can be seen sitting on rocks in and around the large opening of Carlsbad Cavern. In northern parts of New Mexico, this species may hibernate (Findley *et al.* 1975; Findley 1987).

Reproduction. A subadult female weighed 275 g on 24 July, and a young female weighed 165 g on 21 May. Both females showed no sign of reproductive activity. Based on museum specimens at MSB, body masses of adult *S. variegatus* ranged from 432 to 850 g (mean = 577 g; $n = 11$).

Taxonomic remarks. The subspecies of *Spermophilus variegatus* in the park is *S. v. grammurus* (Say, 1823) based on the distribution reported in Hall (1981:400, map 268).

Museum specimens (total 6); Fig. 53:

- Carlsbad Cave [in Walnut Canyon] (USNM 1) *not plotted*;
- Bat Cave Draw (CACA 1) *not plotted*;
- near old naturalist office [near large natural opening of Carlsbad Cavern] (CACA 1) *reef 13*;
- 1.5 mi. up Rattlesnake Canyon (KU 1) *reef 34*;
- 0.15 mi. N, 0.25 mi. E Longview Spring, T25S, R23E, NE $\frac{1}{4}$ Sec. 29 [ravine containing Dog Pen Seep] (MSB 1) *reef 56*;
- Rattlesnake Springs, next to Ranger Station, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) *seabed 41*.

Additional records (Fig. 53):

- large natural opening of Carlsbad Cavern (most recent sighting by KNG and KG was on 4 August 1996) *reef 13*;
- parking lot near large natural opening of Carlsbad Cavern (most recent sighting by KNG was in July 2000) *reef 13*;
- 0.97 mi. N, 0.37 mi. E Visitor Center, T24S, R25E, NW $\frac{1}{4}$ Sec. 30 (sighting by KNG on

- 25 March 1991) reef 21;
- Exhibit #13 in Walnut Canyon, 0.70 mi. E, 0.17 mi. N Lowe Spring, T24S, R24E, W ½ Sec. 34 (sighting by KNG on 23 May 1992) reef 28;
 - foot trail to Slaughter Canyon Cave, T25S, R23E, SE ¼ Sec. 23 (sighting by KNG on 22 March 1993) reef 39;
 - Middle Slaughter Canyon, T25S, R23E, NW ¼ Sec. 14 (sighting by KNG on 23 March 1993) reef 44;
 - along Guadalupe Ridge, T25S, R23E, Sec. 3 (sighting by KG on 10 May 1991) reef 47;
 - Yucca Canyon, T25S, R23E, S ½ Sec. 27 (most recent sighting by KNG and KG was on 12 July 1998) reef 52;
 - 0.52 mi. S New Cave, T25S, R23E, NE ¼ Sec. 26 [arroyo on seabed] (sighting by KNG on 20 March 1993) seabed 27;
 - picnic area at Rattlesnake Springs, T25S, R24E, SE ¼ Sec. 23 (sighting by KNG and KG on 19 May 1992) seabed 39;
 - orchard next to ranger station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23 (sighting by KNG on 28 July 1993) seabed 41;
 - 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 [near horse barn] (captured and released by KNG on 6 May 1991) seabed 43.

Spermophilus mexicanus (Erxleben, 1777) Mexican Ground Squirrel

In New Mexico, *S. mexicanus* occurs only in the southeastern corner of the state in Eddy, Chaves, and Lea counties (Findley *et al.* 1975; Choate 1997). Most records in this region are from mesquite grasslands, irrigated farmlands, golf courses, cemeteries, city parks, and highway rights-of-way (Findley 1987; Choate 1997).

In the park, *S. mexicanus* occurred on the seabed in areas with sparse grass and scattered shrubs (Fig. 53). In desert scrubland, we collected one individual on a rocky substrate containing numerous patches of lechuguilla and another individual on exposed soil with stones and no lechuguilla. In both situations sparse grass grew among widely spaced shrubs. At Rattlesnake Springs, a pair was captured under a viscid acacia in the small area of desert scrub by the shooting range. This area contained fine-textured soil, some stones and rocks, and small amounts of grass. Near the horse barn, we observed an individual harvesting flowers of Mexican vervain, and here grass was absent except for some growing on powdery soils under shrubs. Another individual was seen running into an area dominated by mesquite at the east end of Rattlesnake Springs. Outside the park, we also observed individuals ($n = 7$) along paved highways while we drove from Whites City to

Rattlesnake Springs or Slaughter Canyon Cave. In the park, *S. mexicanus* occurred at elevations of 1,105-1,120 m (3,620-3,680 ft), and none was captured or observed on the reef.

It is not clear whether Mexican ground squirrels hibernate (Young and Jones 1982). We observed individuals above ground from 6 May to 11 August in the park and noticed active individuals in the town of Carlsbad as early as 17 March. Bailey (1928) observed an individual on 11 March in the Carlsbad region.

Reproduction. Adult females weighed 200 and 195 g on 7 and 15 May, respectively. Both females showed no obvious sign of reproductive activity. We collected young females on 20 July and 11 August; body masses were 125 and 120 g, respectively. A male with scrotal testes was captured and released at Rattlesnake Springs on 15 May.

Taxonomic remarks. The subspecies of *Spermophilus mexicanus* in the park is *S. m. parvidens* Mearns, 1896 based on the distribution reported in Hall (1981:394, map 265).

Museum specimens (total 4); Fig. 53:

- 0.24 mi. S, 0.82 mi. W Whites City, T24S, R25E, SW ¼ Sec. 34 (MSB 1) seabed 3;
- 1.43 mi. W, 0.37 mi. S Whites City, T24S, R25E, S ½ Sec. 33 (MSB 1) seabed 7;

- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) seabed 43;
- 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) seabed 44.

Additional records (Fig. 53):

- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (sighting by D. M. Roemer on 11 August 2000) seabed 38.

***Spermophilus spilosoma* Bennett, 1833** **Spotted Ground Squirrel**

Spotted ground squirrels are found in arid grasslands and deserts throughout New Mexico (Findley *et al.* 1975). We obtained one specimen from the park on 27 July 1991. A female was trapped in desert scrubland at 1,130 m (3,700 ft) in a flat area with soil containing stones (Fig. 53). Shrubs consisted of tarbush, creosote bush, mesquite, viscid acacia, javelina bush, mariola, and Christmas cholla. Grass was sparse, and lechuguilla was not present. The burrow of this individual was under a creosote bush.

Spotted ground squirrels hibernate in New Mexico (Findley *et al.* 1975). In short-grass prairies in central parts of the state, most squirrels emerge from hibernation from

mid-March to early April. Our earliest observation of this species occurred on 15 March at a location on the seabed outside the park (1.6 km from the park's southern boundary).

Reproduction. The female was not pregnant or lactating and weighed 110 g.

Taxonomic remarks. The subspecies of *Spermophilus spilosoma* in the park is *S. s. marginatus* V. Bailey, 1902 based on the distribution reported in Hall (1981:397, map 266).

Museum specimens (total 1); Fig. 53:

- 1.79 mi. W, 0.40 mi. S Whites City, T24S, R25E, SW $\frac{1}{4}$ Sec. 33 (MSB 1) seabed 9.

Family Geomyidae ***Thomomys bottae* (Eydoux and Gervais, 1836)** **Botta's Pocket Gopher**

Throughout its range, *T. bottae* occupies a wide variety of habitats (Patton 1999), and this euryecious pattern also was evident at the park. *Thomomys bottae* occurred in all major habitats on the reef and those along the base of the escarpment (Fig. 54). Although it was most abundant in shallow, rocky soils throughout the park, some individuals lived in deep, rockless soils at Rattlesnake Springs. In the park, *T. bottae* was captured at elevations ranging from 1,105 to 1,965 m (3,625-6,450 ft).

On the reef, we noted excavations of Botta's pocket gophers on the face of the escarpment, summits, canyon floors, canyon-sides, and in areas around water holes. They

lived along tiers of narrow ledges high on cliff faces, they burrowed among patches of New Mexico agave in the pine woodland, and they occurred in creek beds on canyon floors. Excavations also were common around residences near Carlsbad Cavern.

On the seabed, *T. bottae* occurred in the scrubland, grassland, juniper plain, alluvial fans, and drainage areas. In desert scrubland, most activity occurred in rocky areas containing lechuguilla and in grassy areas with tall bushes.

Botta's pocket gopher also occurred at Rattlesnake Springs where it coexisted with *Cratogeomys castanops* near the picnic area.

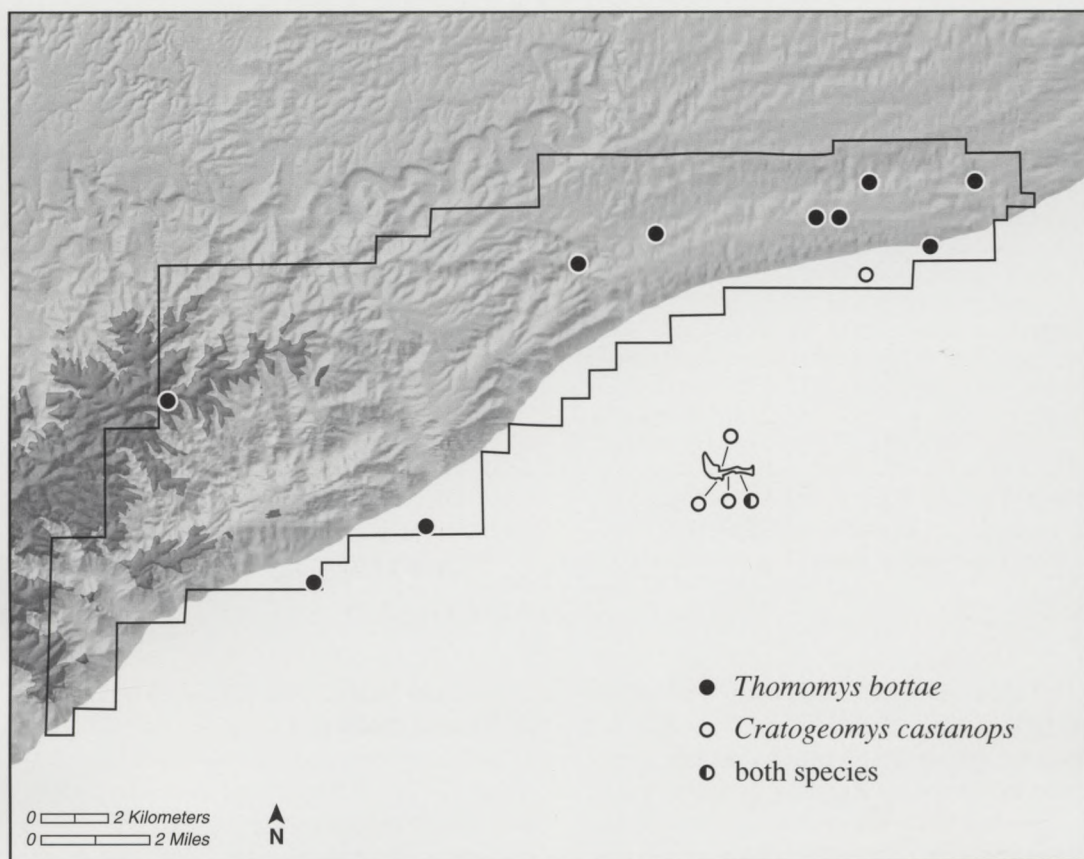


Fig. 54. Distribution of the Botta's pocket gopher (*Thomomys bottae*) and yellow-faced pocket gopher (*Cratogeomys castanops*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

On 9 February 1991, J. J. Krupa and KNG set at least two traps each in five different tunnels along a strip of ground lying between a cement aqueduct and the park's boundary line (Fig. 25). Soil was deep, friable, easy to dig, and contained a few stones and no rocks. The following morning, we captured a *T. bottae* and *C. castanops* in the same tunnel. Two other pocket gophers were caught—one of each species in different tunnels.

Reproduction. A female (body mass 120 g) contained three embryos on 10 February; the largest uterine swelling measured 10 mm. Females that were neither pregnant nor lactating were collected on 20 January (105 g), 25 January (95 g), 6 February (90 g), and 26 May (70 and 80 g). Males captured on 6 February (90 g), 10 February (70 g), 22 March (125 g), and 26 May (77 g) had testes measuring 12.0, 5.0, 20.0, and 10.0 mm in length, respectively.

Taxonomic remarks. The subspecies of *Thomomys bottae* in the park is *T. b. pectoralis* Goldman, 1936 based on the distribution reported in Hall (1981:475, map 307). The type specimen of this subspecies is from Carlsbad Caverns National Park (Hall 1981:490; Goldman 1936:120).

Museum specimens (total 43); Fig. 54:

- 1 mi. W park entrance, Walnut Canyon (CACA 1) reef 5;
- 1 mi. below big curve, Walnut Canyon (CACA 2) reef 8;
- Bat Cave Draw (CACA 3) *not plotted*;
- by guano shafts [Bat Cave Draw] (CACA 5) reef 11;
- Cavern area [near Carlsbad Cavern] (CACA 1) reef 13;
- Carlsbad Cave [on ridge near Carlsbad Cavern; includes type specimen] (USNM 3) reef 13;

- ticket office [near large natural opening of Carlsbad Cavern] (CACA 2) *reef 13*;
- Elevator bridge trail [trail between Visitor Center and large natural opening of Carlsbad Cavern; there is a section of the trail where a small bridge passes over Bat Cave Draw] (CACA 5) *reef 13*;
- 0.16 mi. N, 0.12 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31 (MSB 1) *reef 13*;
- Lee Robinson's garden [residences near park headquarters] (CACA 1) *reef 13*;
- below administration building [park headquarters, 0.10 mi. W of large natural opening of Carlsbad Cavern (CACA 3) *reef 13*;
- 4 mi. W Whites City, Carlsbad Caverns National Park (KU 5) *not plotted*;
- 6 mi. W Whites City, Carlsbad Caverns National Park (KU 1) *not plotted*;
- 0.71 mi. E, 0.12 mi. N Lowe Spring, T24S, R24E, W ½ Sec. 34 (MSB 1) *reef 28*;
- 1 mi. up Rattlesnake Canyon (KU 1) *reef 34*;
- Knoll of Putman Cabin, T25S, R23E, SW ¼ Sec. 18 (MSB 2) *reef 67*;
- 1.53 mi. W, 0.29 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33 (MSB 1) *seabed 8*;
- 1.22 mi. S, 0.44 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 1) *seabed 25*;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 2) *seabed 29*;
- Rattlesnake Springs Picnic Area, T25S, R24E, SE ¼ Sec. 23 (MSB 2) *seabed 39*.

Cratogeomys castanops (Baird, 1852) Yellow-faced Pocket Gopher

Cratogeomys castanops occurs in the eastern half of New Mexico where it overlaps in distribution with the plains pocket gopher (*Geomys bursarius*) and Jones's pocket gopher (*G. knoxjonesi*) in some areas and with Botta's pocket gophers (*Thomomys bottae*) in others (Findley *et al.* 1975; Choate 1997). *Cratogeomys castanops* seems to select deep, friable soils that are relatively free from rocks (Findley *et al.* 1975; Davidow-Henry *et al.* 1989). However, if *C. castanops* and *G. bursarius* coexist in an area, *C. castanops* is restricted to shallower, harder soils that often contain rocks (Findley *et al.* 1975; Davidow-Henry *et al.* 1989). On the other hand, if *C. castanops* and *T. bottae* coexist (such as Carlsbad Caverns National Park), *T. bottae* is restricted to the shallower, rockier soils (Findley 1987; Davidow-Henry *et al.* 1989). In the park, *C. castanops* was found primarily in deep, friable, and rockless soils, while *T. bottae* occurred most often in rocky soils.

Yellow-faced pocket gophers were common only at Rattlesnake Springs (Fig. 54). We observed their earthen mounds regularly on the lawn of the picnic area and adjacent fields. In these areas, soils were well developed, easy to dig with a shovel, and contained a few stones and no rocks. Mounds also were noted on lawns around the ranger station and or-

chard; here stones and rocks were not present in the well-developed soils. Around the pump house, however, soil was difficult to dig because it was compact and contained stones and some rocks intermixed with soil. Nevertheless, *C. castanops* also burrowed in this quality of soil. Mounds constructed by pocket gophers were observed in the "pasture" at Rattlesnake Springs, but we did not set gopher traps in this part of the property. As mentioned in the previous account, both *C. castanops* and *T. bottae* lived together in soils near the picnic area at Rattlesnake Springs.

In 1991, we noticed mounds constructed by pocket gophers along the base of the escarpment near the earthen pond named Sewer Lagoon Tank. A grassy wash with tall bushes intersects the pond, and surrounding habitat is desert scrub. Mounds were in a disturbed area of bare ground 12.8 m from the pond's edge. Soil was compact, fairly easy to dig with a shovel, and contained some stones. We captured a *C. castanops* at this location on 14 February, the only *C. castanops* caught outside Rattlesnake Springs (Fig. 54). We captured no *C. castanops* in other habitats along the base of the escarpment, and it was not present on the reef. In the park, *C. castanops* was captured at elevations 1,105-1,120 m (3,625-3,680 ft).

Reproduction. A pregnant female carrying four embryos and another bearing two were captured on 4 and 10 February, respectively. The largest uterine swelling measured 15 mm in both females. A female collected on 2 February was lactating. On 10 February, an adult female had well-developed nipples but was neither pregnant nor lactating. Body masses of females were as follows: pregnant females were both 235 g, the lactating female was 270 g, and the non-reproductive female was 235 g. A male captured on 14 February weighed 410 g and had testes measuring 8.0 mm in length. Another male collected on 21 March weighed 255 g; its testes measured 7.5 mm in length.

Taxonomic remarks. The subspecies of *Cratogeomys castanops* in the park is *C. c.*

lacrimalis Nelson and Goldman, 1934 based on the taxonomic revision of *C. castanops* by Hollander (1990:49).

Museum specimens (total 8); Fig. 54:

- 0.12 mi. S, 0.21 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1) *seabed 11*;
- Rattlesnake Springs Picnic Area, T25S, R24E, SE ¼ Sec. 23 (MSB 3) *seabed 39*;
- 0.12 mi. E, 0.06 mi. N Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 1) *seabed 40*;
- Rattlesnake Springs Ranger Station (KU 2) *seabed 41*;
- Rattlesnake Springs, near water-storage pond, T25S, R24E, SW ¼ Sec. 23 [in front of pump house] (MSB 1) *seabed 42*.

Family Heteromyidae *Perognathus flavus* Baird, 1855 Silky Pocket Mouse

In New Mexico, silky pocket mice live primarily in deserts and grasslands, although they also occur in pinyon-juniper woodland (Findley *et al.* 1975). At the park, almost all *P. flavus* were captured in lowland habitats, including the scrubland, grassland, juniper plain, alluvial fans, and arroyos (Fig. 55). Of these habitats, largest numbers were taken in the grassland and in grassy areas of the scrubland (Table 15). However, some were captured in open areas of scrubland where grass was sparse on a fine-textured soil. Silky pocket mice also occurred in habitats containing sparse grass at Rattlesnake Springs, especially in places containing dusty soils (Table 18).

We trapped no *P. flavus* on the reef, but we obtained a dead individual along the paved road near park residences. The surrounding habitat was juniper penepain. Another specimen from this habitat was collected near the headquarters in 1950. In the park, silky pocket mice occurred from 1,115 to 1,410 m (3,650-4,630 ft) in elevation.

In central New Mexico, silky pocket mice remain active during winter (Findley *et al.*

1975), and we found the same for animals living in the park. We captured *P. flavus* in February ($n = 4$), March (10), April (3), May (4), July (5), and August (7).

Reproduction. We obtained 33 silky pocket mice in the park and prepared 18 as voucher specimens. Pregnant females were captured on 11 March and 24 April. The former contained four embryos (largest uterine swelling measured 4 mm), and the latter contained three embryos (largest embryo measured 2 mm in crown-to-rump length). Females showing no obvious sign of reproductive activity were collected on 10 February ($n = 1$), 24 April (2), 15 May (1), 21 July (2), and 3 August (1). Males captured on 10 February had testes measuring 5.0, 5.0, and 5.5 mm in length; on 11 March (5.0, 6.0, and 6.0 mm); on 20 March (5.5 mm); on 27 July (6.5 mm); and on 9 August (5.0 mm).

Taxonomic remarks. Based on electrophoretic analyses of proteins, Lee and Engstrom (1991) concluded that silky pocket mice from southeastern New Mexico represent two distinct species, *Perognathus flavus* Baird, 1855 and *P. merriami* J. A. Allen, 1892.

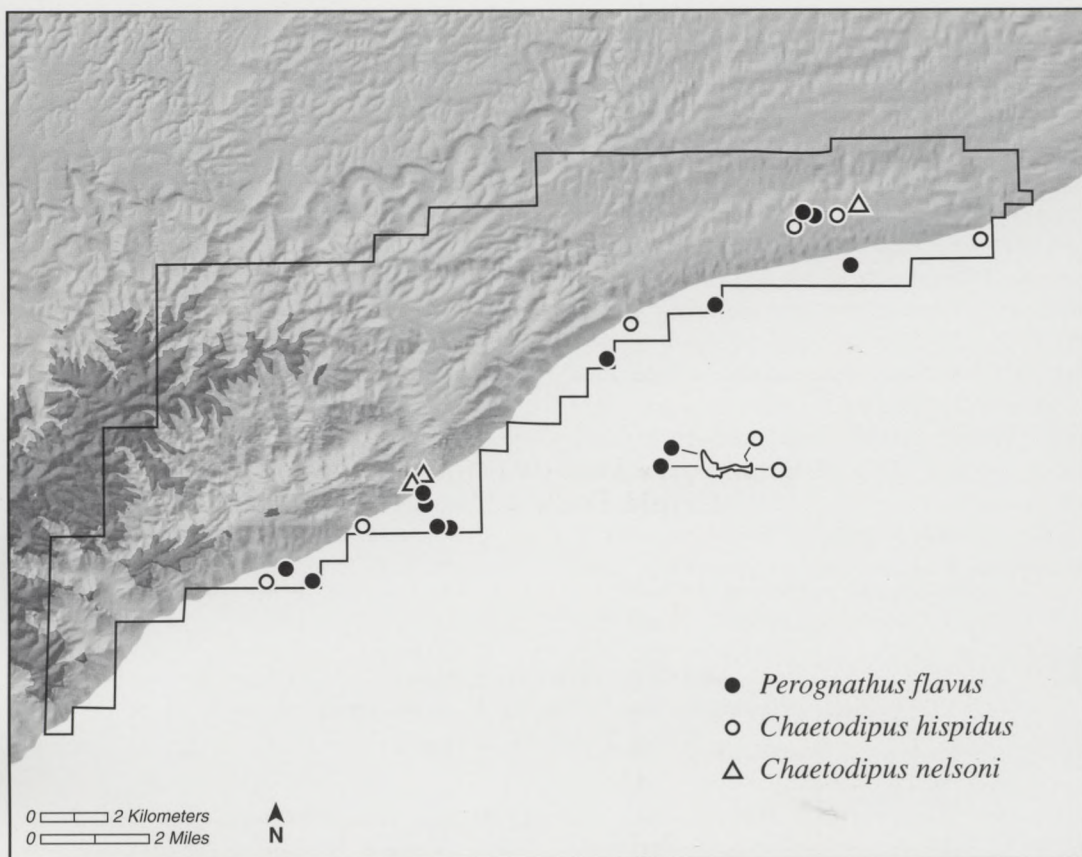


Fig. 55. Distribution of the silky pocket mouse (*Perognathus flavus*), hispid pocket mouse (*Chaetodipus hispidus*), and Nelson's pocket mouse (*C. nelsoni*) in Carlsbad Caverns National Park. The exact location of *C. nelsoni* collected in 1953 is uncertain and is not plotted on the map. For precise location of symbols see Appendix 4.

In fact, one zone of contact between these species is 57.5 km from the park at a location north of the town of Carlsbad. Previous studies by Wilson (1973), Findley *et al.* (1975), and Schmidly (1977) have examined morphological features of these taxa and found no trait that consistently separated them. In more recent analyses, Choate *et al.* (1992) and Jones and Jones (1992) came to the same conclusion. With no reliable way to distinguish these species of pocket mice using morphological traits, we tentatively applied the name *P. flavus* to all specimens from the park. The subspecies of *P. flavus* in this part of New Mexico is *P. f. flavus* Baird, 1855 based on the distribution reported in Hall (1981:535, map 324).

Museum specimens (total 23); Fig. 55:

- headquarter area [0.10 mi. W of large natural opening of Carlsbad Cavern] (CACA 1) reef 13;
- 0.32 mi. N, 0.03 mi. E Visitor Center, T24S, R24E, NE ¼ Sec. 36 (MSB 1) reef 15;
- 6 mi. W Whites City [on reef in park, M. C. Thompson *pers. comm.*] (KU 1) *not plotted*;
- 8 mi. W Whites City [on reef in park, M. C. Thompson *pers. comm.*] (CACA 1, KU 2) *not plotted*;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1) seabed 13;
- 0.09 mi. S, 0.02 mi. E Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 (MSB 1) seabed 13;
- 0.92 mi. S, 0.53 mi. W Chimney Cave, T25S, R24E, SW ¼ Sec. 2 (MSB 2) seabed 16;

- 1.37 mi. S, 0.57 mi. E Stone Spring, T25S, R24E, S $\frac{1}{2}$ Sec. 9 (MSB 1) *seabed* 18;
- 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed* 19;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (MSB 3) *seabed* 20;
- 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed* 24;
- 0.49 mi. S, 0.37 mi. E New Cave, T25S, R23E, NE $\frac{1}{4}$ Sec. 26 (MSB 2) *seabed* 26;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S,

- R23E, SE $\frac{1}{4}$ Sec. 33 (MSB 1) *seabed* 29;
- 0.96 mi. S, 0.78 mi. E Longview Spring, T25S, R23E, W $\frac{1}{2}$ Sec. 33 (MSB 3) *seabed* 31;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) *seabed* 43.

Additional records (Fig. 55):

- 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (captured and released by KNG and KG on 15 May 1991) *seabed* 44.

Chaetodipus hispidus (Baird, 1857) Hispid Pocket Mouse

In New Mexico, hispid pocket mice occupy areas of medium to tall grasses or tall annual forbs (Findley 1987). In the park, we captured seven *C. hispidus*, and each occurred in areas containing moderately dense grasses or forbs. On the seabed, mice were trapped in desert scrubland (in a patch of sand dropseed and threeawn), the juniper plain, and alluvial fans (Table 15; Fig. 55). At Rattlesnake Springs, we captured them in weedy areas and the shrubby area dominated by mesquite (Table 18). We suspect that *C. hispidus* also occurs in the grassland.

On the reef, we obtained a dead *C. hispidus* from the paved parking lot on the east side of the Visitor Center. Grassy areas lined the perimeter of the parking lot. An additional record was collected from the floor of Bat Cave Draw in 1950. This animal was taken in a grassy area near the guano shaft at the end of Bat Cave. Hispid pocket mice were captured at elevations of 1,105–1,385 m (3,620–4,550 ft).

Reproduction. A female contained five embryos on 20 May; the largest uterine swelling measured 5 mm. Another female captured on 13 May was neither pregnant nor lactating. Males captured on 13 March, 23 April, 3 May, and 14 May had testes measuring 9.0,

10.0, 9.5, and 9.0 mm in length, respectively. A male captured on 15 May was released.

Taxonomic remarks. The subspecies of *Chaetodipus hispidus* in the park is *C. h. paradoxus* (Merriam, 1889) based on the distribution reported in Hall (1981:547, map 330).

Museum specimens (total 7); Fig. 55:

- Bat Cave Draw, near second shaft [east guano shaft] (CACA 1) *reef* 11;
- Parking lot of Visitor Center, T24S, R24E, NE $\frac{1}{4}$ Sec. 36 (MSB 1) *reef* 17;
- 0.17 mi. S, 0.55 mi. W Whites City, T24S, R25E, SW $\frac{1}{4}$ Sec. 34 (MSB 1) *seabed* 2;
- 0.57 mi. S, 0.87 mi. E Stone Spring, T25S, R24E, NE $\frac{1}{4}$ Sec. 9 (MSB 1) *seabed* 17;
- 1.08 mi. S, 0.79 mi. W New Cave, T25S, R23E, SE $\frac{1}{4}$ Sec. 27 (MSB 1) *seabed* 28;
- 1.44 mi. S, 0.42 mi. E Longview Spring, T25S, R23E, SW $\frac{1}{4}$ Sec. 33 (MSB 1) *seabed* 32;
- 0.08 mi. N, 0.64 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 1) *seabed* 37.

Additional records (Fig. 55):

- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (captured and released by KNG and KG on 15 May 1991) *seabed* 38.



Fig. 56. Thus far, all records of Nelson's pocket mice (*Chaetodipus nelsoni*) from New Mexico are from Carlsbad Caverns National Park. This individual was captured on the face of the eastern escarpment near the mouth of Slaughter Canyon on 29 April 1991.

Chaetodipus nelsoni (Merriam, 1894) Nelson's Pocket Mouse

The southeastern corner of New Mexico is the northernmost limit of Nelson's pocket mouse in the United States (Hall 1981), and thus far, Carlsbad Caverns National Park is the only place in New Mexico with records of this pocket mouse (Findley *et al.* 1975). The first *C. nelsoni* reported in New Mexico was obtained on 26 January 1953 (Webb 1954), but an unreported specimen in the park's museum was collected earlier on 8 October 1952. We captured four additional animals in 1991, one on 29 April, 20 May, 4 August, and 5 August (Fig. 56). Apparently, this species is active throughout the year in the northern part of its range.

We captured Nelson's pocket mice on exposed slopes of the eastern escarpment at elevations of 1,310-1,370 m (4,300-4,500 ft; Fig. 55 and Table 12). Slopes faced southeasterly, had inclines of 21-25°, and contained many

boulders and large slabs of flat rock. Grasses were moderately dense between rocks and consisted of mesa muhly, sideoats grama, rough tridens, and tanglehead. Other vegetation included sotol, ocotillo, lechuguilla, prickly pear, Roemer acacia, mariola, mescal bean, agarito, Spanish dagger, oreganillo, skeletonleaf goldeneye, and some small oaks.

Although we trapped slopes of the escarpment along its entire length, all four pocket mice were captured west of the mouth of Slaughter Canyon on two adjacent slopes separated by a gully. Mice were caught on either the first or second night of trapping. Nearby slopes with similar characteristics produced no *C. nelsoni*. It appears that *C. nelsoni* is rare in the park.

As mentioned above, the first reported *C. nelsoni* from New Mexico was obtained in 1953 (Webb 1954). The mouse was captured 4

miles (6.4 km) W of Whites City at 1,130 m (3,700 ft) in elevation. This location would be near the large opening of Carlsbad Cavern, but elevations in this area are >1,310 m (4,300 ft). Nevertheless, field notes of the collector (G. H. Heinrich) indicate that the mouse was captured in the park. The specimen is at the University of Kansas, and KNG verified its identity in 1994, although Findley *et al.* (1975) reported the specimen missing. Another *C. nelsoni* was collected in 1952 and deposited in the park's museum. It was trapped in Bat Cave Draw and originally identified as *Perognathus intermedius*.

Reproduction. Nelson's pocket mice caught on 29 April, 20 May, and 5 August were adult males; testes were scrotal and measured 8.0, 8.5, and 8.0 mm in length, respectively. The mouse taken on 4 August was a

female with six well-developed nipples; each nipple produced a clear liquid when the surrounding area was squeezed.

Taxonomic remarks. The subspecies of *Chaetodipus nelsoni* in the park is *C. n. canescens* (Merriam, 1894) based on the distribution reported in Hall (1981:554, map 335).

Museum specimens (total 6); Fig. 55:

- Bat Cave Draw, 1 mi. E of entrance [entrance = large natural opening of Carlsbad Cavern; collected in 1952] (CACA 1) *reef 9*;
- Carlsbad Caverns N. P., 4 mi. W Whites City [collected in 1953] (KU 1) *not plotted*;
- 0.24 mi. S, 0.23 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23 [collected in 1991] (MSB 2) *reef 37*;
- 0.32 mi. S, 0.19 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26 [collected in 1991] (MSB 2) *reef 38*.

Dipodomys spectabilis Merriam, 1890 Banner-tailed Kangaroo Rat

The banner-tailed kangaroo rat inhabits most desert and grassland areas of New Mexico (Findley 1987). Characteristic mounds made by this species can be used to determine the presence of individuals in an area (Fig. 57). In the park, we located these mounds only in lowlands along the base of the escarpment. Mounds were present in the scrubland, grassland, and juniper plain, and we only captured *D. spectabilis* in these habitats (Table 15 and Fig. 58). We observed the highest density of mounds in open areas of desert scrub containing sparse grass and fine-textured soil intermixed with stones. Sometimes mounds were located near rocky areas containing lechuguilla, but mounds themselves were built where the ground surface was relatively smooth and contained only stones. In the grassland and juniper plain, *D. spectabilis* was present in areas that contained stones, some rocks, and variable amounts of grasses.

The only specimen of a *D. spectabilis* from Rattlesnake Springs was collected in 1964. Although we failed to locate a mound or catch a banner-tailed kangaroo rat on this parcel during our study, we discovered mounds con-

structed by this species as close as 18 m from the northwest boundary of Rattlesnake Springs in 1998.

Bailey (1928) stated that during his survey, banner-tailed kangaroo rats were abundant in the Pecos River valley and on high limestone ridges around Carlsbad Cavern. He also mentioned that a young *D. spectabilis* was captured from a mound near the cave. According to Bailey's field notes and catalog, traps placed on a ridge north of the cavern produced both *D. spectabilis* and *D. merriami*. In marked contrast, we found no evidence that banner-tailed or Merriam's kangaroo rats live in the vicinity of the cavern or in any other areas of the reef today (see *Discussion*). During our study, *D. spectabilis* was captured at elevations of 1,110–1,320 m (3,640–4,330 ft).

Reproduction. Most of the 15 *D. spectabilis* captured during our study were released. A female was lactating on 15 March, and an immature female showed no sign of reproductive activity on 23 March. Males having scrotal testes were captured on 4 February, 15 March, and 25 March; testicular lengths were 18.0, 18.0, and 16.0 mm, respec-



Fig. 57. A mound constructed by a banner-tailed kangaroo rat (*Dipodomys spectabilis*) on the seabed (photograph taken on 30 December 1998).

tively. Another male with scrotal testes was taken on 9 August. The specimen from Rattlesnake Springs was a juvenile male collected on 8 June 1964. Bailey (1928) reported capturing "a half-grown young" on 20 April "at a mound near the cave."

Taxonomic remarks. The subspecies of *Dipodomys spectabilis* in the park is *D. s. baileyi* Goldman, 1923 based on the distribution reported in Hall (1981:580, map 346).

Museum specimens (total 10); Fig. 58:

- Carlsbad Cave [captured on ridge near Carlsbad Cavern in 1924] (USNM 2) *not plotted*;
- Carlsbad Cave [collected in 1924] (USNM 1) *not plotted*;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1) *seabed 11*;

- Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 [in adjacent human-disturbed area] (MSB 1) *seabed 13*;
- ¾ mi. S mouth of Slaughter Canyon [T25S, R23E, SW ¼ Sec. 25] (CACA 1) *seabed 21*;
- 1.22 mi. S, 0.44 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 1) *seabed 25*;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 2) *seabed 29*;
- Rattlesnake Springs [collected on 8 June 1964] (CACA 1) *not plotted*.

Additional records (Fig. 58):

- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (captured on 4 February 1991; articulated skeleton in teaching collection of J. J. Krupa) *seabed 5*;
- 0.09 mi. S, 0.02 mi. E Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 (captured and released by KING and KG on 27 July 1991) *seabed 13*.

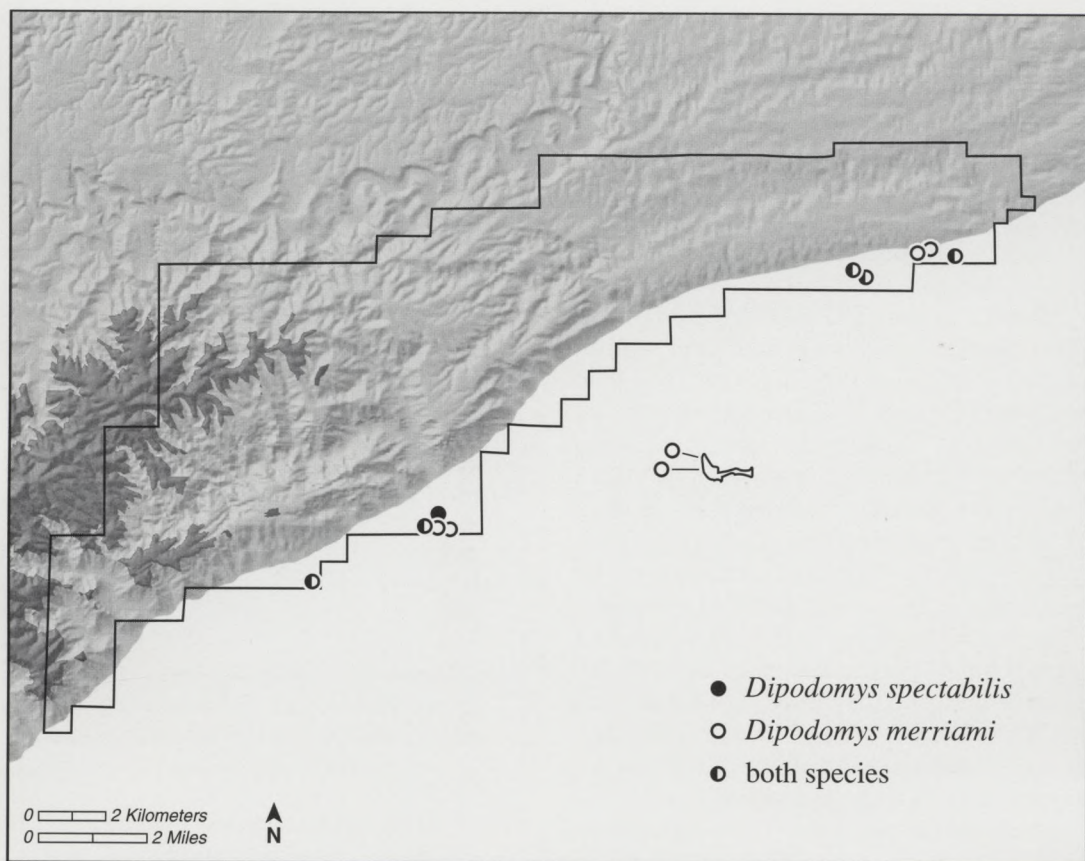


Fig. 58. Distribution of the banner-tailed kangaroo rat (*Dipodomys spectabilis*) and Merriam's kangaroo rat (*D. merriami*) in Carlsbad Caverns National Park. Records of *D. spectabilis* from the reef in 1924 and from Rattlesnake Springs in 1964 and records of *D. merriami* from the reef in 1924 and 1959 are not plotted on the map. For precise location of symbols see Appendix 4.

Dipodomys merriami Mearns, 1890 Merriam's Kangaroo Rat

In central and southern New Mexico, Merriam's kangaroo rat is common in desert and grassland areas, especially along the Rio Grande and Pecos River valleys (Findley *et al.* 1975). In the park, we captured *D. merriami* in the scrubland, grassland, juniper plain, and in two habitats at Rattlesnake Springs (Tables 15 and 18; Fig. 58). In desert scrubland, it occurred in both open and grassy habitats. In open areas, it was more common on fine soils intermixed with stones than in rocky situations containing lechuguilla. In grassy patches, it was captured in areas with low, widely spaced shrubs and in areas where tall

shrubs were moderately dense. At Rattlesnake Springs, *D. merriami* was common in the small section of desert scrub near the shooting range and in shrubby habitat around the horse barn (Table 18).

Similar to *D. spectabilis*, Bailey (1928) found *D. merriami* common in the valley and on high limestone ridges around Carlsbad Cavern. He trapped *D. merriami* near the cavern and in Walnut Canyon. In addition to those early records in 1924, M. C. Thompson captured this species on the reef in 1959. In contrast, we caught no *D. merriami* on the reef in the 1990s. Moreover, we traveled paved

and gravel roads of Walnut Canyon numerous times at night without seeing a single kangaroo rat on the road. In contrast, we saw *D. merriami* along seabed roads at night. In habitats of the reef today, *D. merriami* appears to be absent or, at most, sparsely distributed (see *Discussion*). During our study, *D. merriami* was captured at elevations of 1,110-1,320 m (3,640-4,330 ft).

Reproduction. We captured 40 *D. merriami* during our study and kept ten as voucher specimens. Pregnant females taken on 4 February and 15 March each contained two embryos; the largest uterine swelling measured 5 and 6 mm, respectively. On 15 May, another female contained three fetuses; the largest fetus measured 32 mm in crown-to-rump length. Females captured on 20 January ($n = 2$) and 15 March (1) were not pregnant or lactating. Males captured on 4 February had testes measuring 11.0 and 12.0 mm in length, on 10 February (10.5 mm), and on 7 May (10.0 mm). Males having scrotal testes were noted on 4 February, 10 February, 7 May, 15 May, 27 July, and 28 July.

Taxonomic remarks. The subspecies of *Dipodomys merriami* in the park is *D. m. ambiguus* Merriam, 1890 based on the distribution reported in Hall (1981:585, map 348).

Museum specimens (total 25); Fig. 58:

- Carlsbad Cave [captured in Walnut Canyon in 1924] (USNM 2) *not plotted*;
- Carlsbad Cave [captured on ridge near Carlsbad Cavern in 1924] (USNM 4) *not plotted*;
- 6 mi. W Whites City [captured on reef in park in 1959; M. C. Thompson *pers. comm.*] (CACA 2, KU 1) *not plotted*;
- 8 mi. W Whites City [captured on reef in park in 1959; M. C. Thompson *pers. comm.*] (CACA 1) *not plotted*;
- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE $\frac{1}{4}$ Sec. 33 (MSB 1) *seabed 5*;
- 1.53 mi. W, 0.29 mi. S Whites City, T24S, R25E, SW $\frac{1}{4}$ Sec. 33 (MSB 1) *seabed 8*;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (MSB 3) *seabed 11*;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed 20*;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE $\frac{1}{4}$ Sec. 33 (MSB 2) *seabed 29*;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 2) *seabed 43*;
- below escarpment, 3 mi. W Whites City (CACA 1) *not plotted*;
- Rattlesnake Springs Game Propagation Area, 5.5 mi. S White's City (AMNH 3) *not plotted*;
- mouth of Slaughter Canyon (CACA 1) *not plotted*.

Additional records (Fig. 58):

- 1.79 mi. W, 0.40 mi. S Whites City, T24S, R25E, SW $\frac{1}{4}$ Sec. 33 (captured and released by KNG and KG on 28 July 1991) *seabed 9*;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (captured and released by KNG on 20 and 26 March 1991) *seabed 13*;
- 0.09 mi. S, 0.02 mi. E Sewage Disposal Ponds, T25S, R25E, NE $\frac{1}{4}$ Sec. 6 (captured and released by KNG and KG on 27 July 1991) *seabed 13*;
- 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (captured and released by KNG on 10 February 1991) *seabed 19*;
- 1.22 mi. S, 0.44 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (captured and released by KNG on 23 March 1992) *seabed 25*;
- 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (captured and released by KNG and KG on 15 May 1991) *seabed 44*.

Family Muridae
***Reithrodontomys megalotis* (Baird, 1857)**
Western Harvest Mouse

In New Mexico, the western harvest mouse is widespread and has been captured in most habitats in the state (Findley *et al.* 1975). One important requirement for its presence seems to be adequate ground cover in the form of grasses, weeds, or dense litter (Webster and Jones 1982; Hoffmeister 1986; Webster 1999). At the park, we found *R. megalotis* only in habitats containing moderate to dense amounts of grasses or forbs.

At Rattlesnake Springs, we captured *R. megalotis* in weedy areas at the east end of the property ($n = 1$) and in dense stands of alkali sacaton and Indian grass near the storage pond ($n = 2$; Table 19). Along the base of the

escarpment, *R. megalotis* was captured only in the grassland ($n = 3$; Table 16), and each individual inhabited areas where grasses were moderately dense. On the seabed, we captured *R. megalotis* at elevations 1,105–1,245 m (3,620–4,090 ft).

We collected one *R. megalotis* on the reef (Table 12 and Fig. 59). It was captured in moderately dense grass on the floor of Bat Cave Draw at 1,305 m (4,280 ft). Grasses in the area consisted of blue grama, curlyleaf muhly, green sprangletop, Nealley threeawn, plains bristlegrass, sideoats grama, and Springfield bluestem. This species also was captured in Bat Cave Draw in 1950.

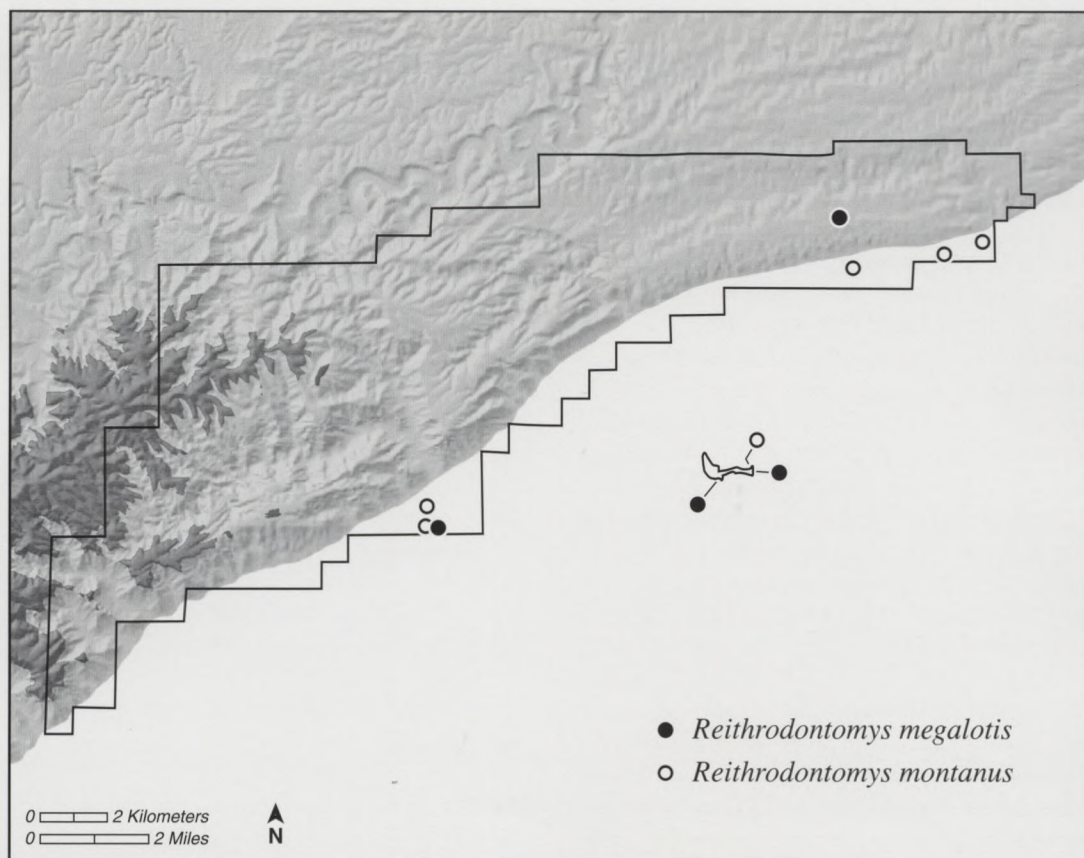


Fig. 59. Distribution of the western harvest mouse (*Reithrodontomys megalotis*) and plains harvest mouse (*R. montanus*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

Reproduction. All seven *R. megalotis* were kept as voucher specimens. One female each was captured on 10 February, 12 March, and 13 March, and none showed sign of reproductive activity. Two males were captured on 10 February; one had testes measuring 4.0 mm in length and the other, 7.0 mm. Two males captured on 13 March each had testes measuring 8.0 mm in length.

Taxonomic remarks. The subspecies of *Reithrodontomys megalotis* in the park is *R. m. megalotis* (Baird, 1857) based on the distribution reported in Hall (1981:639, map 377).

Museum specimens (total 10; includes 3 study skins with preserved bacula at MSB); Fig. 59:

- 0.45 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N $\frac{1}{2}$ Sec. 31 (MSB 1) reef 11;
- Bat Cave Draw (CACA 2) not plotted;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E SW $\frac{1}{4}$ Sec. 25 (MSB 3) seabed 20;
- 0.08 mi. N, 0.64 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 1) seabed 37;
- Rattlesnake Springs, near water-storage pond, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 2) seabed 42;
- Rattlesnake Springs (CACA 1) not plotted.

Reithrodontomys montanus (Baird, 1855) Plains Harvest Mouse

In New Mexico, the plains harvest mouse inhabits short- and mid-grass prairies in eastern, central, and southern regions of the state (Findley *et al.* 1975). According to Findley (1987), *R. montanus* is rare in the state compared to *R. megalotis*. These two species differ in habitat preference—*R. montanus* generally is more common than *R. megalotis* in shorter grasses rather than in taller ones, in open grassy areas rather than in areas where grasses grow densely, and in drier areas rather than in more mesic ones (Jones 1964; Wilkins 1986; Dowler 1999).

At the park, we captured nearly equal numbers of *R. montanus* ($n = 9$) and *R. megalotis* ($n = 7$), and we noticed only a subtle difference in habitats occupied by these species. For example, both species occurred in moderately dense grass in the grassland, but only *R. megalotis* was captured in tall, dense grass at Rattlesnake Springs and only *R. montanus* was captured in grassy areas in desert scrubland.

At the park, six *R. montanus* were captured in grassy areas in the scrubland, two in the grassland, and one at Rattlesnake Springs (Tables 16 and 19). In the scrubland, individuals lived in small patches of tobosa, areas of sand dropseed and threeawn, large expanses of blue grama and tobosa, and a human-made ditch containing blue grama, cane

bluestem, sandy muhly, and sideoats grama. In all cases, grasses were moderately dense. Mice also occurred in moderately dense grass in the grassland. At Rattlesnake Springs, we captured one individual in a stand of mesquite where grasses were sparse to moderately dense and included plains bristle grass, sideoats grama, and slim tridens. On the seabed, *R. montanus* was captured at elevations 1,105–1,270 m (3,620–4,160 ft), and none was captured on the reef (Fig. 59).

Reproduction. All nine *R. montanus* were kept as voucher specimens. A lactating female was captured on 23 March. Females captured on 11 and 22 March were not reproductively active. Males captured on 22 March had testes measuring 4.0, 5.0, and 5.5 mm in length; on 23 March (5.0 mm); on 23 April (5.0 mm); and on 15 May (5.0 mm).

Taxonomic remarks. The line of demarcation between *Reithrodontomys montanus griseus* V. Bailey, 1905 and *R. m. montanus* (Baird, 1855) is close to Carlsbad Caverns National Park (Hall 1981:636, map 375). We did not assign a subspecific name to specimens from the park.

Museum specimens (total 9; includes 4 study skins with preserved bacula); Fig. 59:

- 0.17 mi. S, 0.55 mi. W Whites City, T24S, R25E, SW $\frac{1}{4}$ Sec. 34 (MSB 1) seabed 2;

- 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 33 (MSB 3) *seabed* 6;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (MSB 1) *seabed* 13;
- Sewage Disposal Ponds, T25S, R25E, NE $\frac{1}{4}$ Sec. 6 [in adjacent human-made ditch] (MSB 1) *seabed* 13;
- 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed* 24;
- 1.22 mi. S, 0.44 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed* 25;
- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 1) *seabed* 38.

Peromyscus eremicus (Baird, 1857) Cactus Mouse

In New Mexico, cactus mice generally inhabit rocky habitats in and around desert mountains (Findley *et al.* 1975). Three *P. eremicus* were captured during our study, and each was taken in a different lowland habitat along the base of the escarpment—the juniper plain, the boulder-strewn terrain of Slaughter Canyon Draw, and an open area of desert scrub containing lechuguilla (Table 17; Fig.

60). Elevations at these sites were 1,320 m, 1,270 m, and 1,160 m (4,330 ft, 4,170 ft, and 3,800 ft), respectively. Each habitat contained rocks, some grass, and was dominated by slightly different combinations of desert shrubs, small trees, and succulents.

In the Texas portion of the Guadalupe Mountains, cactus mice also were uncommon along the base of the eastern escarpment, but

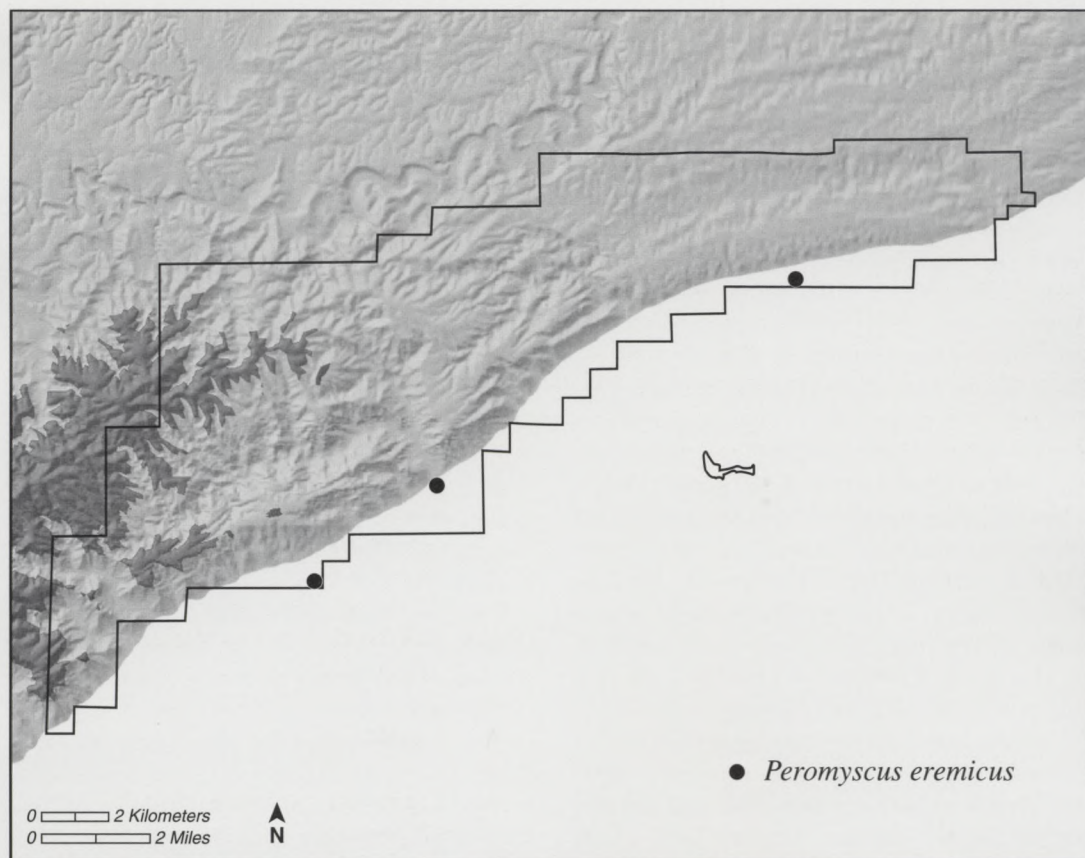


Fig. 60. Distribution of the cactus mouse (*Peromyscus eremicus*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

in southern and western lowlands, *P. eremicus* was common (Cornely *et al.* 1981). One reason for this difference in abundance may relate to different temperature regimes on sides of the mountains (see Gennaro 1968).

Reproduction. Females captured in the park on 23 and 26 January were adults and showed no sign of reproductive activity. An adult male captured on 15 March had testes measuring 7.5 mm in length.

Taxonomic remarks. The subspecies of *Peromyscus eremicus* in the park is *P. e.*

eremicus (Baird, 1857) based on the distribution reported in Hall (1981:660, map 388).

Museum specimens (total 3); Fig. 60:

- 1.15 mi. W, 0.22 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1 (MSB 1) *seabed* 15;
- 0.39 mi. S, 0.48 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25 (MSB 1) *seabed* 23;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 1) *seabed* 29.

Peromyscus leucopus (Rafinesque, 1818) White-footed Mouse

In New Mexico, the white-footed mouse is most common in grasslands in eastern, central, and southern parts of the state, especially in areas without rocks or hard ground (Findley *et al.* 1975). During our surveys in the park, *P. leucopus* was captured only in lowland habitats of the seabed at elevations 1,100-1,410 m (3,610-4,630 ft; Fig. 61).

At Rattlesnake Springs, we found this species in many habitats (Table 19). It was abundant in woodlots, especially in dry areas containing fallen logs and other debris from deciduous vegetation. *Peromyscus leucopus* also was common in areas of dense grass, weedy areas containing some grass, and shrubby areas containing cropped grass. Some mice were trapped in a stand of mesquite, fewer were taken among bushes surrounded by exposed soil, two were trapped in marshy areas of the woodlot, and none was captured in the small area of desert scrub. Krupa (2002) reported *P. leucopus* eaten by bullfrogs (*Rana catesbeiana*) that were captured in pools of water at Rattlesnake Springs and on property owned by The Nature Conservancy. Of six species of *Peromyscus* inhabiting the park, *P. leucopus* was the only one captured at Rattlesnake Springs.

Along the base of the escarpment in desert scrubland, *P. leucopus* was fairly common in flat grassy washes with tall shrubs and in isolated patches of grass with short shrubs; however, it was rare in open areas of desert scrub (one individual was captured in

an area with lechuguilla; Table 17). *Peromyscus leucopus* also inhabited the grassland, juniper plain, alluvial fans, and wide draws. None was taken in rocky arroyos crossing the seabed (Table 17).

Although we never trapped *P. leucopus* on the reef, Bailey (1928) found this species to be fairly common inside Carlsbad Cavern in 1924. He trapped this species in the underground lunchroom, King's Palace, and other rooms of the cavern. Bailey also captured a *P. leucopus* on the surface near the cavern. Specimens from the cavern included lactating females, and contents of their stomachs showed cave crickets to be their main food item. In 1924, Bailey also trapped *P. pectoralis* in Carlsbad Cavern but only in rooms close to the natural openings. In 1959, M. C. Thompson captured numerous mice in the underground lunchroom, but all his animals were *P. pectoralis*. This indicates that *P. pectoralis* eventually replaced *P. leucopus* in the cavern (see *Discussion*). In the 1990s, we did not capture any mice in the lunchroom.

Based on our survey, there is no evidence that *P. leucopus* occurs in the mountainous portion of the park. However, Cornely *et al.* (1981) reported a single record of *P. leucopus* on the reef in Guadalupe Mountains National Park, Texas. In addition, KG captured two *P. leucopus* in the Guadalupe Mountains of New Mexico in 1999; this location is 11.3 km W of the park.

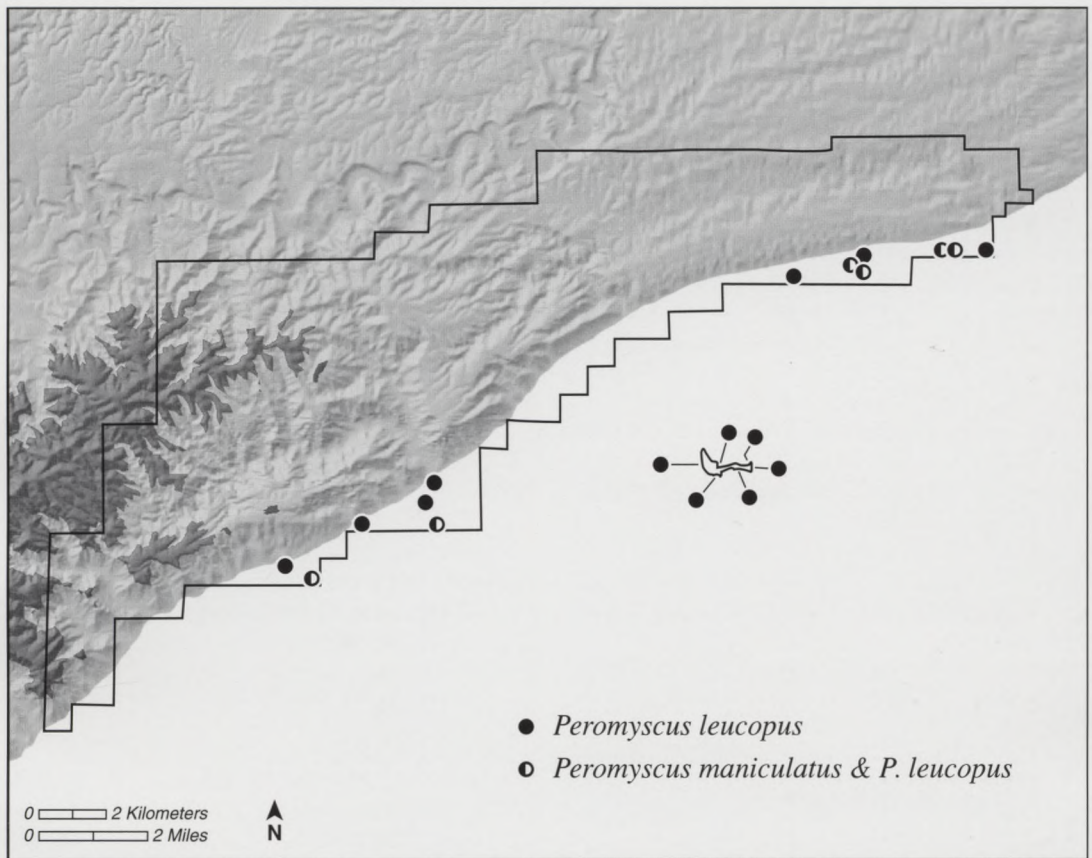


Fig. 61. Distribution of the white-footed mouse (*Peromyscus leucopus*) and deer mouse (*P. maniculatus*) in Carlsbad Caverns National Park. Records of *P. leucopus* inside Carlsbad Cavern and on the surface near the cavern in 1924 are not plotted on the map. For precise location of symbols see Appendix 4.

Reproduction. We captured 113 *P. leucopus* and kept 66 as voucher specimens. Two females were lactating and pregnant at the same time; one was taken on 13 March and the other on 7 May. The former contained three embryos; the largest uterine swelling measured 6 mm. The latter also contained three embryos; its largest embryo measured 10 mm in crown-to-rump length. One lactating female each was captured on 20 January, 24 January, 15 March, 24 April, and 9 August. Females in adult pelage that were neither pregnant nor lactating were taken in midwinter (26 January-10 February, $n = 4$), late winter (11-15 March, $n = 7$), and mid-spring (25 April-15 May, $n = 3$).

In males with adult pelage, testicular lengths averaged 9.2 mm (extremes, 4.0-14.0 mm, $n = 19$) in midwinter (20 January-10 Feb-

ruary), 11.5 mm (8.0-15.0 mm, $n = 17$) in late winter/early spring (10-22 March), 12.3 mm (11.0-14.0 mm, $n = 3$) in mid-spring (9-20 May), and 13.5 mm (13.0-14.0 mm, $n = 2$) in midsummer (26 July-9 August). Young in juvenal pelage were captured on 13 March ($n = 4$; released two), 21 March ($n = 1$; released), and 15 May ($n = 2$; both released). Young in postjuvenal molt were noted on 24 January ($n = 1$; released), 1 February ($n = 1$), and 13 March ($n = 1$).

Taxonomic remarks. The subspecies of *Peromyscus leucopus* in the park is *P. l. tornillo* Mearns, 1896 based on the distribution reported in Hall (1981:687, map 398).

Museum specimens (total 78); Fig. 61:

- Carlsbad Cave [on top of ridge on surface of reef; collected in 1924] (USNM 1) *not plotted*;

- Carlsbad Cave [bottom of Carlsbad Cavern near elevator; collected in 1924] (USNM 4) *not plotted*;
- Carlsbad Cave [in bottom of Carlsbad Cavern; collected in 1924] (USNM 3) *not plotted*;
- Carlsbad Cave [King's Palace in Carlsbad Cavern; collected in 1924] (USNM 2) *not plotted*;
- 0.59 mi. S, 0.38 mi. W Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 34 (MSB 1) *seabed 1*;
- 1.08 mi. W, 0.45 mi. S Whites City, T24S, R25E, SE $\frac{1}{4}$ Sec. 33 (MSB 4) *seabed 5*;
- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE $\frac{1}{4}$ Sec. 33 (MSB 3) *seabed 5*;
- 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 33 (MSB 3) *seabed 6*;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (MSB 1) *seabed 11*;
- 0.12 mi. N, 0.05 mi. E Sewage Disposal Ponds, T24S, R25E, SW $\frac{1}{4}$ Sec. 32 (MSB 2) *seabed 12*;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (MSB 2) *seabed 13*;
- 1.15 mi. W, 0.22 mi. S Sewage Disposal Ponds, T25S, R24E, NE $\frac{1}{4}$ Sec. 1 (MSB 1) *seabed 15*;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (MSB 8) *seabed 20*;
- 0.39 mi. S, 0.48 mi. E New Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (MSB 1) *seabed 23*;
- 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (MSB 2) *seabed 24*;
- 1.08 mi. S, 0.79 mi. W New Cave, T25S, R23E, SE $\frac{1}{4}$ Sec. 27 (MSB 1) *seabed 28*;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE $\frac{1}{4}$ Sec. 33 (MSB 11) *seabed 29*;
- 0.96 mi. S, 0.78 mi. E Longview Spring, T25S, R23E, W $\frac{1}{2}$ Sec. 33 (MSB 1) *seabed 31*;
- 0.08 mi. N, 0.64 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 7) *seabed 37*;
- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 2) *seabed 38*;
- 0.08 mi. N, 0.37 mi. E Rattlesnake Spring, T25S, R24E, SE $\frac{1}{4}$ Sec. 23 (MSB 2) *seabed 39*;
- Ranger Station at Rattlesnake Springs, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 [inside building] (MSB 1) *seabed 41*;
- Rattlesnake Springs, near water-storage pond, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 12) *seabed 42*;
- Rattlesnake Spring (CACA 2) *seabed 42*;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) *seabed 43*.

Peromyscus maniculatus (Wagner, 1845) Deer Mouse

Two subspecies of *P. maniculatus* are recognized in New Mexico (Findley *et al.* 1975). Mice in northern parts of the state are referred to as *P. m. rufinus*, while those to the south (including Carlsbad Caverns National Park) are named *P. m. blandus*. Northern populations occupy coniferous forests and surrounding lowlands, while southern populations live primarily in desert-scrub and grassland habitats.

At the park, deer mice inhabited a variety of habitats along the base of the escarpment (Fig. 61), but in no one habitat were they common (Table 17). In desert scrubland, they lived in grassy areas with tall shrubs, in grassy areas with short shrubs, and in open areas with and without lechuguilla. Deer mice also inhabited the grassland and juniper plain. Capture sites of *P. maniculatus* ranged

in elevation from 1,110 to 1,320 m (3,640-4,330 ft). We captured no *P. maniculatus* at Rattlesnake Springs or on the reef.

Reproduction. We caught 12 *P. maniculatus* and kept ten as voucher specimens. Females ($n = 4$) collected 4-10 February showed no sign of reproductive activity. Testicular lengths measured 8.5, 10.0, and 10.0 mm in males trapped 20 January-10 February and 9.0, 9.0, and 10.0 mm in those taken 15-22 March. All 12 *P. maniculatus* were adults and were pale gray in dorsal coloration.

Taxonomic remarks. The subspecies of *Peromyscus maniculatus* in the park is *P. m. blandus* Osgood, 1904 based on dorsal color of study skins from the park and on distributions reported in Hall (1981:676, map 394) and Findley *et al.* (1975:205).

Museum specimens (total 10); Fig. 61:

- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (MSB 1) *seabed* 5;
- 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S ½ Sec. 33 (MSB 1) *seabed* 6;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 3) *seabed* 11;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1) *seabed* 13;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 3) *seabed* 20;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 1) *seabed* 29.

Peromyscus pectoralis Osgood, 1904 White-ankled Mouse

In New Mexico, white-ankled mice are known only from the Guadalupe Mountains and lowland habitats east of the Sacramento Mountains (Geluso 2004a). Throughout its range, presence of rocks appears to be an important habitat requirement for this species (Schmidly 1999). Of six species of *Peromyscus* in the park, we found *P. pectoralis* to be the most common and widespread, occurring in all habitats along the base of the escarpment and in nearly every habitat on the reef (Fig. 62). Based on 283 captures, *P. pectoralis* occurred from 1,130 to 1,950 m (3,700-6,400 ft) in elevation.

Except for rocky arroyos and the boulder-strewn terrain of Slaughter Canyon Draw, white-ankled mice generally were uncommon on the seabed (Table 17). Some *P. pectoralis* were captured in the scrubland, grassland, juniper plain, and alluvial fans along the base of the escarpment, but none was taken at Rattlesnake Springs. In desert-scrub situations, most were caught in rocky areas containing lechuguilla.

In contrast to the seabed, the white-ankled mouse was abundant on the reef. It was the only species of *Peromyscus* captured in the juniper peneplain (Table 12). On higher summits of the reef, it shared grassy, oak knolls with *P. boylii*; however, both species were uncommon. White-ankled mice were absent from the highest summits that were inhabited solely by *P. boylii*.

The white-ankled mouse was the only species of *Peromyscus* captured along the face of the escarpment and on canyon floors (Table 12). It also was the only *Peromyscus* that inhabited canyonsides at low and mid-eleva-

tions (Table 14). At higher elevations on canyonsides (1,755-1,950 m or 5,750-6,400 ft), it lived in gullies with *P. boylii* and rock outcrops with *P. boylii* and *P. nasutus*. The white-ankled mouse was not captured in cliffs at high elevations where *P. boylii* and *P. nasutus* were numerous (Table 14). We trapped one *P. pectoralis* around Oak Spring in a small canyon that leads into Walnut Canyon (Table 12).

In 1991, we were unsuccessful in capturing mice in the underground lunchroom of Carlsbad Cavern, 229 m (750 ft) below the Visitor Center. In contrast, M. C. Thompson (field journal at the University of Kansas) found *P. pectoralis* abundant in the lunchroom in 1959. His specimens included pregnant females and adult males.

Reproduction. We kept 159 *P. pectoralis* as voucher specimens. Additional reproductive information was recorded from nine individuals released at the capture site. Pregnant females were captured on 15 March (three embryos; largest uterine swelling was 11 mm), 24 April (three embryos; greatest crown-to-rump length was 3 mm), 3 May (three embryos; largest uterine swelling was 10 mm), 3 May (three embryos; largest uterine swelling was 11 mm), 11 May (three embryos; largest uterine swelling was 9 mm), and 12 May (two fetuses; greatest crown-to-rump length was 22 mm). A baby was born in a trap on 5 May; its crown-to-rump length was 30 mm. Lactating females (17 total) were taken on the following days: 8 and 11 March; 23, 26, and 29 April; 1, 3, 5, 8, 11, 12, 19, and 26 May; and 2 and 5 August. Females in adult pelage that were neither pregnant nor lactating were captured in midwinter (19 January-

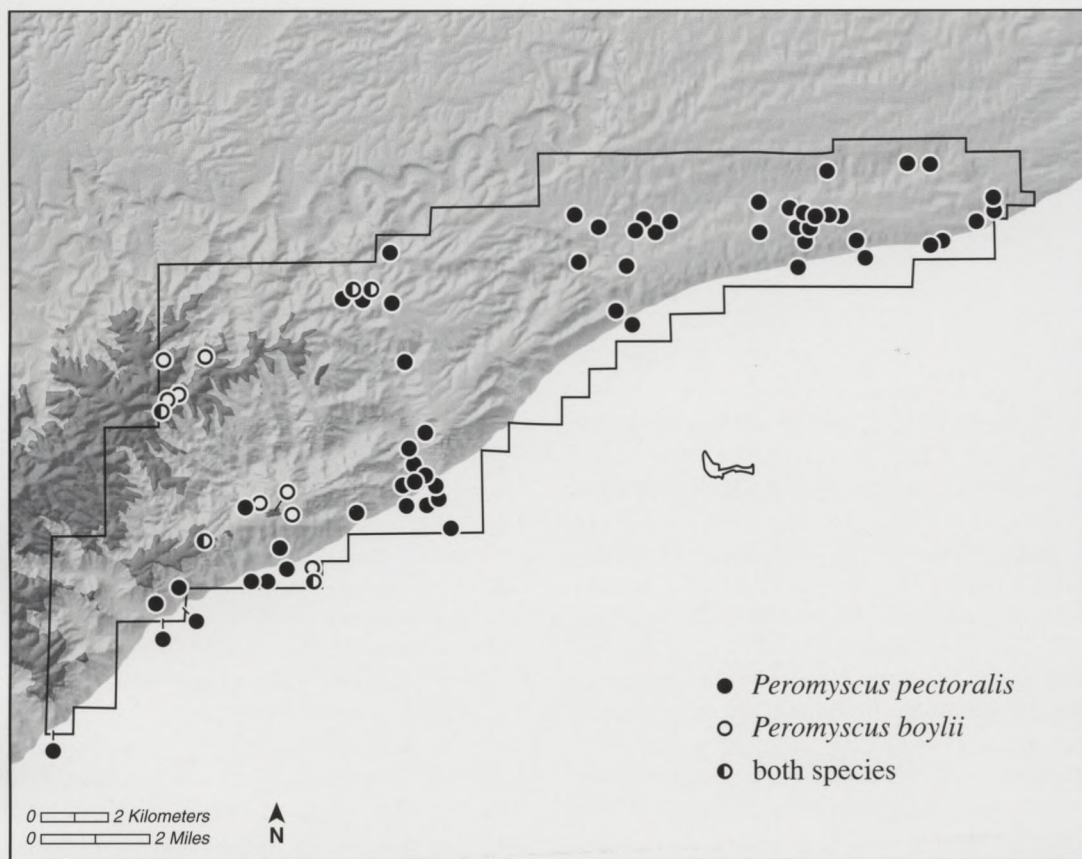


Fig. 62. Distribution of the white-ankled mouse (*Peromyscus pectoralis*) and brush mouse (*P. boylii*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

14 February, $n = 28$), late winter/early spring (10-23 March, $n = 5$), mid-spring (22 April-26 May, $n = 16$), and midsummer (19 July, $n = 1$).

In males with adult pelage, testicular lengths averaged 6.4 mm (extremes, 2.0-13.0 mm, $n = 38$) in midwinter (19 January-14 February), 10.5 mm (8.0-12.0 mm, $n = 9$) in late winter/early spring (10-23 March), 9.8 mm (6.5-12.5 mm, $n = 30$) in mid-spring (22 April-20 May), and 11.9 mm (11.0-12.5 mm, $n = 5$) in midsummer (20 July-11 August).

Young in juvenal, gray pelage were captured on 20 January ($n = 2$), 2 February, 30 April, 14 May, and 19 May. Those in postjuvenal molt were noted on 26 January, 10 March, 14 March, 15 March ($n = 2$), and 23 April. Based on specimens housed in the park's museum, juveniles also have been captured on 3 November, 12 November, 13 November, and 13 December.

Taxonomic remarks. The subspecies of *Peromyscus pectoralis* in the park is *P. p. laceianus* V. Bailey, 1906 based on the distribution reported in Hall (1981:694, map 401). In his account of *Peromyscus boylii* in *Animal Life of the Carlsbad Cavern*, V. Bailey (1928:73) stated that *P. boylii* was the most abundant mammal in the region, occurring in rooms near the natural openings of Carlsbad Cavern and in cliffs and buildings on the surface. Bailey preserved mice from those locations and deposited them (labeled *P. b. rowleyi* in his field catalog) in the United States National Museum of Natural History. At the museum, we found these specimens labeled *Peromyscus pectoralis*. After examining ankles of these specimens, we agreed that these mice were *P. pectoralis* and not *P. boylii* (see Fig. 63). We verified the identity of two specimens from USNM by examining the



Fig. 63. Hind feet of a brush mouse, *Peromyscus boylii* (left); white-ankled mouse, *P. pectoralis* (middle); and northern rock mouse, *P. nasutus* (right) as seen from above on museum specimens. Ankles of *P. pectoralis* are white compared to dark ankles of *P. boylii* and *P. nasutus* (compare areas above horizontal line). These mice were captured in Carlsbad Caverns National Park in 1991 (*P. boylii* MSB 63816; *P. pectoralis* MSB 64008; and *P. nasutus* MSB 63826).

shape of the cartilaginous process at the terminal end of the baculum. Male specimens of *P. pectoralis* and *P. boylii* can easily be distinguished from one another using this characteristic (Clark 1953; Cornely *et al.* 1981). We also discovered 28 specimens misidentified as *P. boylii* in the natural history collection at Carlsbad Caverns National Park; these specimens also were *P. pectoralis*, and we verified three by examining bacula. Other specimens of *P. pectoralis* from New Mexico have been misidentified in the past (Geluso 2004a). Of 159 specimens of *P. pectoralis* collected by us at the park, we verified 39 by examining bacula.

Museum specimens (total 273; includes 44 study skins with preserved bacula—39 at MSB, 3 at CACA, and 2 at USNM); Fig. 62:

- 0.21 mi. N, 0.31 mi. W Whites City, T24S, R25E, N $\frac{1}{2}$ Sec. 34 (MSB 3) reef 1;
- 0.35 mi. W, 0.51 mi. N Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 27 (MSB 7) reef 2;
- 0.06 mi. N, 0.67 mi. W Whites City, T24S, R25E, NW $\frac{1}{4}$ Sec. 34 (MSB 2) reef 4;
- 1.14 mi. N, 1.45 mi. W Whites City, T24S, R25E, NW $\frac{1}{4}$ Sec. 28 (MSB 1) reef 6;
- 1.96 mi. W, 1.17 mi. N Whites City, T24S, R25E, NE $\frac{1}{4}$ Sec. 29 (MSB 1) reef 7;
- Walnut Canyon (CACA 4) not plotted;
- 0.33 mi. N, 0.04 mi. W Sewage Disposal Ponds, T24S, R25E, SE $\frac{1}{4}$ Sec. 31 (MSB 2) reef 10;
- 0.45 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N $\frac{1}{2}$ Sec. 31 (MSB 2) reef 11;
- Bat Cave Draw (CACA 22) not plotted;
- 0.05 mi. N, 0.32 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N $\frac{1}{2}$ Sec. 31 (MSB 8) reef 12;
- Bat Cave [in Carlsbad Cavern] (CACA 1) reef 13;

- Natural Entrance [of Carlsbad Cavern] (CACA 1) *reef 13*;
- Carlsbad Cave [inside Carlsbad Cavern near natural openings; collected in 1924] (USNM 4) *reef 13*;
- Carlsbad Cave [in large natural opening of Carlsbad Cavern; collected in 1924] (USNM 4) *reef 13*;
- Carlsbad Cave [in first hall near large natural opening of Carlsbad Cavern; collected in 1924] (USNM 1) *reef 13*;
- Carlsbad Cavern, -750 feet [in underground lunchroom; collected by Max Thompson in May 1959] (KU 10) *reef 13*;
- near Carlsbad Cavern (KU 1) *reef 13*;
- 0.15 mi. N, 0.12 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31 [inside building] (MSB 1) *reef 13*;
- 0.16 mi. N, 0.12 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31 [in or around building] (MSB 4) *reef 13*;
- Carlsbad Cave [inside house near Carlsbad Cavern; collected in 1924] (USNM 1) *reef 13*;
- Headquarters area [0.10 mi. W of large natural opening of Carlsbad Cavern] (CACA 2) *reef 13*;
- Women's Dorm, Carlsbad Caverns National Park [same building as park headquarters] (MSB 1) *reef 13*;
- near Naturalist Office [near large opening of Carlsbad Cavern] (CACA 1) *reef 13*;
- 0.13 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31 (MSB 1) *reef 14*;
- 0.28 mi. N, 0.05 mi. E Visitor Center, T24S, R24E, NE ¼ Sec. 36 (MSB 1) *reef 15*;
- Visitor Center, T24S, R24E, NE ¼ Sec. 36 [inside building in garbage pail] (MSB 1) *reef 17*;
- Carlsbad Caverns National Park, 4 mi. W Whites City (KU 3) *not plotted*;
- 1.0 mi. N, 0.52 mi. E Visitor Center, T24S, R25E, N ½ Sec. 30 (MSB 1) *reef 20*;
- Oak Spring, T24S, R24E, NE ¼ Sec. 36 (MSB 1, CACA 2) *reef 22*;
- 0.77 mi. W, 0.15 mi. S Visitor Center, T24S, R24E, SW ¼ Sec. 36 (MSB 22) *reef 23*;
- 0.56 mi. W, 0.17 mi. N Oak Spring, T24S, R24E, SW ¼ Sec. 25 (MSB 6) *reef 24*;
- 6 mi. W Whites City [on reef in park, M. C. Thompson *pers. comm.*] (CACA 2) *not plotted*;
- 0.34 mi. N, 0.91 mi. E Lowe Spring, T24S, R24E, N ½ Sec. 34 (MSB 2) *reef 27*;
- 0.71 mi. E, 0.12 mi. N Lowe Spring, T24S, R24E, W ½ Sec. 34 (MSB 6) *reef 28*;
- 0.47 mi. E, 0.36 mi. N Lowe Spring, T24S, R24E, NE ¼ Sec. 33 (MSB 3) *reef 29*;
- 0.18 mi. N, 0.37 mi. E Lowe Spring, T24S, R24E, NE ¼ Sec. 33 (MSB 2) *reef 30*;
- 0.13 mi. E, 0.46 mi. S Lowe Spring, T25S, R24E, NE ¼ Sec. 4 (MSB 4) *reef 31*;
- 0.43 mi. S, 0.64 mi. E Stone Spring, T25S, R24E, S ½ Sec. 4 (MSB 2) *reef 32*;
- 0.30 mi. W, 0.30 mi. N Lowe Spring, T24S, R24E, NW ¼ Sec. 33 (MSB 2) *reef 33*;
- 1½ mi. up Rattlesnake Canyon, 30 mi. SW Carlsbad (KU 45) *reef 34*;
- 0.73 mi. W, 0.48 mi. N Lowe Spring, T24S, R24E, NE ¼ Sec. 32 (MSB 1) *reef 35*;
- 8 mi. W Whites City [on reef in park, M. C. Thompson *pers. comm.*] (CACA 1) *not plotted*;
- Slaughter Canyon (CACA 3) *not plotted*;
- 0.22 mi. SW Ogle Cave, T25S, R23E, NE ¼ Sec. 23 (MSB 3) *reef 36*;
- 0.24 mi. S, 0.28 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23 (MSB 1) *reef 37*;
- 0.24 mi. S, 0.23 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23 (MSB 2) *reef 37*;
- 0.18 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23 (MSB 3) *reef 39*;
- 0.30 mi. N, 0.12 mi. E New Cave, T25S, R23E, NE ¼ Sec. 23 (MSB 1) *reef 40*;
- 0.39 mi. S New Cave, T25S, R23E, NE ¼ Sec. 26 (MSB 2) *reef 41*;
- near Goat Cave, Slaughter Canyon [Goat Cave is in a side canyon of North Slaughter Canyon, T25S, R23E, SE ¼ Sec. 11] (CACA 3) *reef 43*;
- 1.12 mi. N, 0.23 mi. W Goat Cave, T25S, R23E, SW ¼ Sec. 2 (MSB 1) *reef 45*;
- 2.03 mi. N, 0.27 mi. W Goat Cave, T24S, R23E, SW ¼ Sec. 35 (MSB 1) *reef 46*;
- 1.37 mi. N, 0.65 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3 (MSB 1) *reef 47*;
- 1.23 mi. N, 0.78 mi. W Goat Cave, T25S, R23E, SE ¼ Sec. 3 (MSB 2) *reef 48*;
- 1.33 mi. N, 0.95 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3 (MSB 3) *reef 49*;
- 1.22 mi. N, 1.05 mi. W Goat Cave, T25S, R23E, S ½ Sec. 3 (MSB 4) *reef 50*;
- 0.95 mi. S, 0.90 mi. W New Cave, T25S, R23E, SE ¼ Sec. 27 (MSB 2) *reef 51*;
- 18 yards E Longview Spring, T25S, R23E, E ½ Sec. 29 (MSB 2) *reef 57*;
- 0.62 mi. S, 0.61 mi. E Longview Spring, T25S, R23E, NW ¼ Sec. 33 (MSB 4) *reef 58*;
- 0.29 mi. N, 0.03 mi. W Red Cave, T25S, R23E, NE ¼ Sec. 31 (MSB 1) *reef 59*;

- 0.57 mi. S, 0.52 mi. W Red Cave, T25S, R23E, SW ¼ Sec. 31 (MSB 3) reef 60;
- 0.95 mi. S, 0.86 mi. W Red Cave, T26S, R23E, NW ¼ Sec. 6 (MSB 2) reef 61;
- 0.06 mi. S, 0.03 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 18 (MSB 2) reef 68;
- 1.43 mi. W, 0.26 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33 (MSB 2) seabed 7;
- 1.53 mi. W, 0.29 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33 (MSB 1) seabed 8;
- 0.23 mi. N, 0.07 mi. E Sewage Disposal Ponds, T24S, R25E, SW ¼ Sec. 32 (MSB 1) seabed 12;
- 1.01 mi. W, 0.05 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1 (MSB 5) seabed 14;
- 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 2) seabed 19;
- 0.58 mi. S, 0.52 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25 (MSB 1) seabed 22;
- 0.39 mi. S, 0.48 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25 (MSB 4) seabed 23;
- 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25 (MSB 2) seabed 24;
- 0.52 mi. S New Cave, T25S, R23E, NE ¼ Sec. 26 (MSB 1) seabed 27;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 2) seabed 29;
- 0.96 mi. S, 0.78 mi. E Longview Spring, T25S, R23E, W ½ Sec. 33 (MSB 1) seabed 31;
- 1.44 mi. S, 0.42 mi. E Longview Spring, T25S, R23E, SW ¼ Sec. 33 (MSB 3) seabed 32;
- 1.40 mi. S, 0.23 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 32 (MSB 3) seabed 33;
- 0.78 mi. S, 0.56 mi. W Red Cave, T26S, R23E, NW ¼ Sec. 6 (MSB 4) seabed 34;
- 1.15 mi. S, 0.85 mi. W Red Cave, T26S, R23E, W ½ Sec. 6 (MSB 2) seabed 35;
- 2.14 mi. S, 0.76 mi. W Double Cave, T26S, R22E, NW ¼ Sec. 14 (MSB 1) seabed 36.

Additional records (Fig. 62):

- 0.28 mi. S, 0.04 mi. E Visitor Center, T24S, R24E, SE ¼ Sec. 36 (captured and released by KNG and KG on 24 July 1993) reef 16;
- 0.32 mi. S, 0.19 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26 (captured and released by KNG and KG on 5 and 6 August 1991) reef 38;
- 0.57 mi. S, 0.87 mi. E Stone Spring, T25S, R24E, NE ¼ Sec. 9 (captured and released by KNG and KG on 14 May 1991) seabed 17.

***Peromyscus boylii* (Baird, 1855)** **Brush Mouse**

Throughout its range in New Mexico and elsewhere, a combination of rocky hillsides and shrubby vegetation provides ideal habitat for *P. boylii* (Wilson 1968; Findley *et al.* 1975; Schmidly 1977; Bradley and Schmidly 1999). In the park, we discovered that brush mice had a disjunct distribution. Forty-three animals were captured on the reef at elevations of 1,745–1,965 m (5,720–6,450 ft), and four were captured on the seabed at 1,325 m (4,340 ft). None was obtained at intermediate elevations (Fig. 62).

The brush mouse was the only species of *Peromyscus* captured on the highest summits of the reef where coniferous woodlands predominate (Table 12). This habitat is prevalent on knolls and saddles around Yucca (1,830 m or 6,000 ft) and Putman (1,965 m or 6,450 ft) cabins, and in both areas brush mice were common. On summits dominated by shrubby

oaks and grass at 1,745 m (5,720 ft), *P. boylii* was less common and was captured with *P. pectoralis*. Brush mice were absent from the juniper penepain; these lower summits were inhabited by numerous *P. pectoralis*.

On canyonsides $\geq 1,755$ m (5,750 ft), *P. boylii* inhabited tall cliffs, rock outcroppings, and rocky gullies (Table 14). Both *P. boylii* and *P. nasutus* were common and lived together on faces of rugged cliffs. On rock outcrops and gullies, *P. boylii* was fairly common and shared these habitats with either *P. nasutus* and *P. pectoralis* or just *P. pectoralis*. We suspect that *P. boylii* also inhabits rocky slopes at high elevations, but we did not trap in that habitat. On canyonsides at lower elevations, no *P. boylii* was captured; *P. pectoralis* was the only *Peromyscus* present.

When trapping habitats of the seabed, we located an isolated population of *P. boylii* liv-

ing in a rocky arroyo that cut through the juniper plain (Table 17; Fig. 62). The arroyo was 5 m deep and 9 m wide, and its walls were composed of conglomerate rock. Vegetation included oak, juniper, Texas madrone, fragrant sumac, Wright silktassel, mescal bean, catclaw, viscid acacia, sotol, and some clumps of grass. Three *P. boylii* were the only animals captured in this arroyo, and an additional one was taken nearby on the flatlands (Table 17). We never caught another *P. boylii* on the seabed. When we trapped adjacent arroyos in this area and many others along the base of the escarpment, *P. pectoralis* was the only *Peromyscus* obtained. It is unclear whether other colonies of *P. boylii* exist on the seabed. The disjunct distribution of *P. boylii* in the park may be related, in part, to the presence and abundance of *P. pectoralis*. That is, without *P. pectoralis*, *P. boylii* might have a wider distribution in the park. Studies examining competition between these two species would be informative.

Reproduction. Of 47 *P. boylii* captured, we kept 42 as voucher specimens. Three pregnant females containing three young each were captured on 24 July. The crown-to-rump length of the largest fetus measured 18 mm in one female and 23 mm in the other. The third female had embryos contained in uterine swellings measuring 5 mm each. One lactating female each was taken on 28 March, 17 May, and 24 July. Females in adult pelage that were neither lactating nor pregnant were captured 6-8 February ($n = 13$), 28 March (2), and 17 May (3).

Testicular length of eight males in adult pelage averaged 4.6 mm (extremes, 3.0-6.0 mm); these males were collected from 6 to 8 February. An additional adult male was collected on 7 February, but we have no measurement of its testes. Adult males captured on 15 March had testes measuring 8.0 mm in length, on 12 May (12.0 and 12.5 mm), on 17 May (9.0, 9.0, and 12.0 mm), and on 31 July (14.5 mm). Young in juvenal, gray pelage were captured on 17 May ($n = 1$) and 24 July ($n = 2$; one released).

Taxonomic remarks. The subspecies of *Peromyscus boylii* in the park is *P. b. rowleyi* (J. A. Allen, 1893) based on the distribution reported in Hall (1981:697, map 402). To the best of our knowledge, Bailey (1928) did not capture any *P. boylii* during his studies in and around Carlsbad Cavern. His account of *P. boylii* on page 73 in *Animal Life of the Carlsbad Cavern* actually refers to *P. pectoralis*.

Museum specimens (total 42; includes 5 study skins with preserved bacula); Fig. 62:

- 1.37 mi. N, 0.65 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3 (MSB 1) reef 47;
- 1.33 mi. N, 0.95 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3 (MSB 1) reef 49;
- 0.13 mi. S, 0.72 mi. E Longview Spring, T25S, R23E, SW ¼ Sec. 28 (MSB 1) reef 54;
- 0.03 mi. S, 0.52 mi. E Longview Spring, T25S, R23E, W ½ Sec. 28 (MSB 5) reef 55;
- 0.15 mi. N, 0.25 mi. E Longview Spring, T25S, R23E, NE ¼ Sec. 29 [ravine containing Dog Pen Seep] (MSB 5) reef 56;
- 0.29 mi. N, 0.03 mi. W Red Cave, T25S, R23E, NE ¼ Sec. 31 (MSB 2) reef 59;
- 0.72 mi. E, 0.83 mi. N Putman Cabin, T25S, R23E, SE ¼ Sec. 7 (MSB 8) reef 63;
- 0.02 mi. N, 0.12 mi. E Putman Cabin, T25S, R23E, SW ¼ Sec. 18 [summit portion of trapline] (MSB 2) reef 66;
- Knoll of Putman Cabin, T25S, R23E, SW ¼ Sec. 18 (MSB 7) reef 67;
- Putman Cabin, T25S, R23E, SW ¼ Sec. 18 [in wooden storage shed next to cabin] (MSB 1) reef 67;
- 0.06 mi. S, 0.03 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 18 (MSB 4) reef 68;
- 0.73 mi. N, 0.06 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 7 (MSB 1) reef 69;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 1) seabed 29;
- 1.25 mi. S, 1.32 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 3) seabed 30.

Additional records (Fig. 62):

- inside Yucca Cabin, T25S, R23E, W ½ Sec. 28 (captured and released by KG on 16 May 1991) reef 55.

***Peromyscus nasutus* (J. A. Allen, 1891)**
Northern Rock Mouse

Northern rock mice live in rocky places including outcrops, cliffs, rimrocks, talus slopes, boulder piles, lava beds, and other places containing large amounts of rock (Hoffmeister 1986; Planz 1999). In New Mexico, they are most common in these rocky areas within or near woodlands comprised of pinyon pine, junipers, and oak (Findley *et al.* 1975).

In the park, *P. nasutus* inhabited cliffs and rocky outcrops at high elevations on the reef (Fig. 64). All individuals were captured at elevations $\geq 1,920$ m (6,300 ft). Eight rock mice were trapped on the face of a tall cliff overlooking Putman Canyon, and an equal number of *P. boylii* were captured in the same trapline (Table 14). Two other *P. nasutus* were

captured in rock outcroppings lying below a wooded summit. These individuals were taken with *P. boylii*, *P. pectoralis*, and *Neotoma mexicana* (Table 14). On the summit above the outcrops, alligator junipers, pinyon pines, and oaks were present.

Reproduction. Rock mice were captured on 6 and 7 February. Four females showed no evidence of reproductive activity, and testicular lengths of males measured 3.5, 6.0, 6.0, 7.0, 7.0, and 9.0 mm. We did not capture any juveniles.

Taxonomic remarks. The subspecies of *Peromyscus nasutus* in the park is *P. n. nasutus* (J. A. Allen, 1891) based on the distribution reported in Hall (1981:705, map 406).

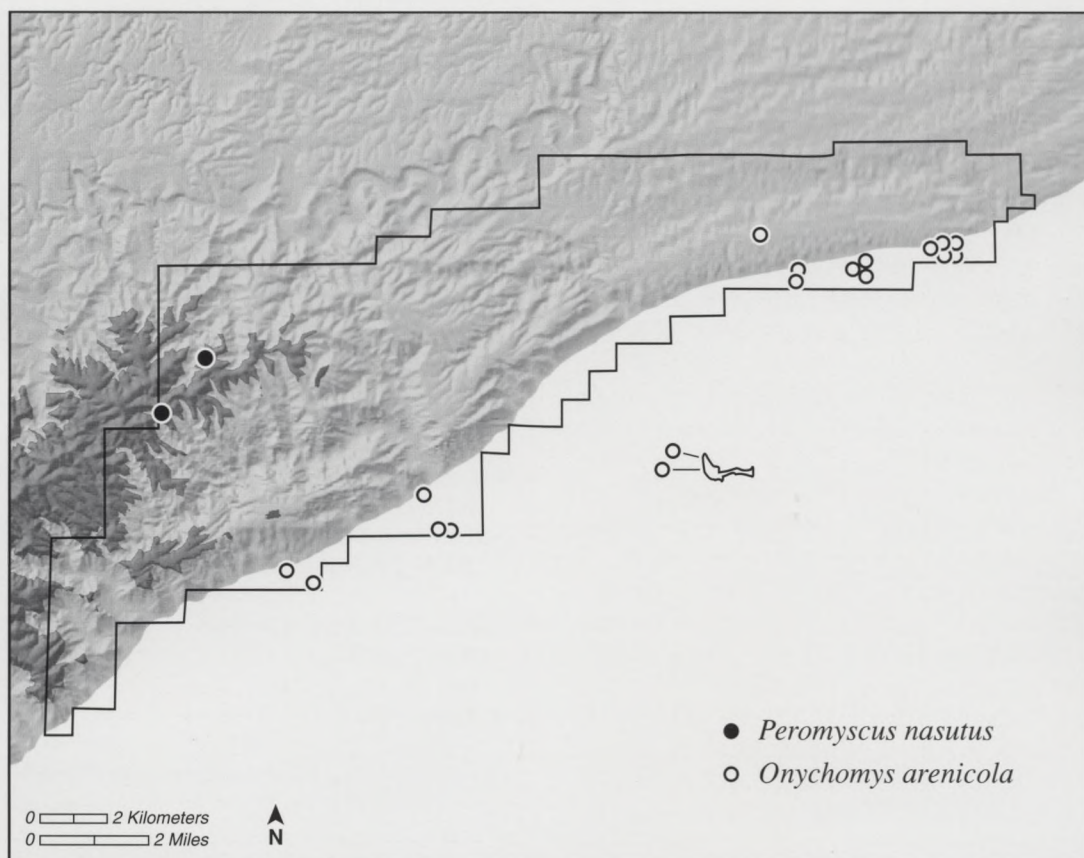


Fig. 64. Distribution of the northern rock mouse (*Peromyscus nasutus*) and Mearns's grasshopper mouse (*Onychomys arenicola*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

Museum specimens (total 10; includes 6 study skins with preserved bacula); Fig. 64:

- 0.72 mi. E, 0.83 mi. N Putman Cabin, T25S, R23E, SE ¼ Sec. 7 (MSB 8) reef 63;
- 0.06 mi. S, 0.03 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 18 (MSB 2) reef 68.

Additional records (not plotted in Fig. 64):

- Slaughter Canyon, 4¾ mi. S, 11 mi. W White City (Diersing and Hoffmeister 1974).

***Onychomys arenicola* Mearns, 1896 Mearns's Grasshopper Mouse**

In New Mexico, Mearns's grasshopper mice are most common in desert habitats in southern parts of the state (Findley 1987). At the park, we captured *O. arenicola* in all major habitats along the base of the escarpment, in two habitats at Rattlesnake Springs, and in one habitat on the reef (Fig. 64).

Below the escarpment, grasshopper mice lived in the scrubland, grassland, juniper plain, alluvial fans, and drainage areas (Table 16). In desert scrubland, they inhabited both open and grassy areas. In open areas, they occurred on fine-textured soils intermixed with stones, as well as in areas containing many rocks and lechuguilla. In grassy areas, they occurred in flat washes with tall shrubs and in isolated patches of grass with short shrubs. At Rattlesnake Springs, *O. arenicola* inhabited shrubby areas containing dusty soils near the horse barn and desert-scrub areas near the shooting range (Table 19). On the reef, the juniper peneplain was the only habitat where *O. arenicola* was captured (Table 13). Elevations of traplines containing *O. arenicola* ranged from 1,105 to 1,410 m (3,630-4,630 ft).

Reproduction. We captured 37 *O. arenicola* and kept 31 as voucher specimens. One pregnant female was captured on 11 March and another on 15 May. Each contained three young; greatest crown-to-rump lengths were 13 and 27 mm, respectively. Lactating females were captured on 15 May and 9 August. Thirteen females collected 19 January-14 February were neither pregnant nor lactating. Testicular lengths of males were 4.0, 5.0, 6.0, 6.5, 7.5, 8.0, 10.0, 10.5, and 11.0 mm in midwinter (20 January-10 February); 10.0, 12.0, 18.0, and 18.0 mm in late winter/early spring (10-22 March); and 8.5 mm in

mid-spring (24 April). We did not capture any juveniles.

Taxonomic remarks. The subspecies of *Onychomys arenicola* in the park is *O. a. arenicola* Mearns, 1896 based on the distribution reported in Hall (1981:731, map 422) and the taxonomic revision of *O. torridus* by Hinesley (1979).

Museum specimens (total 37); Fig. 64:

- 0.77 mi. W, 0.15 mi. S Visitor Center, T24S, R24E, SW ¼ Sec. 36 (MSB 2) reef 23;
- 8 mi. W Whites City [on reef in park, M. C. Thompson pers. comm.] (CACA 1) not plotted;
- Slaughter Canyon (CACA 1) not plotted;
- 1 mi. W Whites City, along high line [= along road to Sewage Disposal Ponds] (CACA 3) seabed 4;
- 1.08 mi. W, 0.45 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (MSB 4) seabed 5;
- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (MSB 4) seabed 5;
- 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S ½ Sec. 33 (MSB 1) seabed 6;
- 1.43 mi. W, 0.26 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33 (MSB 1) seabed 7;
- 1.53 mi. W, 0.29 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33 (MSB 2) seabed 8;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 3) seabed 11;
- 0.23 mi. N, 0.07 mi. E Sewage Disposal Ponds, T24S, R25E, SW ¼ Sec. 32 (MSB 1) seabed 12;
- 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5 (MSB 1) seabed 13;
- 1.01 mi. W, 0.05 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1 (MSB 1) seabed 14;
- 1.15 mi. W, 0.22 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1 (MSB 1) seabed 15;

- 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 2) *seabed* 19;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 2) *seabed* 20;
- 0.49 mi. S, 0.37 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26 (MSB 2) *seabed* 26;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33 (MSB 1) *seabed* 29;
- 0.96 mi. S, 0.78 mi. E Longview Spring, T25S, R23E, W ½ Sec. 33 (MSB 1) *seabed* 31;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 1) *seabed* 43;
- 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 1) *seabed* 44;
- Rattlesnake Springs, 5.5 mi. S White's City (AMNH 1) *not plotted*.

Sigmodon hispidus Say and Ord, 1825 Hispid Cotton Rat

In New Mexico, the hispid cotton rat occurs in grasslands in southern and eastern portions of the state (Findley 1987). Vegetative cover in the form of grasses and forbs is an important habitat requirement for *S. hispidus* (Cameron 1999). In the park, we captured most cotton rats at Rattlesnake Springs (66 individuals out of 84). Here they occurred in all areas containing dense grass and weeds on dry ground and in marshy areas (Table 19). Near the picnic area, well-defined runways formed by this species were numerous in dense grasses growing beside the stream. In midwinter, some individuals used runs with standing water 3.5 cm in depth. In woodlots, cotton rats were captured in marshy areas containing dense vegetation and in drier sections containing fallen leaves and exposed soil. Cotton rats were less common in shrubby areas containing mesquite or cropped grass, and none was taken in shrubby areas containing exposed soil or desert pavement. At Rattlesnake Springs, cotton rats were often captured with *Peromyscus leucopus* (Table 19).

Along the base of the escarpment, cotton rats were captured in the scrubland and grassland ($n = 2$ and 13, respectively; Table 16). In desert scrub, they lived in grassy areas supporting tall shrubs, and each cotton rat was captured under a mesquite containing a dense understory of bush muhly. In the grassland, we captured cotton rats in areas having moderately dense grasses.

We captured three cotton rats on the reef (Table 13). One was trapped in bush mulhy under a mesquite on the floor of Walnut Can-

yon, and the others were captured under shrubs on the grassy floor of Slaughter Canyon (Fig. 65). Specimens at the park's museum indicate that this species may be more abundant on the reef during certain years. For example, 11 animals were captured in Bat Cave Draw from 1949 to 1950, although we failed to capture cotton rats on the grassy floor of this draw in 1991. Populations of hispid cotton rats can fluctuate greatly in size from year to year (Findley *et al.* 1975; Schmidly 1977). Hispid cotton rats probably are common on the reef only in years of high population density. At the park, cotton rats occurred at elevations of 1,105–1,330 m (3,620–4,360 ft).

Reproduction. We captured 84 *S. hispidus* and kept 15 as voucher specimens. The first female that was noticeably pregnant was captured on 13 March, weighed 115 g, and carried two fetuses (largest fetus measured 45 mm in crown-to-rump length). Other pregnant females were captured on 25 April (five fetuses; greatest crown-to-rump length was 30 mm), 2 May (six embryos; largest uterine swelling was 5 mm), and 19 May (six embryos; largest uterine swelling was 13 mm); body masses of females were 180, 105, and 145 g, respectively. A lactating female was caught on 8 May and weighed 90 g. Two females taken on 24 January and one on 11 March were neither pregnant nor lactating; their body masses were 135, 155, and 55 g, respectively.

Males captured from 20 January to 10 February had testes measuring 12.0, 16.0, 16.0, 16.0, and 20.0 mm in length. Their body masses ranged from 95 to 110 g. Testicular

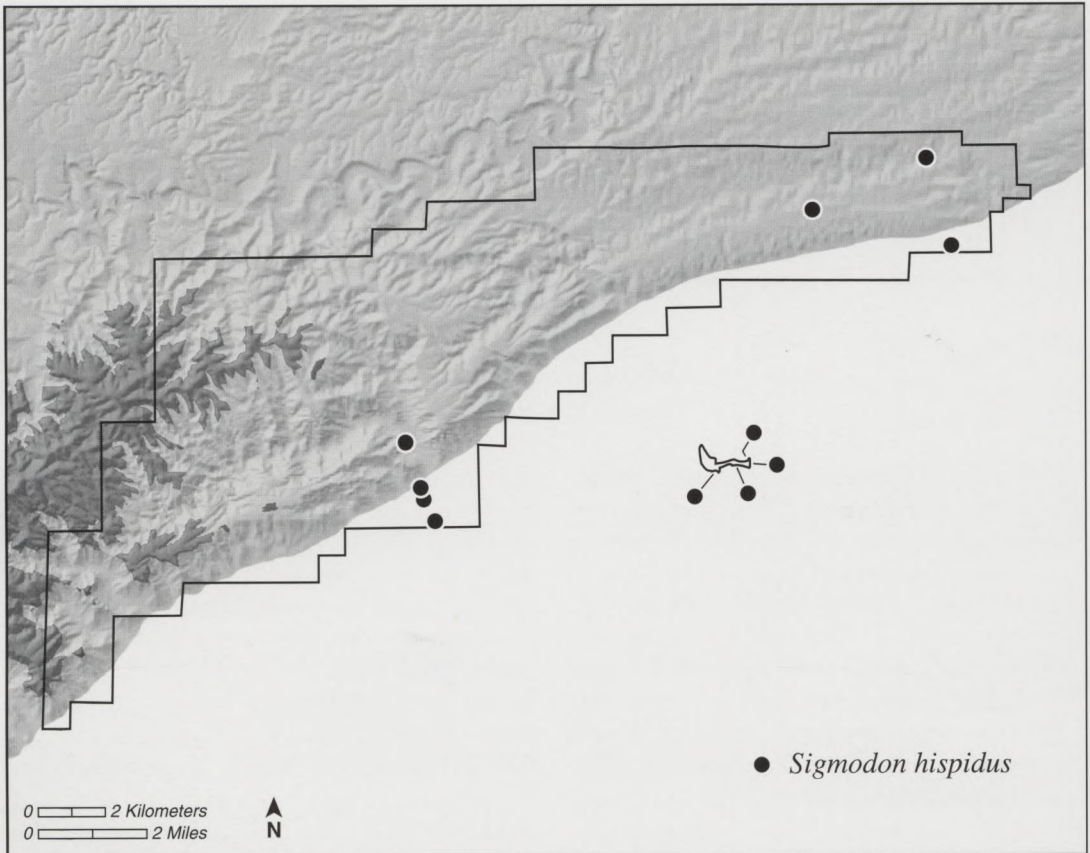


Fig. 65. Distribution of the hispid cotton rat (*Sigmodon hispidus*) in Carlsbad Caverns National Park. For precise location of symbols see Appendix 4.

length of an adult (125 g) measured 23.0 mm on 13 March and of a juvenile (15 g) measured 8.0 mm on 8 May.

Taxonomic remarks. The subspecies of *Sigmodon hispidus* in the park is *S. h. berlandieri* Baird, 1855 based on the distribution reported in Hall (1981:738, map 426). Although Hall referred all specimens from New Mexico to this subspecies, animals living east of the Pecos River may belong to *S. h. texianus* (Audubon and Bachman, 1853)—see Frey (2004). Carlsbad Caverns National Park is west of the Pecos River (Fig. 51).

Museum specimens (total 31); Fig. 65:

- 1.14 mi. N, 1.45 mi. W Whites City, T24S, R25E, NW ¼ Sec. 28 (MSB 1) reef 6;
- elevator building trail bridge [small bridge over Bat Cave Draw between Visitor Center and large natural opening of Carlsbad Cavern] (CACA 6) reef 13;
- Bat Cave Draw (CACA 5) not plotted;

- 0.30 mi. N, 0.12 mi. E New Cave, T25S, R23E, NE ¼ Sec. 23 (MSB 2) reef 40;
- 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (MSB 2) seabed 5;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 2) seabed 20;
- 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25 (MSB 1) seabed 24;
- 0.08 mi. N, 0.64 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (MSB 2) seabed 37;
- 0.08 mi. N, 0.37 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (MSB 2) seabed 39;
- Rattlesnake Springs, near water-storage pond, T25S, R24E, SW ¼ Sec. 23 (MSB 3) seabed 42;
- Rattlesnake Springs (CACA 5) not plotted.

Additional records (Fig. 65):

- 0.49 mi. S, 0.37 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26 (captured and released by KNG and KG on 11 March 1991) seabed 26;
- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (captured and released by KNG and KG on 15 May 1991) seabed 38.

Neotoma leucodon Merriam, 1894 Eastern White-throated Woodrat

In New Mexico, *N. leucodon* lives in a variety of habitats ranging from desert lowlands to mixed coniferous forests (Findley *et al.* 1975). Of three species of woodrats inhabiting the park, *N. leucodon* had the widest distribution. It coexisted with *N. micropus* in lowlands of the seabed, and it lived in the same habitat as *N. mexicana* at high elevations on the reef. Areas between were occupied solely by *N. leucodon* (Fig. 66). In the park, *N. leucodon* occurred at elevations of 1,115-1,790 m (3,650-5,880 ft).

Along the base of the escarpment, *N. leucodon* was captured in the juniper plain, on alluvial fans, in rocky arroyos, and on the boulder-strewn terrain of Slaughter Canyon Draw (Table 16). Although none was taken in desert-scrub areas in this portion of the park, some were trapped in this habitat at Rattlesnake Springs (Table 19). On the seabed, *N. leucodon* and *N. micropus* occurred together in the juniper plain and in the shrubby area containing exposed soil at Rattlesnake Springs (Tables 16 and 19).

On the reef, we captured *N. leucodon* on exposed slopes and gullies of the eastern escarpment, in grassy and desert-scrub areas on canyon floors, and in several habitats on canyonsides (Tables 13 and 14). We also captured an individual next to Log Cabin Seep in Putman Canyon. On canyonsides, *N. leucodon* inhabited rock outcroppings, rocky slopes, gullies, and ravines, but none was captured on faces of tall cliffs. Although Table 14 indicates that eastern white-throated woodrats were captured only in outcroppings 1,705-1,735 m (5,600-5,700 ft), we also caught them in outcroppings at 1,315 m (4,320 ft) in Bat Cave Draw, using our second trapping method (captured on 3rd and 4th nights). Both *N. leucodon* and *N. mexicana* were trapped in mesic gullies or ravines of canyonsides at high elevations on the reef (Table 14).

In 1924, Bailey (1928) also found *N. leucodon* abundant on the reef. It lived in the large opening of Carlsbad Cavern and took up residence in several storehouses and cabins in the vicinity of the cavern.

Reproduction. We captured 39 *N. leucodon* and kept 17 as voucher specimens. A female contained two fetuses on 11 May; the largest measured 23 mm in crown-to-rump length. On 9 August, we discovered two baby woodrats (each 6.4 cm in crown-to-rump length) squeaking under a shrub; a lactating *N. leucodon* was found in a nearby trap and released. Other lactating females were captured on 24 April, 15 May (released), and 20 May. Adult females that were not pregnant or lactating were captured on 29 April, 15 May, 19 May, and 1 August. Adult females weighed 140 (pregnant), 140 and 135 (lactating), and 120-145 g (non-reproductive, $n = 4$).

Adult males captured on 23 January, 15 March, 21 March, 22 March, and 24 July had testes measuring 8.0, 13.0, 10.0, 18.0, and 12.0 mm in length, respectively. Adult males ($n = 5$) weighed 100-140 g. Younger individuals were captured on 2 February (body masses, 70 and 72.5 g), 15 March (90 g), 25 April (38 g), and 19 May (70 g).

Taxonomic remarks. We followed Edwards *et al.* (2001) in use of the name *Neotoma leucodon* instead of *N. albigula* Hartley, 1894 for populations of white-throated woodrats east of the Rio Grande in New Mexico. We did not assign a subspecific name to specimens from the park. Frey (2004) applied the name *N. l. melas* Dice, 1929 to specimens from southeastern and other parts of New Mexico based on the taxonomic study by Rogers and Schmidly (1981).

Museum specimens (total 31); Fig. 66:

- 0.35 mi. W, 0.51 mi. N Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 27 (MSB 2) reef 2;
- 1.14 mi. N, 1.45 mi. W Whites City, T24S, R25E, NW $\frac{1}{4}$ Sec. 28 (MSB 1) reef 6;
- Bat Cave Draw (CACA 2) *not plotted*;
- 0.05 mi. N, 0.32 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N $\frac{1}{2}$ Sec. 31 (MSB 2) reef 12;
- below ticket office [near large natural opening of Carlsbad Cavern] (CACA 4) reef 13;
- residence area [near park headquarters] (CACA 1) reef 13;
- headquarters area [0.10 mi. W of large natural opening of Carlsbad Cavern] (CACA 1) reef 13;

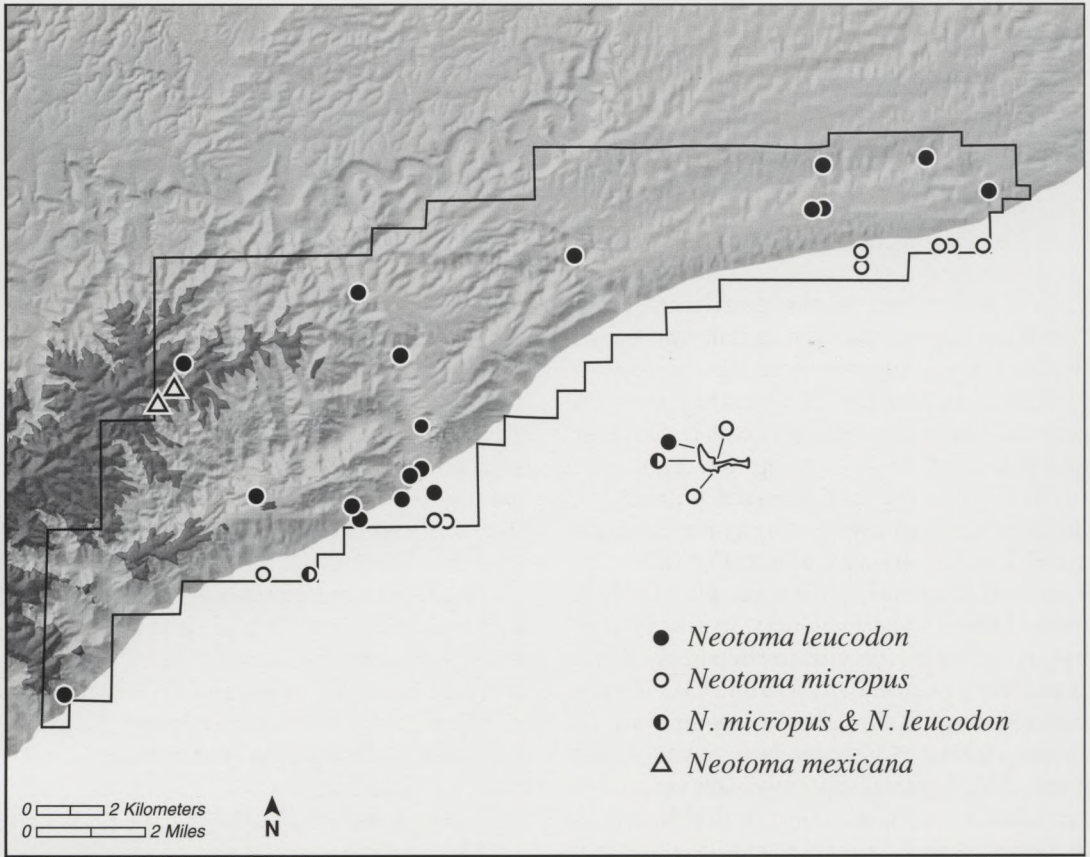


Fig. 66. Distribution of the eastern white-throated woodrat (*Neotoma leucodon*), southern plains woodrat (*N. micropus*), and Mexican woodrat (*N. mexicana*) in Carlsbad Caverns National Park. Records of *N. micropus* from the vicinity of Carlsbad Cavern in 1924 and 1930 are not plotted on the map. For precise location of symbols see Appendix 4.

- Carlsbad Cave [in large natural opening of Carlsbad Cavern] (USNM 1) reef 13;
 - 1.0 mi. N, 0.52 mi. E Visitor Center, T24S, R25E, N $\frac{1}{2}$ Sec. 30 (MSB 1) reef 20;
 - 1.5 mi. up Rattlesnake Canyon, 30 mi. SW Carlsbad (KU 1) reef 34;
 - Rattlesnake Canyon (KU 1) not plotted;
 - 0.22 mi. SW Ogle Cave, T25S, R23E, NE $\frac{1}{4}$ Sec. 23 (MSB 1) reef 36;
 - near Goat Cave, Slaughter Canyon [Goat Cave is in a side canyon of North Slaughter Canyon, T25S, R23E, SE $\frac{1}{4}$ Sec. 11] (CACA 1) reef 43;
 - 1.23 mi. N, 0.78 mi. W Goat Cave, T25S, R23E, SE $\frac{1}{4}$ Sec. 3 (MSB 1) reef 48;
 - 0.95 mi. S, 0.90 mi. W New Cave, T25S, R23E, SE $\frac{1}{4}$ Sec. 27 (MSB 1) reef 51;
 - 0.15 mi. N, 0.25 mi. E Longview Spring, T25S, R23E, NE $\frac{1}{4}$ Sec. 29 [ravine containing Dog Pen Seep] (MSB 1) reef 56;
 - 1.76 mi. S, 0.37 mi. W Double Cave, T26S, R22E, NW $\frac{1}{4}$ Sec. 14 (MSB 1) reef 62;
 - 0.51 mi. N, 0.30 mi. E Putman Cabin, T25S, R23E, NW $\frac{1}{4}$ Sec. 18 [next to Log Cabin Seep] (MSB 1) reef 64;
 - Putman Canyon (CACA 2) not plotted;
 - 0.58 mi. S, 0.52 mi. E New Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (MSB 1) seabed 22;
 - 0.52 mi. S New Cave, T25S, R23E, NE $\frac{1}{4}$ Sec. 26 (MSB 1) seabed 27;
 - 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE $\frac{1}{4}$ Sec. 33 (MSB 2) seabed 29;
 - 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW $\frac{1}{4}$ Sec. 23 (MSB 1) seabed 44.
- Additional records (Fig. 66):*
- 0.24 mi. S, 0.23 mi. E New Cave, T25S, R23E, SE $\frac{1}{4}$ Sec. 23 (captured and released by KNG and KG on 5 August 1991) reef 37;
 - 0.32 mi. S, 0.19 mi. E New Cave, T25S, R23E, NE $\frac{1}{4}$ Sec. 26 (captured and released by KNG and KG on 5 August 1991) reef 38;

- 1.08 mi. S, 0.79 mi. W New Cave, T25S, R23E, SE ¼ Sec. 27 (captured and released by KNG and KG on 20 May 1991) *seabed* 28;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (captured and released by KNG and KG on 15 May 1991) *seabed* 43.

Neotoma micropus Baird, 1855 Southern Plains Woodrat

In New Mexico, the southern plains woodrat is most common in flat, open areas dominated by grasses and desert shrubs. Unlike other *Neotoma* in the state, this species usually is not found in rocky situations (Findley *et al.* 1975). During our surveys at the park, *N. micropus* occurred only in lowland habitats of the seabed at elevations of 1,100–1,385 m (3,610–4,550 ft; Fig. 66).

At Rattlesnake Springs, *N. micropus* lived in dry areas of woodlots, in grassy areas bordering woodlots, and in the shrubby area containing exposed soil (Table 19). We also captured an individual in a woodpile by the ranger station. Along the base of the escarpment, *N. micropus* inhabited the scrubland, grassland, and juniper plain (Table 16). In desert scrubland, it lived in grassy areas with short shrubs, in grassy areas with tall shrubs, and in open areas without lechuguilla.

On the seabed, woodrat houses seemed most numerous in grassy areas of desert scrub that contained tall shrubs, and in this habitat we captured only one species of woodrat—*N. micropus*. We also observed woodrat houses under shrubs in the juniper plain. In this habitat, some houses might have been constructed by *N. leucodon* (Table 16). Although we never located a woodrat house at Rattlesnake Springs, Parker (1932) reported *N. micropus* occupying houses in apple trees; one house was 2.4 m above the ground.

We captured no *N. micropus* on the reef in the 1990s, but others have trapped this species in the vicinity of Carlsbad Cavern in the past. V. Bailey caught two individuals in 1924, and J. E. Hill trapped one in 1930. Today no evidence exists that *N. micropus* occurs on the reef (see *Discussion*).

Reproduction. We captured 20 *N. micropus* and kept seven as voucher speci-

mens. A pregnant female contained three fetuses on 1 February; the crown-to-rump length of the largest fetus was 44 mm. Lactating females were captured on 28 January, 10 March (released), 15 March (released, $n = 2$), 22 March, and 26 July (released). Adult females weighed 220 (pregnant), 160 (lactating in January), and 155 g (lactating on 22 March).

Adult males captured on 1 February, 10 February, and 7 May had testes measuring 17.0, 20.0, and 21.0 mm in length, respectively. Adult males weighed 230, 190, and 265 g, respectively. A young male weighing 65 g was captured on 3 May and had testes measuring 7.0 mm in length.

Taxonomic remarks. The subspecies of *Neotoma micropus* in the park is *N. m. canescens* J. A. Allen, 1891 based on the distribution reported in Hall (1981:750, map 433).

Museum specimens (total 11); Fig. 66:

- Carlsbad Cave [on ridge near Carlsbad Cavern; collected in 1924] (USNM 2) *not plotted*;
- rocks near Carlsbad Cavern, 4450 feet [collected in 1930] (KU 1) *not plotted*;
- 1.08 mi. W, 0.45 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33 (MSB 1) *seabed* 5;
- 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S ½ Sec. 33 (MSB 1) *seabed* 6;
- 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25 (MSB 1) *seabed* 20;
- 1.44 mi. S, 0.42 mi. E Longview Spring, T25S, R23E, SW ¼ Sec. 33 (MSB 1) *seabed* 32;
- Rattlesnake Spring, 30 mi. SW Carlsbad [in apple tree; Parker 1932] (KU 1) *seabed* 41;
- Rattlesnake Springs, near water-storage pond, T25S, R24E, SW ¼ Sec. 23 (MSB 2) *seabed* 42;
- 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23 (MSB 1) *seabed* 43.

Additional records (Fig. 66):

- 0.59 mi. S, 0.38 mi. W Whites City, T24S, R25E, S $\frac{1}{2}$ Sec. 34 (captured and released by KNG and KG on 9 May 1991) *seabed 1*;
- 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW $\frac{1}{4}$ Sec. 5 (captured on 4 February 1991; articulated skeleton in teaching collection of J. J. Krupa) *seabed 11*;
- 0.12 mi. N, 0.05 mi. E Sewage Disposal Ponds, T24S, R25E, SW $\frac{1}{4}$ Sec. 32 (captured and released by KNG and KG on 10 March 1991) *seabed 12*;
- 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (captured and released by KNG on 10 February 1991) *seabed 19*;
- 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE $\frac{1}{4}$ Sec. 33 (captured and released by KNG and KG on 15 March 1991) *seabed 29*;
- next to ranger station at Rattlesnake Springs [in woodpile] (captured and released by KNG and KG on 20 and 21 May 1992) *seabed 41*.

Neotoma mexicana Baird, 1855 Mexican Woodrat

In New Mexico, *N. mexicana* reaches its greatest abundance in mixed coniferous forests; however, at some sites it also occurs at lower elevations such as the lava fields near Carrizozo (Findley *et al.* 1975). In the park, *N. mexicana* was captured only at high elevations on the reef (Fig. 66). On 8 February, we captured an *N. mexicana* beneath a large boulder in a northeast-facing gully near Putman Cabin (Table 14). The capture site was at 1,905 m (6,250 ft). Trees in this mesic habitat included ponderosa pine, Rocky Mountain juniper, pinyon pine, bigtooth maple, chinkapin oak, and velvet ash. We also captured an *N. mexicana* on 6 February just below the wooded summit of Putman Cabin. Here the trap was placed under a rock ledge along an outcrop at 1,940 m (6,360 ft; Table 14). The summit above the outcrop contained alligator junipers, pinyon pines, and oaks.

Reproduction. The woodrat captured on 8 February was an adult male with scrotal testes measuring 18.0 mm in length. The in-

dividual captured on 6 February was an adult female that was neither pregnant nor lactating. The male and female weighed 125 and 110 g, respectively.

Taxonomic remarks. The line of demarcation between *Neotoma mexicana* Baird, 1855 and *N. m. scopulorum* Finley, 1953 is close to Carlsbad Caverns National Park (Hall 1981:764, map 438). We did not assign a subspecific name to the two specimens from the park. Both Genoways *et al.* (1979:299) and Hall (1981:762) applied *N. m. mexicana* to specimens from the Guadalupe Mountains in Texas and New Mexico. However, animals from this mountain range are genetically more similar to *N. m. scopulorum* (see Sullivan 1994).

Museum specimens (total 2); Fig. 66:

- 0.02 mi. N, 0.12 mi. E Putman Cabin, T25S, R23E, SW $\frac{1}{4}$ Sec. 18 [gully portion of trapline] (MSB 1) *reef 66*;
- 0.06 mi. S, 0.03 mi. W Putman Cabin, T25S, R23E, SW $\frac{1}{4}$ Sec. 18 (MSB 1) *reef 68*.

Mus musculus Linnaeus, 1758 House Mouse

House mice are widespread and locally common in New Mexico (Findley *et al.* 1975; Findley 1987). They live in human-made habitats such as buildings, cultivated fields, and roadside ditches, as well as in natural habitats such as arid grasslands and desert areas.

Four specimens of *M. musculus* are known from the park. One was collected on 4 December 1949 in a building once operated by the Cavern Supply Company. This building, which no longer exists, was located near the large opening of Carlsbad Cavern (Nymeyer and Halliday 1991). Remaining specimens

were captured in Bat Cave of Carlsbad Cavern in July 1930. Two were obtained by Parker (1932). He reported capturing ten *M. musculus* after setting 20 traps on top of bat guano; most mice were destroyed by cave crickets.

Although the building used by the Cavern Supply Company no longer exists, we collected mice inside other buildings and structures in the park, including residences near Carlsbad Cavern, the ranger station at Rattlesnake Springs, Yucca Cabin, and a wooden storage shed next to Putman Cabin. We only caught *Peromyscus* in these situations. In 1991, park personnel gave us a mouse from the Visitor Center, and it also was a *Peromyscus*.

We also set traps in the underground lunchroom in Carlsbad Cavern, and we did not capture any mice. Although no record of

M. musculus has been reported from the park since 1949, the possibility always exists of discovering newly introduced individuals or discovering new colonizers from nearby human habitations (see *Discussion*).

Reproduction. The house mouse collected on 4 December had scrotal testes measuring 10 mm in length.

Taxonomic remarks. We did not assign a subspecific name to specimens of this introduced species.

Museum specimens (total 4); not mapped:

- Bat Cave, Carlsbad Cavern [one collected by J. E. Hill on 29 July 1930 and two collected by H. C. Parker on 30 July 1930] (KU 3);
- in garbage can at curio building [building used by Cavern Supply Company, see Nymeyer and Halliday 1991:91; collected on 4 December 1949] (CACA 1).

Family Erethizontidae *Erethizon dorsatum* (Linnaeus, 1758) North American Porcupine

Porcupines occur in all habitats throughout New Mexico, and although they are most abundant in forested areas, they occasionally inhabit areas that seem unsuited to them such as open grasslands and deserts (Findley 1987). From time to time, porcupines probably occur in every habitat of the park, but the best chance of observing one is at Rattlesnake Springs in winter. From January to mid-March 1991, we observed at least one individual on almost every visit. Density of porcupines on this parcel of land is not known, and we were possibly seeing the same individuals over and over again. Individuals usually were located high in cottonwoods near the picnic area. On 23 January, KNG saw an adult porcupine standing in snow and stripping bark from the base of an apple tree. Porcupines also have been observed at Rattlesnake Springs during summer (D. M. Roemer *pers. comm.*). At Rattlesnake Springs, obvious signs of porcupines include stripped bark on trunks and branches of Russian olives, fruit trees, and cottonwoods and fecal material of porcupines beneath these trees. Along the base of the escarpment, the carcass of a por-

cupine was noted on the gravel road leading to the Sewage Disposal Ponds (Fig. 67); surrounding habitat was desert scrub.

During our studies, we observed 13 porcupines on the reef; each was sighted along the floor of Walnut Canyon. Other observations on the reef include those in the large opening of Carlsbad Cavern, those at Spider Cave Seep and Longview Spring, and those on summits containing Yucca and Putman cabins. Quills of porcupines are common on the floor of small caves and shelters throughout the reef (D. A. Ek *pers. comm.*).

Reproduction. No information is available regarding reproductive biology of porcupines in the park.

Taxonomic remarks. The subspecies of *Erethizon dorsatum* in the park is *E. d. epixanthum* Brandt, 1835 based on the taxonomic study of southern populations of porcupines by Stangl *et al.* (1991).

Museum specimens (total 2); Fig. 67:

- 1 mi. below wayside #2 exhibit parking area [T24S, R25E, SW ¼ Sec. 27 in Walnut Canyon; exhibit #2 = Chihuahuan Desert

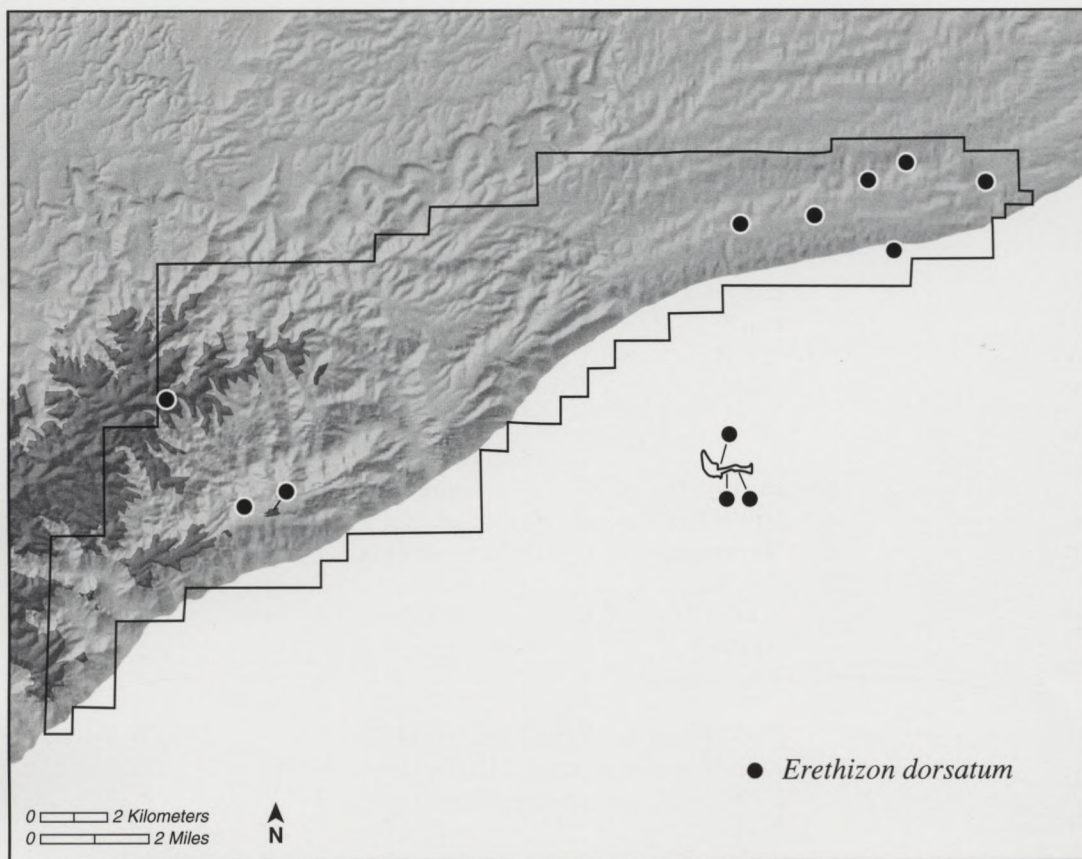


Fig. 67. Distribution of the North American porcupine (*Erethizon dorsatum*) in Carlsbad Caverns National Park, excluding most of our sightings along the paved road between Whites City and the Visitor Center. For precise location of symbols see Appendix 4.

Exhibit located in Section 28, 1.08 mi. N, 1.35 mi. W Whites City] (CACA 1) reef 3;

- Park Headquarters near old ticket office [near large natural opening of Carlsbad Cavern] (CACA 1) reef 13.

Additional records (Fig. 67):

- floor of Walnut Canyon, T24S, R25E, NE $\frac{1}{4}$ Sec. 29 (sighting by T. L. Best on 20 July 1995) reef 7;
- near Indian Shelter Exhibit in Walnut Canyon (sighting by KNG and KG on 8 August 1991 and 17 May 1992) reef 8;
- large natural opening of Carlsbad Cavern (sighting by S. G. Oakes on 14 April 1998) reef 13;
- near Spider Cave, T24S, R24E, NE $\frac{1}{4}$ Sec. 35 (sighting by R. D. Kieffe on 16 December 1990) reef 25;
- near Yucca Cabin, T25S, R23E, W $\frac{1}{2}$ Sec. 28 (sighting by R. M. Turner; date unknown) reef 55;
- Longview Spring, T25S, R23E, E $\frac{1}{2}$ Sec. 29 (sighting by R. M. Turner; date unknown) reef 57;
- near Putman Cabin, T25S, R23E, SW $\frac{1}{4}$ Sec. 18 (sighting by R. M. Turner; date unknown) reef 67;
- 0.74 mi. E, 0.21 mi. N Sewage Disposal Ponds, T24S, R25E, SE $\frac{1}{4}$ Sec. 32 (observation of a dead individual by KNG on 8 July 1997) seabed 10;
- near picnic area at Rattlesnake Springs (most recent sighting by KNG and KG was on 14 March 1991 and by D. M. Roemer on 28 February 2000) seabed 39;
- 250 meters E, 75 meters N Rattlesnake Spring (sighting by D. M. Roemer on 20 May 2000) seabed 40;
- orchard at Rattlesnake Springs (sighting by KNG on 23 January 1991 and D. M. Roemer on 18 June 2000) seabed 41;
- front yard of ranger station at Rattlesnake Springs (sighting by D. M. Roemer on 8 August 1997) seabed 41.

Order Carnivora
Family Canidae
Canis latrans Say, 1823
 Coyote

Although coyotes occur in all habitats in New Mexico (Findley *et al.* 1975), they are observed most often in open grasslands and deserts (Findley 1987). At the park, coyotes are commonly heard at night on the seabed by park personnel residing at Rattlesnake Springs. In contrast, they are seldom heard on the reef by residents living in the vicinity of Carlsbad Cavern.

At Rattlesnake Springs, coyotes have been observed in the front yard of the ranger station, the woodlot next to the storage pond, the orchard, weedy areas near the east entrance, and near the picnic area (Fig. 68). Along the base of the escarpment, KG observed an individual traveling through the

juniper plain. Observations on the reef include those near Lowe Ranch and the Visitor Center and those in Walnut Canyon, Lefthook Canyon, Double Canyon, and Bat Cave Draw (Fig. 68). A specimen also exists from Rattlesnake Canyon.

Reproduction. No information is available regarding reproductive biology of coyotes in the park.

Taxonomic remarks. The subspecies of *Canis latrans* in the park is *C. l. texensis* V. Bailey, 1905 based on the distribution reported in Hall (1981:926, map 489).

Museum specimens (total 1); not plotted in Fig. 68:
 • Rattlesnake Canyon (KU 1).

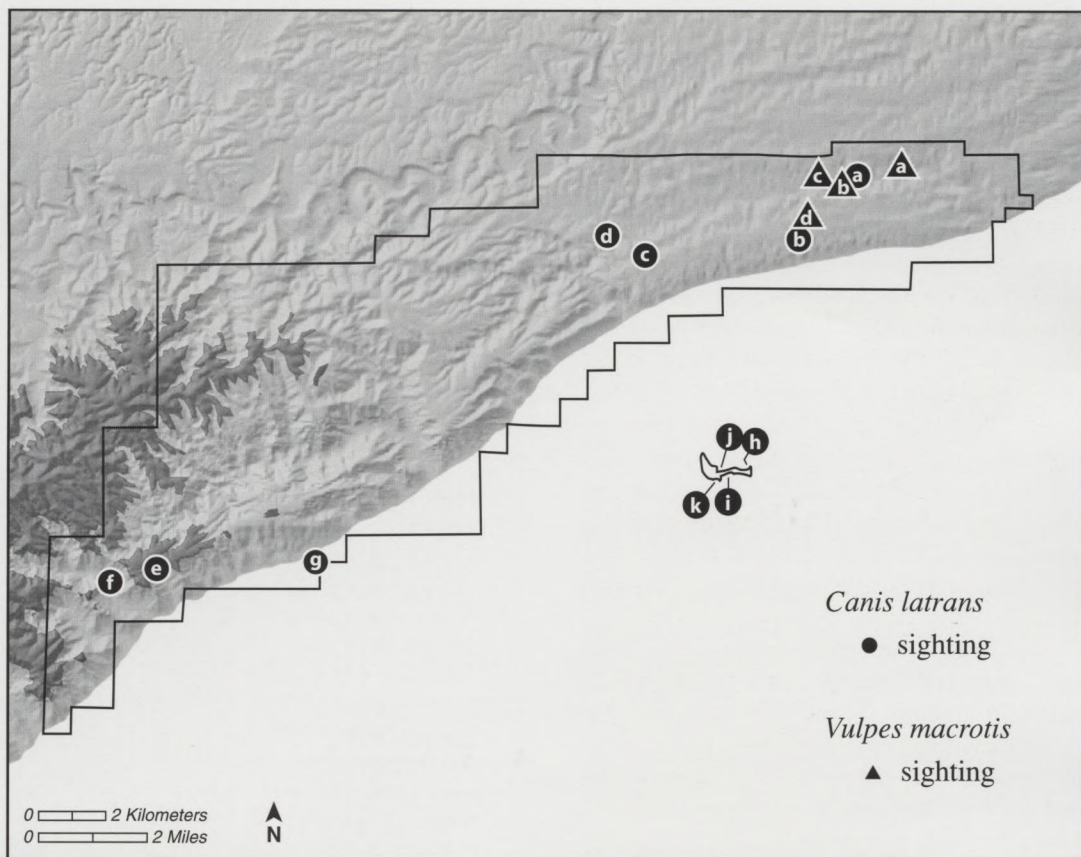


Fig. 68. Distribution of the coyote (*Canis latrans*) and kit fox (*Vulpes macrotis*) in Carlsbad Caverns National Park. Letters in symbols correspond to italicized letters in *Additional records*.

Additional records (Fig. 68):

- lower portion of Walnut Canyon (sighting by KNG on 13 June 1974) *not plotted*;
- Walnut Canyon, T24S, R25E, NE ¼ Sec. 30 (sighting by D. M. Roemer on 17 October 1999) *a*;
- Bat Cave Draw (sighting by R. G. Prasil on 23 November 1951) *not plotted*;
- near the Visitor Center (sighting by M. A. Littlejohn on 6 May 1977) *b*;
- 1 mi. W of West Water Tank, T24S, R24E, SW ¼ Sec. 34 [West Water Tank is in SW ¼ Sec. 35, 1.93 mi. W, 0.37 mi. S Visitor Center] (sighting by W. B. O'Neal on 4 December 1970) *c*;
- ¼ mi. NW of Lowe Ranch [remnants of Lowe Ranch are near Lowe Spring; both spring and ranch are near center of Sec. 33, T24S, R24E] (sighting by D. W. Bridwell and K. I. Carson on 5 October 1979) *d*;
- Lefthook Canyon (sighting by R. J. Heying on 9 December 1964) *e*;
- North Double Canyon [= Double Canyon] (sighting by C. M. Peterson in 1972) *f*;
- juniper plain on seabed, T25S, R23E, E ½ Sec. 33 (sighting by KG in November 1998) *g*;
- 0.08 mi. NW of east entrance to Rattlesnake Springs, T25S, R24E, SE ¼ Sec. 23 (sighting by D. M. Roemer on 9 October 1999) *h*;
- near picnic area, 0.21 mi. E, 0.10 mi. N Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (sighting by D. M. Roemer on 31 May 2000) *i*;
- orchard next to ranger station at Rattlesnake Springs (sighting by D. M. Roemer on 6 October 1998 and 5 August 2000) *j*;
- front yard of ranger station at Rattlesnake Springs (sighting by D. M. Roemer on 29 September 1999) *j*;
- woodlot on east side of Rattlesnake Spring (sighting by D. M. Roemer on 22 October 2000) *k*;
- near storage pond at Rattlesnake Springs (sighting by B. D. Munyan on 20 December 1994) *k*.

Vulpes macrotis Merriam, 1888 Kit Fox

In New Mexico, kit foxes generally occur in grasslands and deserts (Findley *et al.* 1975; Findley 1987), but at the park, records of this canid are known only from the reef. To date, three sightings are available from the floor of Walnut Canyon, and one sighting is from an area near park headquarters (Fig. 68). Observations of kit foxes occurred at elevations 1,185–1,340 m (3,880–4,400 ft).

Although kit foxes have been observed only on the reef, they probably are more common on the seabed along the base of the escarpment. Sightings of kit foxes, as well as coyotes, would be more common if park roads in lowlands were traveled as often as those on the reef.

Reproduction. No information is available regarding reproductive biology of kit foxes in the park.

Taxonomic remarks. Based on mitochondrial DNA, Mercure *et al.* (1993) concluded that kit foxes (*Vulpes macrotis* Merriam, 1888) and swift foxes (*V. velox* [Say, 1823]) should be recognized as separate species. They also discovered a region of hybrid-

ization in southeastern New Mexico. Of 22 foxes examined from this region, 59% had genotypes of the kit fox clade and 41% had genotypes of the swift fox clade. Their samples were from Lea ($n = 2$), Chavez ($n = 19$), and Lincoln counties ($n = 1$). Lea and Chavez counties border Eddy County. At the park, we tentatively refer to these small foxes as kit foxes and did not assign a subspecific name.

Additional records (Fig. 68):

- Walnut Canyon, T24S, R25E, NE ¼ Sec. 29 [1,185 m or 3,880 ft] (sighting by L. A. McWilliams on 19 June 1998) *a*;
- Walnut Canyon, T24S, R25E, SE ¼ Sec. 30 [1,220 m or 4,000 ft] (sighting by K. E. Kelly on 2 November 1991) *b*;
- Walnut Canyon, T24S, R25E, NW ¼ Sec. 30 [1,245 m or 4,080 ft] (sighting by L. A. McWilliams on 9 April 1998) *c*;
- between housing area and park headquarters, T24S, R25E, NW ¼ Sec. 31 [1,340 m or 4,400 ft] (sighting by D. M. Roemer on 9 September 1998) *d*.

***Urocyon cinereoargenteus* (Schreber, 1775)**
Common Gray Fox

The gray fox is common in rugged, rocky country throughout New Mexico (Findley 1987), and the Guadalupe Mountains provide ideal habitat for this canid. Through the years, we observed 82 gray foxes in the park, and most were seen at night while we drove the paved road between Whites City and the Visitor Center. Foxes were observed in Walnut Canyon and at higher elevations where the road passes through the juniper peneplain. While driving the paved road at various times of the year, we observed most gray foxes in mid-spring (Fig. 41). Gray foxes also have been observed along Open Hollow Gulch and Bat Cave Draw, at Oak Spring, and in Slaughter, Yucca, and Double canyons (Fig. 69). Others have been sighted on the slope of

the escarpment, and museum specimens exist from Rattlesnake Canyon and Carlsbad Cavern.

On the seabed, gray foxes have been observed at mouths of large canyons and at Rattlesnake Springs. At Rattlesnake Springs, sightings occurred near the picnic area and in the woodlot, orchard, and horse pasture. Elevational records of *U. cinereoargenteus* in the park ranged from 1,105 m (3,625 ft) on the seabed at Rattlesnake Springs to 1,830 m (6,000 ft) on the reef in Open Hollow Gulch.

Reproduction. No information is available regarding reproductive biology of gray foxes in the park.

Taxonomic remarks. The subspecies of *Urocyon cinereoargenteus* in the park is *U. c.*

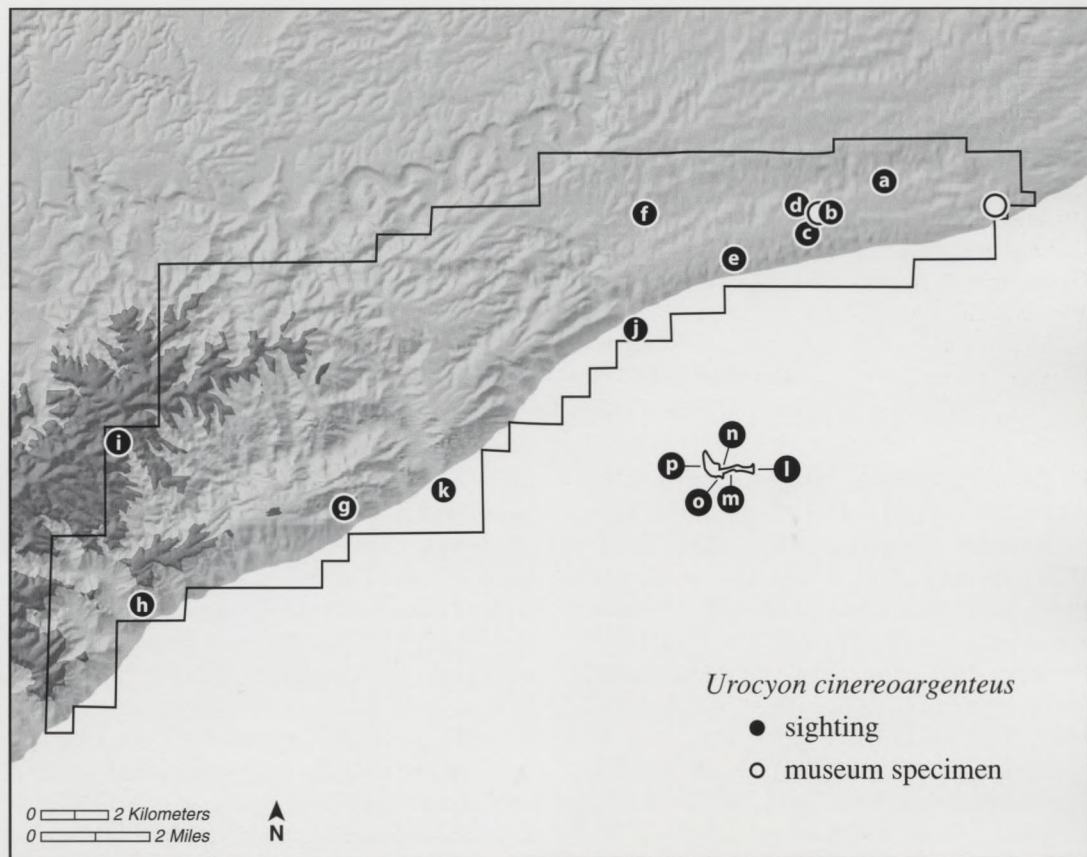


Fig. 69. Distribution of the common gray fox (*Urocyon cinereoargenteus*) in Carlsbad Caverns National Park, excluding most of our sightings along the paved road between Whites City and the Visitor Center. Letters in symbols correspond to italicized letters in *Additional records*.

scottii Mearns, 1891 based on the distribution reported in Hall (1981:944, map 495).

Museum specimens (total 5); Fig. 69:

- park entrance [Walnut Canyon] (CACA 1);
- Walnut Canyon Road (CACA 1) *not plotted*;
- Bat Cave, Carlsbad Cavern (KU 1);
- Rattlesnake Canyon (KU 2) *not plotted*.

Additional records (Fig. 69):

- Indian Shelter Exhibit in Walnut Canyon (sighting by KNG on 24 March 1991) *a*;
- east of amphitheater in Bat Cave Draw (sighting by KNG on 22 April 1991) *b*;
- near Carlsbad Cavern (Bailey 1928:95) *not plotted*;
- around Visitor Center (most recent sighting by KNG and KG was on 30 December 1998) *c*;
- Oak Spring (sighting by KNG on 1 September 1973) *d*;
- ravine of escarpment, 0.27 mi. SW Chimney Cave, T25S, R24E, NE ¼ Sec. 2 (sighting by D. M. Roemer on 7 October 1999) *e*;
- Walnut Canyon, 0.47 mi. E, 0.36 mi. N Lowe Spring, T24S, R24E, NE ¼ Sec. 33 (sighting by KNG on 23 May 1992) *f*;
- Slaughter Canyon (sighting by K. E. Kelly; date unknown) *not plotted*;
- Yucca Canyon (sighting by R. E. Reisch on 19 February 1962 and G. J. Emmons on 9 April 2000) *g*;
- ¼ mile up North Double Canyon [= Double Canyon] (sighting by C. M. Peterson on 7 February 1972) *h*;
- Open Hollow Gulch, T25S, R22E, NW ¼ Sec. 24 (observation of a dead fox by D. M. Roemer on 14 May 2000) *i*;
- on seabed near mouth of Rattlesnake Canyon, T25S, R24E, NE ¼ Sec. 9 (sighting by G. J. Emmons on 19 September 2000) *j*;
- on seabed at mouth of Slaughter Canyon, 0.27 mi. S, 0.42 mi. E Slaughter Canyon Cave, T25S, R23E, junction of Sections 24 and 25 (sighting by G. J. Emmons on 2 November 2000) *k*;
- near east entrance to Rattlesnake Springs, 0.64 mi. E, 0.11 mi. N Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (sighting by D. M. Roemer on 13 June 2000) *l*;
- next to picnic area at Rattlesnake Springs (sighting by B. D. Munyan in 1997 and D. M. Roemer on 4 June 2000) *m*;
- orchard near ranger station at Rattlesnake Springs (sighting by L. A. McWilliams on 23 August 1997 and D. M. Roemer on 1 May 2000) *n*;
- woodlot on east side of Rattlesnake Spring (sighting by D. M. Roemer on 15 August 1997) *o*;
- horse pasture at Rattlesnake Springs (sighting by D. M. Roemer on 23 February 2000) *p*.

Family Ursidae *Ursus americanus* Pallas, 1780 American Black Bear

Once abundant in the Guadalupe Mountains of New Mexico and Texas, black bears are now rare in this mountain range (Bailey 1931; Genoways *et al.* 1979). The most recent evidence of black bears in the park is based on feces observed in Open Hollow Gulch on 13 October 1999. The previous record of *U. americanus* in the park comes from a wildlife report filed by James C. McBride on 15 August 1992. KNG spoke to Mr. McBride about his experience a year later. While driving along the floor of Walnut Canyon on the Scenic Loop Drive, McBride discovered an adult female and her cub standing in the road at

0900 h. He stopped his car 12 m from the bears, and he commented that the female was "dark brown and appeared almost black." The bears were not alarmed, and eventually they walked slowly across the canyon floor and disappeared. Bailey (1928) observed bear tracks in a cave in Slaughter Canyon presently known as Window Cave. No museum specimen of *U. americanus* is known from the park.

Reproduction. Except for mention of "a cub" observed on 15 August, no information is available regarding reproductive biology of black bears in the park.

Taxonomic remarks. The subspecies of *Ursus americanus* in the park is *U. a.*

amblyceps Baird, 1859 based on the distribution reported in Hall (1981:950, map 497).

Additional records (not mapped):

- Walnut Canyon along the Scenic Loop Drive

(sighting of mother and cub by J. C. McBride on 15 August 1992);

- Window Cave in West Slaughter Canyon (tracks; Bailey 1928:54);
- Open Hollow Gulch, T25S, R22E, Sec. 24 (observation of feces by D. M. Roemer and R. J. [Beymer] West on 13 October 1999).

Family Procyonidae *Bassariscus astutus* (Lichtenstein, 1830) Ringtail

Although widespread in New Mexico, ringtails are most common in the southern half of the state (Findley *et al.* 1975). Because they live in rocky areas such as cliffs, outcroppings, and rock piles, it is not surprising that most records of ringtails in the park are from the reef; there is only one record from the lowlands (Fig. 70).

Through the years, we observed 157 ringtails, and except for six instances, each was seen along the paved road between Whites City and the Visitor Center. Most animals were observed in Walnut Canyon, but some were seen at higher elevations where the road passes through the juniper peneplain. While driving the paved road in the park at various times of the year, we observed most ringtails in late winter and early spring and fewest in midsummer (Fig. 41).

While netting bats, we observed ringtails in both the small and large openings of Carlsbad Cavern. Many ringtails also have been reported inside the cavern.

Bailey (1928) noted three poisoned ringtails lying in the entrance of Goat Cave in a side canyon of North Slaughter Canyon. Ringtails also have been observed on wooded summits near Putman Cabin at 1,965 m (6,450 ft). The only report of a ringtail from the lowlands comes from Rattlesnake Springs; an individual was observed at the base of a cottonwood next to the pump house (elevation 1,105 m or 3,630 ft).

Reproduction. No information is available regarding reproductive biology of ringtails in the park.

Taxonomic remarks. The subspecies of *Bassariscus astutus* in the park is *B. a. flavus* Rhoads, 1894 based on the distribution reported in Hall (1981:964, map 500).

Museum specimens (total 8); Fig. 70:

- Walnut Canyon (MSB 1) *not plotted*;
- Carlsbad Cavern National Park, ca. 5.5 mi. NW Whites City, Walnut Canyon Rd. (UTEP 1) *not plotted*;
- Carlsbad Cave [in Walnut Canyon] (USNM 1) *not plotted*;
- Carlsbad Cave [inside Carlsbad Cavern] (USNM 1) *see b in Additional records*;
- Headquarters Area [0.10 mi. W of large natural opening of Carlsbad Cavern] (CACA 1);
- Slaughter Canyon [poisoned at entrance to Goat Cave; Bailey (1928:127, fig. 47) referred to Goat Cave as "Slaughter Cave in Slaughter Canyon." Actually, Goat Cave is in a side canyon of North Slaughter Canyon, T25S, R23E, SE ¼ Sec. 11] (USNM 1);
- 25 mi. SW Carlsbad, T25S, R24E, Sec. 6 (MSB 1) *not plotted*;
- Carlsbad Caverns National Park (MSB 1) *not plotted*.

Additional records (Fig. 70):

- Walnut Canyon (most recent sighting by KNG and KG was on 20 October 2000) *not plotted*;
- small natural opening of Carlsbad Cavern (sighting by KNG on 15 July 1997) *a*;
- large natural opening of Carlsbad Cavern (most recent sighting by KNG and KG was on 8 July 1999) *b*;
- Bat Cave in Carlsbad Cavern (sighting by J. M. Richards in May 1998) *b*;

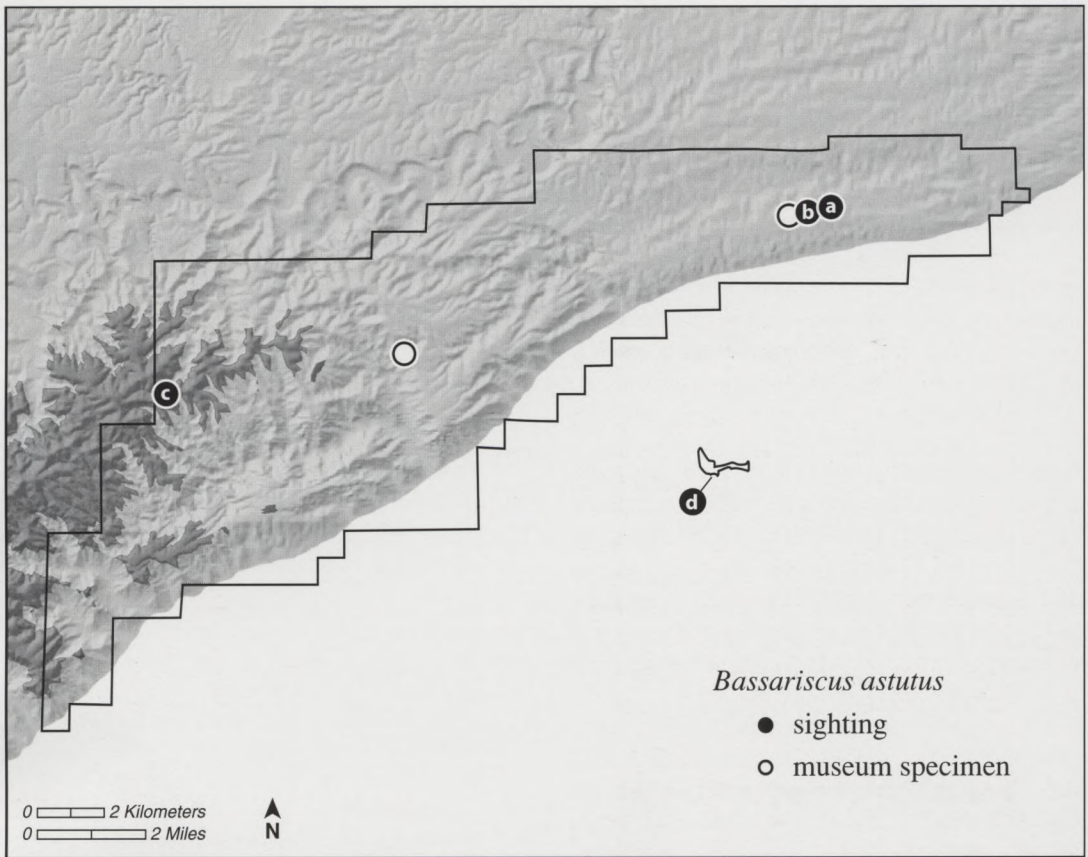


Fig. 70. Distribution of the ringtail (*Bassariscus astutus*) in Carlsbad Caverns National Park, excluding our many sightings along the paved road between Whites City and the Visitor Center. Letters in symbols correspond to italicized letters in *Additional records*. Letter *b* includes all records inside Carlsbad Cavern.

- Lunch Room in Carlsbad Cavern (sighting by J. M. Richards in May 1998) *b*;
- Pickle Alley [adjacent to Lunch Room in Carlsbad Cavern] (sighting by H. F. Ballard in 1957) *b*;
- between Hall of Giants and Headless Statue in Big Room of Carlsbad Cavern (sighting by D. Standiford on 3 January 1963) *b*;
- between Rock of Ages and Painted Grotto in Big Room of Carlsbad Cavern (sighting by R. W. Reaves III on 26 January 1964) *b*;
- Doll Theater [between Jim White Tunnel and Painted Grotto in Big Room of Carlsbad Cavern] (sighting by R. W. Reaves III on 21 July 1964 and J. F. Martin on 13 October 1964) *b*;
- near Hall of Giants [area of Twin Domes and Giant Dome in Big Room of Carlsbad Cavern] (sighting by W. C. Birdsell on 23 October 1964) *b*;
- Green Lake Room in Carlsbad Cavern (sighting by J. L. Massey and J. F. Haman in January 1965) *b*;
- King's Palace in Carlsbad Cavern (sighting by M. S. Mayer in January 1965) *b*;
- Whale's Mouth in Main Corridor of Carlsbad Cavern (sighting by R. W. Reaves III in 1965) *b*;
- Boneyard in Carlsbad Cavern (sighting by T. J. Speer in 1965) *b*;
- Devil's Den in Carlsbad Cavern (sighting by S. E. Cowles in 1969) *b*;
- Big Room in Carlsbad Cavern (sighting by H. L. Parent in 1971) *b*;
- between Devil's Den and Whale's Mouth in Main Corridor of Carlsbad Cavern (sighting by P. L. Jablonsky on 29 March 1995) *b*;
- storage shed next to Putman Cabin (sighting by K. E. Kelly in early 1990s) *c*;
- next to pump house at Rattlesnake Springs (sighting by B. D. Munyan in spring 1997) *d*.

Procyon lotor (Linnaeus, 1758) Northern Raccoon

In New Mexico, raccoons are most common near permanent bodies of water (Findley *et al.* 1975). According to Bailey (1928), raccoons lived along the Black and Pecos rivers in the early 1920s, but they rarely were observed in the vicinity of Carlsbad Cavern. In contrast, raccoons were common and the most frequently observed carnivore on the reef in the 1970s due to their foraging behavior in and around trash cans located along Walnut Canyon and near the Visitor Center, residences, and main entrance to Carlsbad Cavern. It was common at night to see several raccoons around each trash can near the Visitor Center. In the mid-1980s, the National Park Service replaced trash cans with ones that were "raccoon proof" (Fig. 71). Since then, fewer raccoons are seen on the reef. From mid-winter to midsummer in 1991, we observed

most raccoons in late winter and early spring and fewest in midwinter (Fig. 41).

Raccoons sometimes forage for fallen bats under the maternity roost of Brazilian free-tailed bats (*T. brasiliensis*) in Bat Cave of Carlsbad Cavern. For example, at least three different individuals took advantage of this convenient source of food during the bats' birthing period in 1976. Raccoons also have been observed in the King's Palace, Main Corridor, and large natural opening of the cavern (Fig. 72).

Because raccoons occupy areas with permanent water nearby, they probably have always been common at Rattlesnake Springs. On 12 March, KNG captured an adult along the stream near the picnic area (Fig. 72); the live-trap was placed in a well-formed run in grasses adjacent to the bank. Raccoons also frequented the woodlots.

Reproduction. No information is available regarding reproductive biology of raccoons in the park.

Taxonomic remarks. The subspecies of *Procyon lotor* in the park is *P. l. mexicanus* Baird, 1857 based on the distribution reported in Hall (1981:971, map 502).

Museum specimens (total 3); Fig. 72:

- Walnut Canyon (CACA 1) not plotted;
- Headquarters Area [0.10 mi. W of large natural opening of Carlsbad Cavern] (CACA 1);
- 0.17 mi. N Visitor Center, T24S, R24E, NE ¼ Sec. 36 (CACA 1).

Additional records (Fig. 72):

- large natural opening of Carlsbad Cavern (most recent sighting by KNG and KG was on 8 July 1999) a;
- Bat Cave in Carlsbad Cavern (observations by KNG from 22 June to 23 July 1976) a;
- King's Palace in Carlsbad Cavern (sighting by C. J. Dillon on 20 October 1980) a;
- Iceberg Rock in Main Corridor of Carlsbad Cavern (sighting by E. J. Buehler on 21 September 1982 and L. Villalva on 6 January 1984) a;
- near Visitor Center (most recent sighting by KNG and KG was on 17 August 1990) b;



Fig. 71. A "raccoon-proof" trash can in Walnut Canyon (photograph taken July 1995).

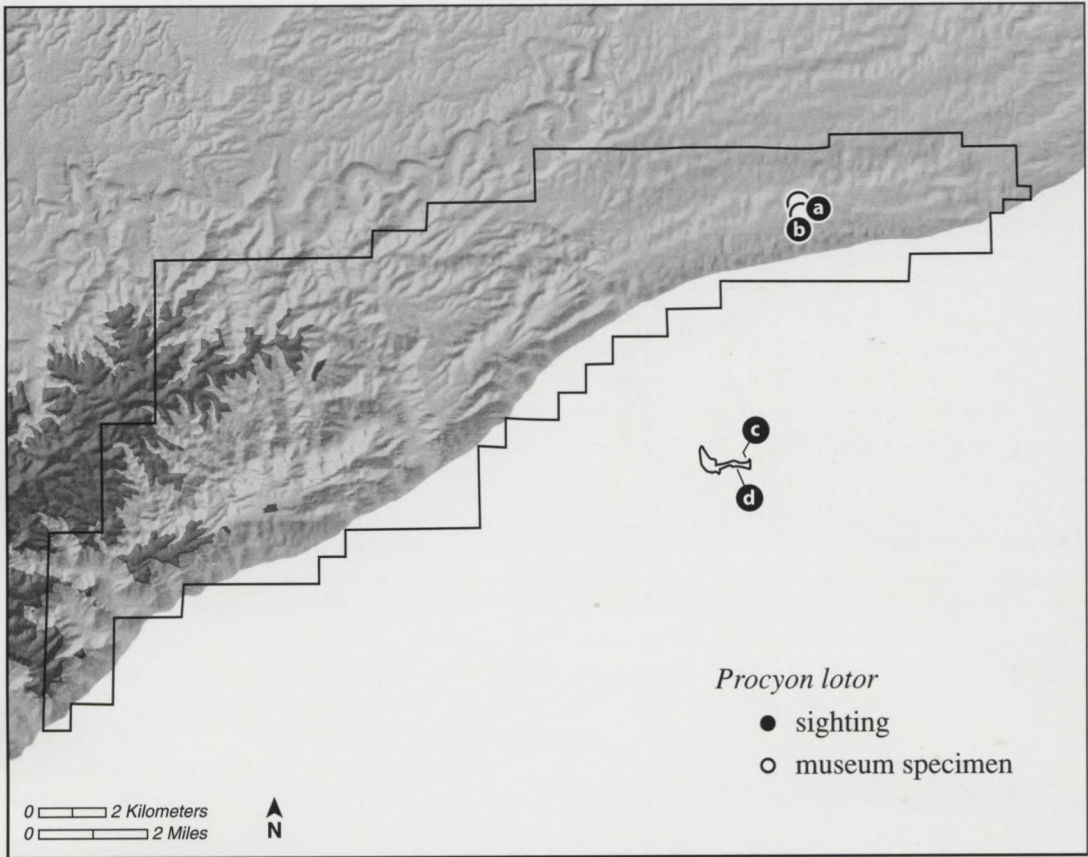


Fig. 72. Distribution of the northern raccoon (*Procyon lotor*) in Carlsbad Caverns National Park, excluding our many sightings along the paved road between Whites City and the Visitor Center. Letters in symbols correspond to italicized letters in *Additional records*. Letter *a* includes all records inside Carlsbad Cavern.

- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (sighting by D. M. Roemer on 10 May 2000) *c*;
- near the picnic area at Rattlesnake Springs (captured and released by KING on 12 March 1991) *d*.

Family Mustelidae
***Mustela frenata* Lichtenstein, 1831**
Long-tailed Weasel

Long-tailed weasels live in a wide variety of habitats, and in New Mexico, records exist from low elevations along the Rio Grande and Pecos River valleys to high elevations in the Sangre de Cristo Mountains (Findley *et al.* 1975). In the park, long-tailed weasels have been documented on the seabed and reef (Fig. 73).

On 13 August 1991, KING observed a long-tailed weasel at Rattlesnake Springs at 1340 h. An adult was standing on a metal rail of a cattle guard at the east entrance to the property. The individual ducked under the rails, but when it reappeared its masked facial pattern was evident. The surrounding area consisted of fields comprised of forbs and

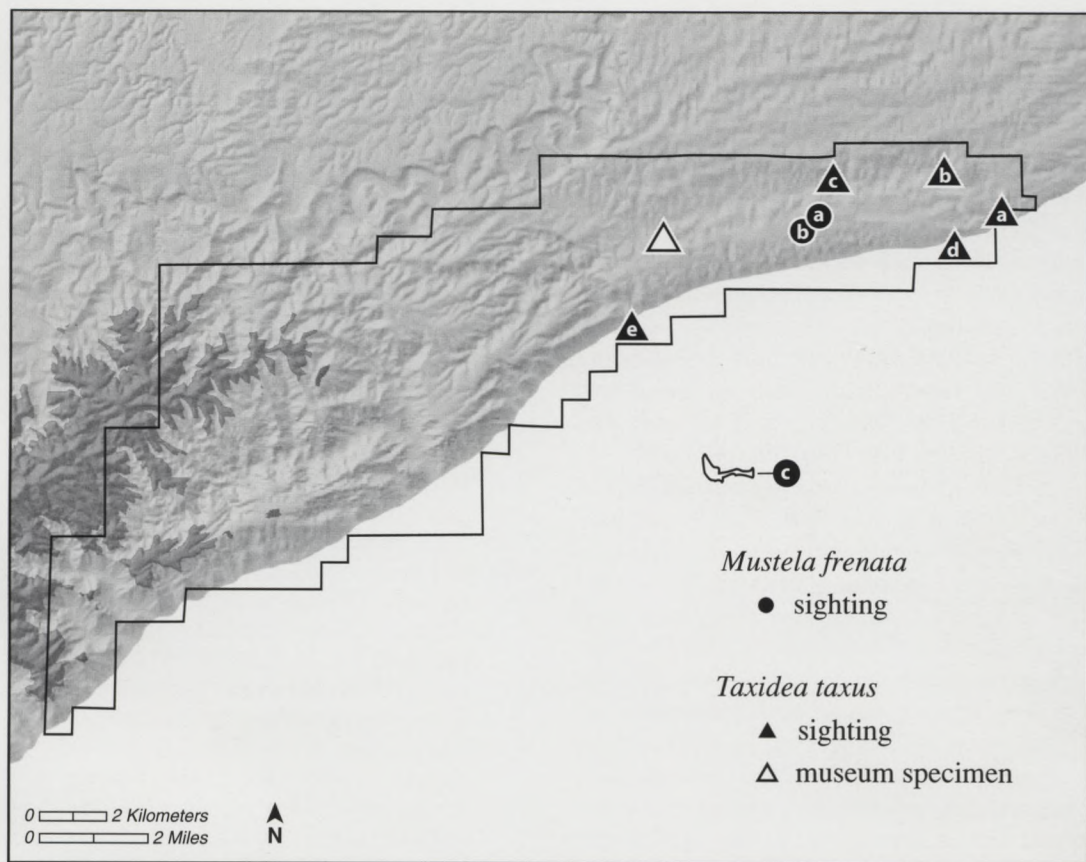


Fig. 73. Distribution of the long-tailed weasel (*Mustela frenata*) and American badger (*Taxidea taxus*) in Carlsbad Caverns National Park. Letters in symbols correspond to italicized letters in *Additional records*.

grasses. Some trees were present along the fence that separated the park from private land. Elevation at the cattle guard was 1,105 m (3,620 ft).

Weasels also have been observed and captured on the reef near Carlsbad Cavern (Bailey 1928). Recent sightings in this area occurred in March 1976, January 1980, and July 1995. A long-tailed weasel also was observed in Walnut Canyon in May 1983. No museum specimen exists from the park.

Reproduction. No information is available regarding reproductive biology of long-tailed weasels in the park.

Taxonomic remarks. The subspecies of *Mustela frenata* in the park is *M. f. neomexicana* (Barber and Cockerell, 1898) based on the masked facial pattern observed at Rattlesnake Springs (see Findley *et al.*

1975:305) and on the distribution reported in Hall (1981:996, map 511).

Additional records (Fig. 73):

- Walnut Canyon (sighting by R. W. Parsons on 6 May 1983) *not plotted*;
- near Carlsbad Cavern (Bailey 1928:97) *a*;
- Bat Cave Draw near large natural opening of Carlsbad Cavern (sighting by A. H. Burgess on 15 July 1995) *a*;
- cactus garden near large natural opening of Carlsbad Cavern (sighting by H. L. Parent on 29 March 1976) *a*;
- near bridge on trail between the Visitor Center and large natural opening of Carlsbad Cavern; the bridge goes over Bat Cave Draw (sighting by T. B. Bemis on 9 January 1980) *b*;
- cattle guard at east entrance to Rattlesnake Springs (sighting by KING on 13 August 1991) *c*.

***Taxidea taxus* (Schreber, 1777)
American Badger**

In New Mexico, badgers occur in all types of open habitats including lowland deserts and alpine meadows, but they are most common in grasslands (Findley *et al.* 1975; Findley 1987). In lowlands around the park, Bailey (1928) stated that badgers were fairly common in the Black River and Pecos River valleys, particularly around prairie-dog towns. At the park, we are aware of two records from the lowlands and a handful of records from the reef (Fig. 73).

A badger was seen at the mouth of Rattlesnake Canyon in November 1969, and one was observed along the gravel road leading to the Sewage Disposal Ponds in November 1970. A report from March 1965 documented an individual at the entrance to Rattlesnake Springs; however, it is unclear if the sighting of this individual was on park property.

All records of badgers on the reef are from the floor of Walnut Canyon. In 1990, KG discovered a cranium next to a narrow creek bed at an elevation of 1,330 m (4,360 ft). Sightings of living animals occurred in August 1982 at 1,160 m (3,800 ft), in July 1989 at 1,235 m (4,060 ft), and in March 1992 at 1,120 m (3,680 ft).

Reproduction. No information is available regarding reproductive biology of badgers in the park.

Taxonomic remarks. The subspecies of *Taxidea taxus* in the park is *T. t. berlandieri* Baird, 1857 based on the distribution reported in Hall (1981:1012, map 517).

Museum specimens (total 1); Fig. 73:

- Exhibit #13 on Scenic Loop Road, T24S, R24E, W ½ Sec. 34 [in Walnut Canyon; cranium only] (MSB 1).

Additional records (Fig. 73):

- Walnut Canyon, T24S, R25E, NE ¼ Sec. 34 (sighting by T. C. Stubbs on 27 March 1992) a;
- Chihuahuan Desert Exhibit in Walnut Canyon, 1.08 mi. N, 1.35 mi. W Whites City, T24S, R25E, N ½ Sec. 28 (sighting by J. Whitworth on 20 August 1982) b;
- Walnut Canyon, T24S, R25E, NW ¼ Sec. 30 (sighting by D. A. Ek in July 1989) c;
- gravel road between Sewage Disposal Ponds and park's entrance SW of Whites City; sighting in S ½ Sec. 33, T24S, R25E (sighting by P. F. Van Cleave on 24 November 1970) d;
- on seabed at mouth of Rattlesnake Canyon, T25S, R24E, NE ¼ Sec. 9 (sighting by N. R. Bullington on 22 November 1969) e.

**Family Mephitidae
Conepatus leuconotus (Lichtenstein, 1832)
White-backed Hog-nosed Skunk**

In New Mexico, white-backed hog-nosed skunks are most common in deserts, grasslands, and woodlands in southern parts of the state (Findley *et al.* 1975). In the park, records are available only from the reef. Most of our sightings of hog-nosed skunks were along the floor of Walnut Canyon, but KNG observed one in Bat Cave Draw and collected a dead individual in the juniper peneplain (Fig. 74). Hog-nosed skunks also have been observed by others in Lechuguilla Canyon, North Slaughter Canyon, and Open Hollow Gulch. The highest record occurred on the floor of Open Hollow Gulch at 1,805 m (5,920 ft).

Although no record of *C. leuconotus* exists from the seabed within park boundaries, KNG observed a dead individual in lowlands outside the park near Whites City. Certainly this species also occurs in habitats of the park along the base of the escarpment. Thus far, the only species of skunk observed at Rattlesnake Springs has been the striped skunk (*Mephitis mephitis*).

Reproduction. We observed a juvenile *C. leuconotus* (about a fifth the size of an adult) on 23 June 1974 and another (about ½ size of an adult) on 18 May 1992. Both observations occurred along Walnut Canyon.

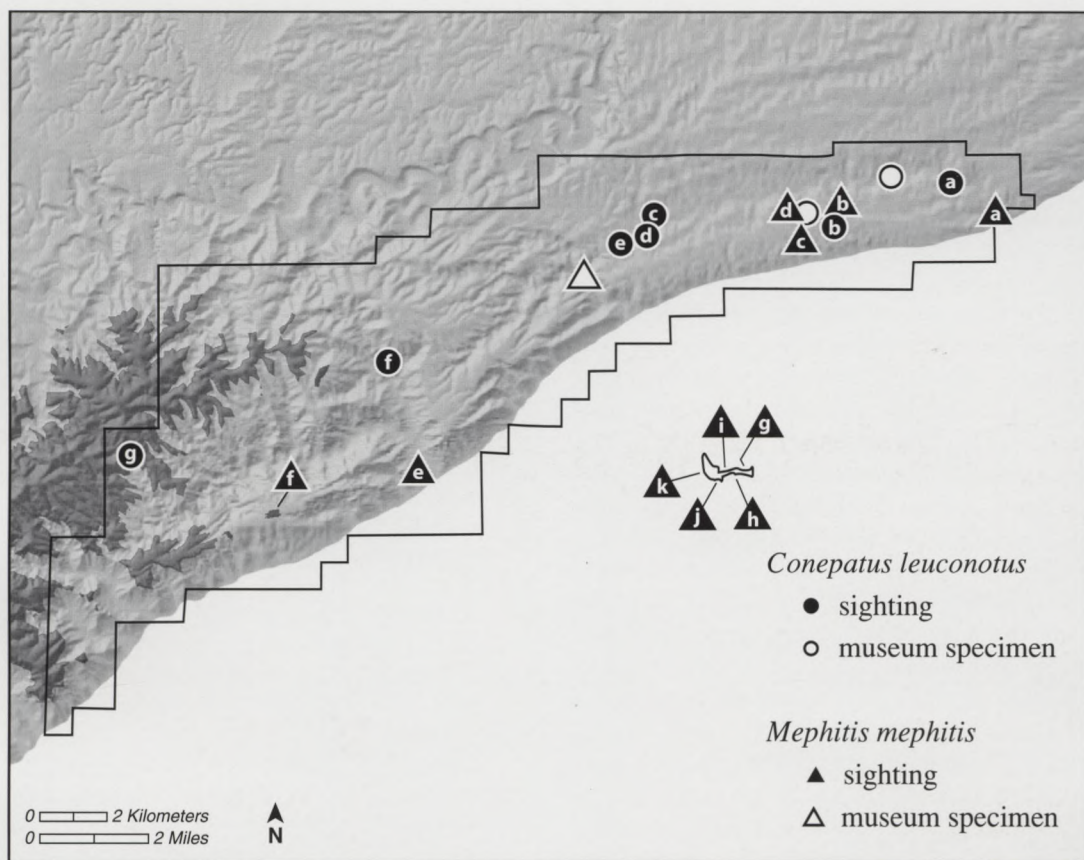


Fig. 74. Distribution of the white-backed hog-nosed skunk (*Conepatus leuconotus*) and striped skunk (*Mephitis mephitis*) in Carlsbad Caverns National Park, excluding most of our sightings along the paved road between Whites City and the Visitor Center. Letters in symbols correspond to italicized letters in *Additional records*.

Taxonomic remarks. The subspecies of *Conepatus leuconotus* in the park is *C. l. leuconotus* (Lichtenstein, 1832) based on the taxonomic revision by Dragoo *et al.* (2003). The white-backed hog-nosed skunk was formerly recognized as two species, *C. leuconotus* and *C. mesoleucus*.

Museum specimens (total 5); Fig. 74:

- Walnut Canyon (MSB 1) *not plotted*;
- Carlsbad Cave [in Walnut Canyon] (USNM 1) *not plotted*;
- 2.25 mi. W, 0.99 mi. N Whites City, T24S, R25E, NE ¼ Sec. 29 [in Walnut Canyon] (MSB 1);
- 0.17 mi. N Visitor Center, T24S, R24E, NE ¼ Sec. 36 [in juniper peneplain near residential area] (MSB 1);
- Carlsbad Cave (USNM 1) *not plotted*.

Additional records (Fig. 74):

- Walnut Canyon, 1.14 mi. W, 0.92 mi. N Whites City, T24S, R25E, NE ¼ Sec. 28 (sighting by D. M. Roemer on 10 November 2000) *a*;
- Bat Cave Draw, near small natural opening of Carlsbad Cavern (sighting by KNG on 21 June 1974) *b*;
- Lechuguilla Canyon, T24S, R24E, NE corner of Sec. 33 (sighting by G. J. Emmons on 21 October 2000) *c*;
- Walnut Canyon, 0.11 mi. N, 0.40 mi. E Lowe Spring, T24S, R24E, E ½ Sec. 33 (sighting by KNG and KG on 29 December 1998) *d*;
- next to Lowe Spring, T24S, R24E, near center of Sec. 33 (sighting by G. J. Emmons on 24 September 2000) *e*;
- next to Slaughter Pothole in North Slaughter Canyon, 0.08 mi. N, 0.34 mi. W Goat Cave, T25S, R23E, SW ¼ Sec. 11 (sighting by G. J. Emmons on 20 October 2000) *f*;
- floor of Open Hollow Gulch, T25S, R22E, near center of Sec. 24 (sighting by D. M. Roemer on 29 May 1998) *g*.

***Mephitis mephitis* (Schreber, 1776)**
Striped Skunk

In New Mexico, the striped skunk occurs at all elevations and in all habitats (Findley 1987). In the park, we observed this species from lowlands of the seabed at Rattlesnake Springs to wooded knolls on summits of the reef (Fig. 74).

On the seabed, we regularly observed striped skunks at Rattlesnake Springs. We recorded individuals in the picnic area, grassy fields, and shrubby area dominated by mesquite. They also have been observed in the horse pasture, in the woodlot next to the storage pond, and on the lawn of the ranger station. Although lowland records of *M. mephitis* are known only from Rattlesnake Springs, this species surely occurs in other habitats along the base of the escarpment. Thus far, the striped skunk has been the only species of skunk reported at Rattlesnake Springs.

On the reef, we observed striped skunks from the lowest elevations (desert-scrub area in Walnut Canyon) to one of the highest summits (knoll of Yucca Cabin containing ponderosa pine, pinyon pine, and alligator juniper; elevation 1,830 m or 6,000 ft). Most of our sightings on the reef occurred along the road between Whites City and the Visitor Center where we observed individuals on the floor of Walnut Canyon and in the juniper penepplain. During our many trips along this road, we documented more *M. mephitis* than *C. leucurus* (29 compared to 19). Other records of striped skunks in the park include a specimen from Rattlesnake Canyon and observations of individuals at Oak Spring and along Slaughter Canyon.

Reproduction. We observed young striped skunks (about ½ size of an adult) on two occasions along Walnut Canyon. One pair

was seen on 3 August 1996, and another pair was accompanied by an adult on 16 July 1997.

Taxonomic remarks. The subspecies of *Mephitis mephitis* in the park is *M. m. varians* Gray, 1837 based on the distribution reported in Hall (1981:1021, map 519).

Museum specimens (total 1); Fig. 74:

- 1.5 mi. up Rattlesnake Canyon, 30 mi. SW Carlsbad (KU 1).

Additional records (Fig. 74):

- Walnut Canyon, desert-scrub area near entrance of park at Whites City (sighting by KNG on 6 July 1995) a;
- 0.43 mi. N, 0.70 mi. E Visitor Center, T24S, R25E, SE ¼ Sec. 30 (sighting by KNG on 23 October 1999) b;
- near Visitor Center (most recent sighting by KNG and KG was on 30 December 1998) c;
- Oak Spring, T24S, R24E, NE ¼ Sec. 36 (sighting by L. E. Parent on 6 October 1974) d;
- below New Cave in Slaughter Canyon [New Cave = Slaughter Canyon Cave] (sighting by J. K. Baker in March 1959) e;
- knoll of Yucca Cabin, T25S, R23E, W ½ Sec. 28 (sighting by KG on 23 July 1991) f;
- 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23 (sighting by KNG on 18 March 1995) g;
- picnic area and adjacent field at Rattlesnake Springs (most recent sighting by KNG and KG was on 19 March 1995) h;
- next to ranger station at Rattlesnake Springs (sighting by KNG on 7 October 1995 and D. M. Roemer on 12 April and 8 May 2000) i;
- woodlot next to Rattlesnake Spring (sighting by D. M. Roemer on 6 June 2000) j;
- horse pasture at Rattlesnake Springs (sighting by K. E. Kelly, date unknown) k.

***Spilogale gracilis* Merriam, 1890**
Western Spotted Skunk

The western spotted skunk occurs throughout New Mexico and is most often associated with rocky and brushy areas, espe-

cially in deserts, grasslands, and woodlands (Findley *et al.* 1975). At the park, Bailey (1928) captured a spotted skunk in the large

opening of Carlsbad Cavern and kept it as a pet for a while. Another individual was observed in the residential area near Carlsbad Cavern in 1946. In the 1950s, three spotted skunks were trapped in Walnut Canyon (D. G. Constantine *pers. comm.*), and they were used in experiments concerning transmission of rabies from bats to carnivores (Constantine *et al.* 1968). In 1985, a dead spotted skunk was reported along Walnut Canyon, and this individual represents the most recent record of this species in the park. In the 1990s, we attempted to capture spotted skunks by placing live-traps in culverts and on rock walls along Walnut Canyon, but we captured only ring-tails.

Although no museum specimen of *S. gracilis* exists from the park, Bailey (1928) published a photograph of one standing on a rock ledge "at the doorway of the Carlsbad Cavern." The paucity of records of spotted skunks in the park may be a result of their secretive

habits rather than a true reflection of abundance (Verts and Carraway 1998).

Reproduction. No information is available regarding reproductive biology of western spotted skunks in the park.

Taxonomic remarks. The subspecies of *Spilogale gracilis* in the park is *S. g. leucoparia* Merriam, 1890 based on the distribution reported in Hall (1981:1016, map 518).

Additional records (not mapped):

- Walnut Canyon (three individuals trapped by D. G. Constantine from 1955 to 1958; two individuals observed by L. N. Locke on 1 November 1957; and one dead individual observed by G. M. Stolz on 21 June 1985);
- in storehouse near one of the guano shafts in Bat Cave Draw (Bailey 1928:102);
- large natural opening of Carlsbad Cavern (photograph, Bailey 1928:100);
- residential area near park headquarters (sighting by B. T. Gale in June 1946).

Family Felidae

Puma concolor (Linnaeus, 1771)

Puma or Mountain Lion

Except for the eastern plains, pumas occur throughout New Mexico, especially in mountainous areas (Findley 1987). Based on radiotracking studies, censuses, and sightings, the Guadalupe Mountains appear to be one of the strongholds for this species in the state.

From 1982 to 1985, the National Park Service funded an ecological study of pumas in the Guadalupe Mountains of New Mexico and Texas (Smith *et al.* 1986). The study area encompassed 1,036 km² (400 mi²) and included Carlsbad Caverns and Guadalupe Mountains national parks. During the three-year study, 22 pumas were radiocollared and monitored, and 11 had home ranges within parts of Carlsbad Caverns National Park. Average home range of adult males was 207 km² (80 mi²) and of adult females, 59 km² (23 mi²). Investigators estimated that a maximum of 58 pumas (24 adults, 12 subadults, and 22 kittens) occupied the study area at any one time.

The National Park Service continues to monitor pumas in Carlsbad Caverns National Park by searching for scat, tracks, and scraps along a transect that was established in 1987. The curvilinear transect is 76 km in length and is walked twice a year; 98% of the transect lies on the reef. Analyses of data obtained from 1987 to 1996 showed no change in size of the population of pumas in the park during the nine-year period (Harveson *et al.* 1999).

Although direct observations of these large cats have been few through the years, sightings have become somewhat regular in the past decade, especially along Walnut Canyon (Fig. 75). Besides Walnut Canyon, recent observations on the reef include those around the park's housing area, near Spider Cave Seep, and inside Midnight Goat Cave. In 1993, a complete skeleton was discovered in Lefthook Canyon. The park's museum has a skull of a young puma collected near Cueva

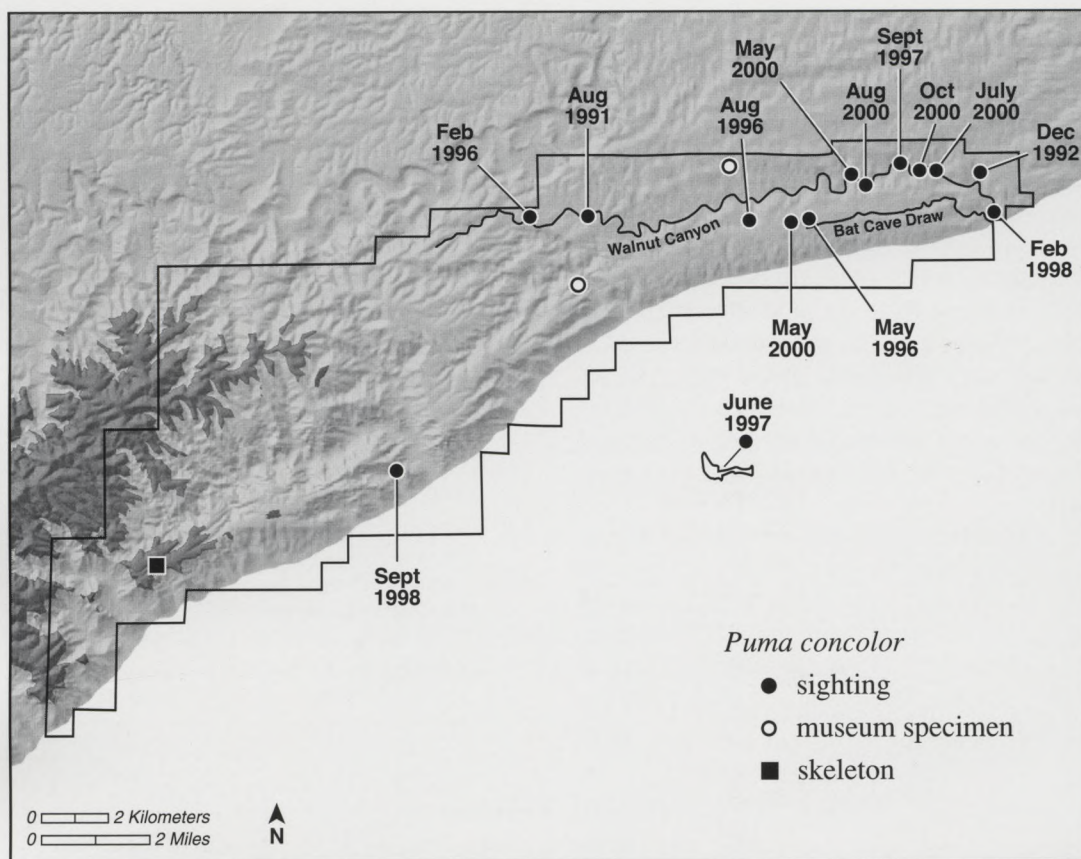


Fig. 75. Distribution of the puma (*Puma concolor*) in Carlsbad Caverns National Park based on recent sightings (1991-2000), museum specimens collected in 1987 and 1998, and a skeleton discovered in 1993. Dates on map correspond to dates in *Additional records*.

de León and of an adult collected at Stone Spring. Bailey (1928) mentioned that a puma was killed in the mouth of Carlsbad Cavern in the 1920s. Records of pumas also are available from the seabed at Rattlesnake Springs. An individual was observed near the orchard in 1997, and fresh tracks were observed between the metal barn and shooting range in 2000.

Food habits. Examination of fecal material of pumas indicates that their main food item in the Guadalupe Mountains is mule deer (*Odocoileus hemionus*; Smith *et al.* 1986). Remains of deer occurred in 82% of the scats, while 15% contained remains of porcupines (*Erethizon dorsatum*), 7% rabbits, 6% domestic sheep (*Ovis aries*), 3% rodents, 2% cattle (*Bos taurus*), and 1% domestic goats (*Capra hircus*). Traces of raccoons (*Procyon lotor*), gray foxes (*Urocyon cinereoargenteus*), aoudads (*Ammotra-*

gus lervia), and elk (*Cervus canadensis*) also were found in scat. In the early 1990s, D. A. Ek (*pers. comm.*) came upon a dead aoudad between Slaughter and Midnight canyons after following a trail of blood and tracks of a puma. Reports of fresh kills by pumas in 2000 include an aoudad and mule deer in Lechuguilla Canyon and a mule deer at Oak Spring (D. M. Roemer *pers. comm.*).

Reproduction. Of 22 pumas radio-collared by Smith *et al.* (1986) in the Guadalupe Mountains, four were "kittens." Kittens were captured on 29 March (female; body mass 20 kg), 21 October (male; 19 kg), 11 November (male; 19 kg), and 16 November (female; 15 kg). All kittens were estimated to be five months old, and the latter three kittens had home ranges within boundaries of Carlsbad Caverns National Park. In the Guadalupe Mountains, litter size ranged from

one to three kittens with an average of two kittens per litter (Smith *et al.* 1986). These data were based on five litters with kittens from five to seven months old.

Taxonomic remarks. The line of demarcation between *Puma concolor azteca* (Merriam, 1901) and *P. c. stanleyana* (Goldman, 1938) is close to Carlsbad Caverns National Park (Hall 1981:1042, map 525). We did not assign a subspecific name to specimens from the park. A specimen from Queen, New Mexico (8.9 km from the park) was assigned *P. c. azteca* by Goldman (1946).

Museum specimens (total 2); Fig. 75:

- near Cueva de León [T24S, R24E, N ½ Sec. 26, in side canyon of Walnut Canyon; skull collected in 1987] (CACA 1);
- Stone Spring, T25S, R24E, E ½ Sec. 5 [skull collected on 16 June 1998] (CACA 1).

Additional records (Fig. 75):

- maps showing 11 home ranges based on radiotracking (Smith *et al.* 1986) *not plotted*;
- Walnut Canyon, 100 yards inside park entrance at Whites City, T24S, R25E, NE ¼ Sec. 34 (sighting by B. D. Munyan on 17 February 1998);
- Walnut Canyon, T24S, R25E, NW ¼ Sec. 27 (sighting by B. Stubbs on 27 December 1992);
- Walnut Canyon, 1.52 mi. W, 1.14 mi. N Whites City, T24S, R25E, NW ¼ Sec. 28 (sighting by J. Cwiklik on 8 July 2000);
- Walnut Canyon, 1.70 mi. W, 1.17 mi. N Whites City, T24S, R25E, NW ¼ Sec. 28 (sighting by D. L. Pate and P. Bauer on 11 October 2000);

- Walnut Canyon, T24S, R25E, NE ¼ Sec. 29 (sighting by G. W. Vequist and S. Vequist in September 1997);
- Walnut Canyon, 2.70 mi. W, 0.79 mi. N Whites City, T24S, R25E, SW ¼ Sec. 29 (sighting by D. M. Roemer on 5 August 2000);
- Walnut Canyon, 2.88 mi. W, 0.87 mi. N Whites City, T24S, R25E, E ½ Sec. 30 (sighting by D. M. Roemer on 1 May 2000);
- large natural opening of Carlsbad Cavern (Bailey 1928:93) *not plotted*;
- near park's residential area, T24S, R24E, NE ¼ Sec. 36 (sighting by T. B. Bemis on 13 May 1996);
- start of Scenic Loop Drive, 0.10 mi. N, 0.23 mi. W Visitor Center, T24S, R24E, NE ¼ Sec. 36 (sighting by P. Burger on 15 May 2000);
- near Spider Cave, T24S, R24E, NE ¼ Sec. 35 (sighting by D. L. Pate on 26 August 1996);
- T24S, R24E, NE ¼ Sec. 32 [just west of parking lot for Lechuguilla Cave] (sighting by R. D. Kieffe on 6 August 1991);
- upper Walnut Canyon, T24S, R24E, NE ¼ Sec. 31 (sighting by P. D. Mulligan on 16 February 1996);
- inside Midnight Goat Cave in Midnight Canyon, T25S, R23E, SW ¼ Sec. 23 (sighting by G. Roemer on 7 September 1998);
- upper portion of Lefthook Canyon (skeleton discovered by J. Cronk in 1993; skeleton was photographed and bones were left in canyon);
- Rattlesnake Springs, near orchard (sighting by C. Munyan on 1 June 1997);
- Rattlesnake Springs, between metal barn and shooting range (observation of fresh tracks by D. M. Roemer on 19 May 2000) *not plotted*.

Lynx rufus (Schreber, 1777) Bobcat

Bobcats are widespread in New Mexico and are most common in areas of rough, rocky terrain (Findley *et al.* 1975; Findley 1987). At the park, bobcats are seldom observed, but recent sightings indicate that they occur on the seabed and reef (Fig. 76). In January 1996, a bobcat was observed on two consecutive days in a plum thicket near the center of Rattlesnake Springs. Investigation of the thicket revealed remains of two mule deer (*Odocoileus hemionus*)—a doe and a young individual. Both carcasses were fresh, to-

gether in a single pile, and sparsely covered with leaves and sticks. Remains of carcasses were consistent with the feeding pattern of a felid. Another bobcat was observed at Rattlesnake Springs on 23 November 1999; this sighting occurred near the picnic area.

In addition to sightings of bobcats on the seabed at Rattlesnake Springs, recent sightings on the reef include Walnut Canyon in 1995 and near the Visitor Center in 1994. Specimens also are available from Bat Cave Draw and Rattlesnake Canyon. Bailey (1928)

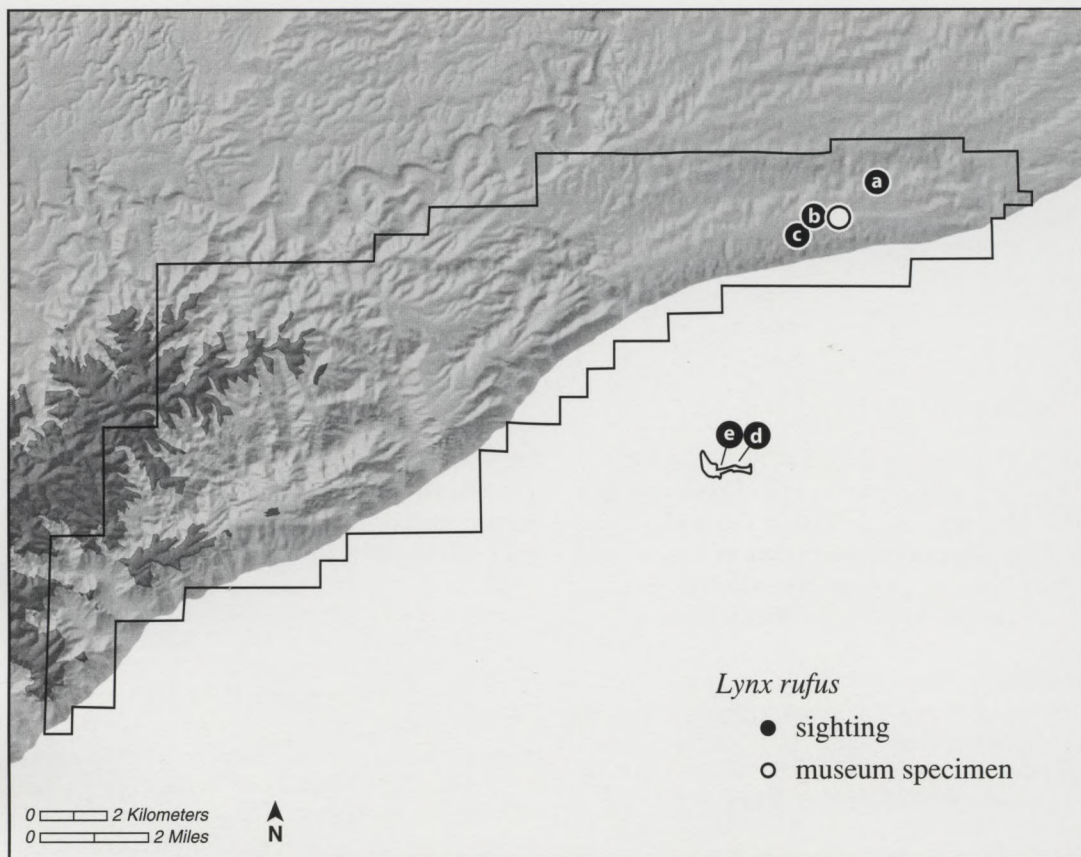


Fig. 76. Distribution of the bobcat (*Lynx rufus*) in Carlsbad Caverns National Park. Letters in symbols correspond to italicized letters in *Additional records*.

reported bobcats in the large opening of Carlsbad Cavern.

Reproduction. No information is available regarding reproductive biology of bobcats in the park.

Taxonomic remarks. The subspecies of *Lynx rufus* in the park is *L. r. texensis* J. A. Allen, 1895 based on the taxonomic study of bobcats in Texas and surrounding states by Schmidly and Read (1986).

Museum specimens (total 2); Fig. 76:

- ½ mile E Cavern entrance [in Bat Cave Draw] (CACA 1);
- Rattlesnake Canyon (KU 1) *not plotted*.

Additional records (Fig. 76):

- Walnut Canyon (sighting by T. F. Ela, R. W. Munck, and C. D. Wyatt on 26 February 1960 and W. C. Birdsell on 12 May 1961) *not plotted*;

- Indian Shelter Exhibit in Walnut Canyon, T24S, R25E, SW ¼ Sec. 29 (sighting by W. T. Route and C. A. Skubiszewski in December 1995) *a*;
- large natural opening of Carlsbad Cavern (Bailey 1928:94) *b*;
- near Visitor Center (sighting by M. Emken on 20 February 1994) *c*;
- near picnic area at Rattlesnake Springs (sighting by D. M. Roemer on 23 November 1999) *d*;
- Rattlesnake Springs, east of orchard in a stand of soapberries (sighting by K. E. Kelly on 24 December 1991) *e*;
- Rattlesnake Springs, east of orchard in thicket of plums (sighting by B. D. Munyan on 23 and 24 January 1996) *e*.

Order Artiodactyla
Family Tayassuidae
Pecari tajacu (Linnaeus, 1758)
Collared Peccary

In New Mexico, collared peccaries are most common in southwestern and southeastern parts of the state where they occupy desert-scrub communities, rocky and brushy foothills, streambeds, and river valleys (Findley 1987). At one time, peccaries were common east of the Pecos River in southeastern New Mexico, but this population was drastically reduced and possibly eliminated during the early 1900s (Bailey 1931; Findley *et al.* 1975). In the mid-1960s, the New Mexico Department of Game and Fish introduced peccaries into the Guadalupe Mountains of New Mexico by trans-

planting animals from Big Bend National Park, Texas (Donaldson 1967; Lee 1967). Eighteen peccaries were released at the head of Double Canyon on 21 November 1965 and another 18 individuals in Last Chance Canyon on 23 April 1966. Release sites were 1.6 and 13.2 km from the nearest park boundary, respectively. Based on recent sightings of peccaries in the park (Fig. 77), the Department's effort to establish this game species in the Guadalupe Mountains was successful (see *Discussion*). Apparently, an undetermined number of peccaries lived in the Guadalupe Mountains prior to the

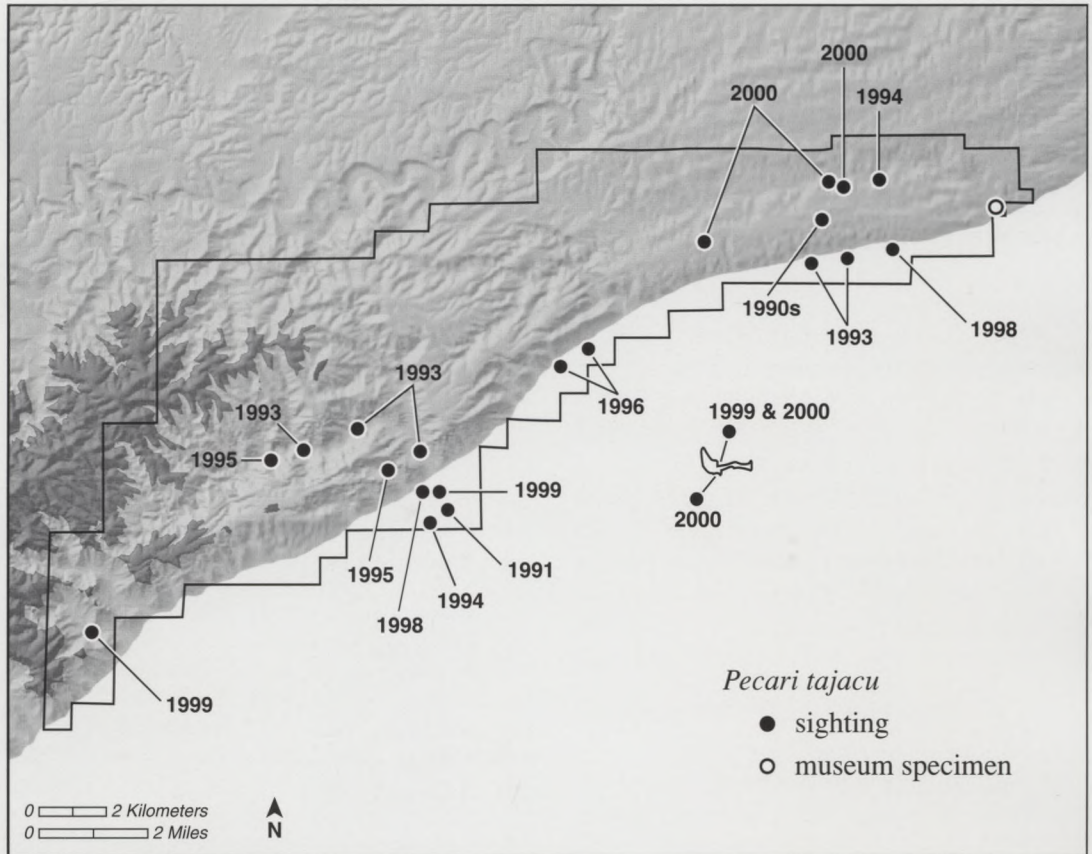


Fig. 77. Distribution of the collared peccary (*Pecari tajacu*) in Carlsbad Caverns National Park based on sightings (1990s and 2000) and on a museum specimen collected in 1992. Dates on map correspond to dates in *Additional records*.

introductions. An individual was reported west of the park in 1954 (Donaldson 1967).

The first reported sightings of peccaries in the park occurred in 1986 (*e.g.*, near mouth of Slaughter Canyon; P. S. West *pers. comm.*). Since then, peccaries have been sighted regularly on the seabed and reef (Fig. 77). On the seabed, individuals have been observed at Rattlesnake Springs and along the base of the escarpment in desert scrubland, arid grassland, and drainage areas. On the reef, peccaries have been seen in Walnut Canyon, Slaughter Canyon, West Slaughter Canyon, Midnight Canyon, South Double Canyon, Bat Cave Draw, and along the Scenic Loop Drive where the road passes through the juniper peneplain. Observations of peccaries in the park include groups of 2-19 individuals, including young.

The only museum specimen from the park was an adult collected in Walnut Canyon. On 17 February 1992, rangers located a dying animal that was presumably hit by an automobile near the park's east entrance by Whites City (Fig. 77). The peccary was immediately killed and dragged away from the paved road. Thirty-five days later, KNG located the carcass and collected the skull. At an elevation of 1,120 m (3,680 ft), this portion of Walnut Canyon is dominated by a desert-scrub community.

Reproduction. Young individuals have been reported on 16 January, 13 February, 18 March, 31 March, 8 November, and 12 November.

Taxonomic remarks. As noted above, collared peccaries in the park are descendants of animals from southeastern New Mexico and Big Bend National Park, Texas. Peccaries from both areas are referred to as *Pecari tajacu angulatus* (Cope, 1889) based on the distribution reported in Hall (1981:1081, map 533).

Museum specimens (total 1); Fig. 77:

- 0.33 mi. W, 0.32 mi. N Whites City, T24S, R25E, N $\frac{1}{2}$ Sec. 34 [in Walnut Canyon] (MSB 1).

Additional records (Fig. 77):

- near Indian Shelter Exhibit in Walnut Canyon, T24S, R25E, SW $\frac{1}{4}$ Sec. 29 (sighting by L. A. Hardin on 7 September 1994);
- Walnut Canyon, 0.71 mi. N, 0.71 mi. E Visitor Center, T24S, R25E, SE $\frac{1}{4}$ Sec. 30 (sighting by D. M. Roemer on 12 November 2000);
- Walnut Canyon, 0.74 mi. N, 0.53 mi. E Visitor Center, T24S, R25E, SW $\frac{1}{4}$ Sec. 30 (sighting by D. L. Pate and P. Bauer on 11 October 2000);
- Bat Cave Draw, near small natural opening of Carlsbad Cavern, T24S, R25E, N $\frac{1}{2}$ Sec. 31 (sighting by D. L. Carruth in early 1990s);
- West Water Tank along Scenic Loop Drive, 1.93 mi. W, 0.37 mi. S Visitor Center, T24S, R24E, SW $\frac{1}{4}$ Sec. 35 (sighting by J. Denny on 25 July 2000 and G. J. Emmons on 26 July 2000);
- Slaughter Canyon, 0.5 mi. from mouth, T25S, R23E, E $\frac{1}{2}$ Sec. 23 (sighting by T. Carter on 2 November 1993);
- Midnight Canyon, T25S, R23E, SW $\frac{1}{4}$ Sec. 23 (sighting by A. H. Burgess on 18 February 1995);
- West Slaughter Canyon, T25S, R23E, NE $\frac{1}{4}$ Sec. 22 (sighting by J. O' Haver, J. M. Richards, and B. Stubbs on 11 July 1993);
- West Slaughter Canyon, T25S, R23E, NE $\frac{1}{4}$ Sec. 21 (sighting by A. Rusk on 16 January 1993);
- West Slaughter Canyon, T25S, R23E, SW $\frac{1}{4}$ Sec. 21 (sighting by W. T. Route on 18 September 1995);
- South Double Canyon, 0.57 mi. S, 0.05 mi. E Double Cave (sighting by D. L. Pate on 17 September 1999);
- on seabed, T24S, R25E, center of SE $\frac{1}{4}$ Sec. 32 (sighting by D. M. Roemer on 12 January 1998);
- 0.25 mi. NW Sewage Disposal Ponds, T24S, R25E, SE $\frac{1}{4}$ Sec. 31 (sighting by A. Rusk on 31 March 1993);
- 0.11 mi. N, 0.79 mi. W Sewage Disposal Ponds, T24S, R25E, SW $\frac{1}{4}$ Sec. 31 (sighting by A. Rusk on 18 March 1993);
- flats below base of eastern escarpment, T25S, R24E, SE $\frac{1}{4}$ Sec. 8 (sighting by W. T. Route and B. Nygren on 25 January 1996);
- flats below base of eastern escarpment, T25S, R24E, SW $\frac{1}{4}$ Sec. 8 (sighting by W. T. Route and B. Nygren on 25 January 1996);

- both sides of gravel road adjacent to Slaughter Canyon Draw, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (sighting by K. E. Kelly on 16 December 1991);
- both sides of gravel road adjacent to Slaughter Canyon Draw, 0.60 mi. S, 0.48 mi. E Slaughter Canyon Cave, T25S, R23E, NW $\frac{1}{4}$ Sec. 25 (sighting by KNG on 23 October 1999);
- 1.24 mi. S, 0.42 mi. E Slaughter Canyon Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 25 (sighting by J. O'Haver on 13 February 1994);
- on flats of seabed near mouth of Slaughter Canyon, T25S, R23E, NE $\frac{1}{4}$ Sec. 26 (sighting by D. M. Roemer on 9 January 1998);
- next to ranger station at Rattlesnake Springs (sighting by D. M. Roemer on 6 October 1999, 24 November 1999, and 15 July 2000);
- woodlot on east side of Rattlesnake Spring (sighting by D. M. Roemer on 8 November 2000).

Family Cervidae
***Odocoileus hemionus* (Rafinesque, 1817)**
Mule Deer

Mule deer occur across western North America, inhabiting deserts, grasslands, brushlands, woodlands, and forests (Jones *et al.* 1983; McCullough 1999). This cervid is common and widespread in the park. On the seabed, we observed mule deer in the scrubland, grassland, juniper plain, and drainage areas. We also observed them at Rattlesnake Springs in the orchard, woodlots, and weedy fields. Park personnel have seen them in shrubby areas.

On the reef, we often observed mule deer on canyon floors, canyonsides, and summits. They occurred from the lowest portions of Walnut Canyon to the highest summits near Putman Cabin. We discovered that one of the best opportunities to observe mule deer in the park is at daybreak along the Scenic Loop Drive.

Food habits. From 1967 to 1971, Kitams *et al.* (1979) determined the diet of mule deer in the park. Most information was obtained from observations made along the Scenic Loop Drive and paved road between Whites City and the Visitor Center. These roads pass through Walnut Canyon and portions of the juniper peneplain. Shrubs were the major portion of the year-round diet with

Roemer acacia comprising the largest proportion consumed during most years. Other important food items were other acacias, catclaw mimosa, lechuguilla, red berry juniper, little walnut, Apache plume, feather dalea, sotol, prickly pear, silver dalea, mountain mahogany, cholla, and oak. Important forbs included tubetongue, shaggy stenandrium, Louisiana sagewort, wild buckwheat, and fleabane. Grasses primarily showed up in the diet during poor growing seasons.

Reproduction. In the park or just outside its boundaries, we observed antlered deer on 18, 22, and 29 January; 8 and 14 February; 9-11, 15, 18, 19, 22, and 23 March; 30 April; 22, 23, 25, 27, and 28 July; 5 August; 9 October; and 29 December.

Taxonomic remarks. The subspecies of *Odocoileus hemionus* in the park is *O. h. crooki* (Mearns, 1897) based on the distribution reported in Hall (1981:1090, map 536).

Museum specimens (total 3); not mapped:

- west of housing area [T24S, R24E, NE $\frac{1}{4}$ Sec. 36] (CACA 1);
- slope above Spider Cave, T24S, R24E, NE $\frac{1}{4}$ Sec. 35 (CACA 1);
- Upper Lowe Spring, 0.33 mi. S, 0.02 mi. W Lowe Spring, T24S, R24E, S $\frac{1}{2}$ Sec. 33 (MSB 1).

***Cervus canadensis* Erxleben, 1777**
Elk or Wapiti

Elk originally were found in most mountainous regions of New Mexico, but by the early 1900s they were essentially gone from the state (Findley *et al.* 1975). Elk in the park today represent descendants of Rocky Mountain elk (*Cervus canadensis nelsoni*) that were introduced into the Texas portion of the Guadalupe Mountains (Lee 1967; Genoways *et al.* 1979). In the late 1920s, 44 individuals were imported from the Black Hills of South Dakota and released in McKittrick Canyon where they eventually expanded their range into other parts of the Guadalupe Mountains (Davis 1940). Elk were reestablished after the native subspecies, Merriam's elk (*C. c. merriami*), became extinct around 1900 (Bailey 1931; Findley *et al.* 1975; see *Discussion*).

Elk are seen infrequently in the park, but through the years there have been a number of sightings—all of which are from the reef (Fig. 78). KING observed one along the floor of North Slaughter Canyon on 21 June 1986. Elk also have been reported in West Slaughter Canyon, Rattlesnake Canyon, and Open Hollow Gulch; along Guadalupe Ridge; and in high country near Yucca and Putman cabins. Most reports mentioned that bulls and cows were present; however, one report also mentioned calves. The current number of elk inhabiting the park is unknown, but based on infrequent sightings, numbers are probably few.

An antler discovered on the floor of Open Hollow Gulch represents the only specimen from the park. The antler was located on 11

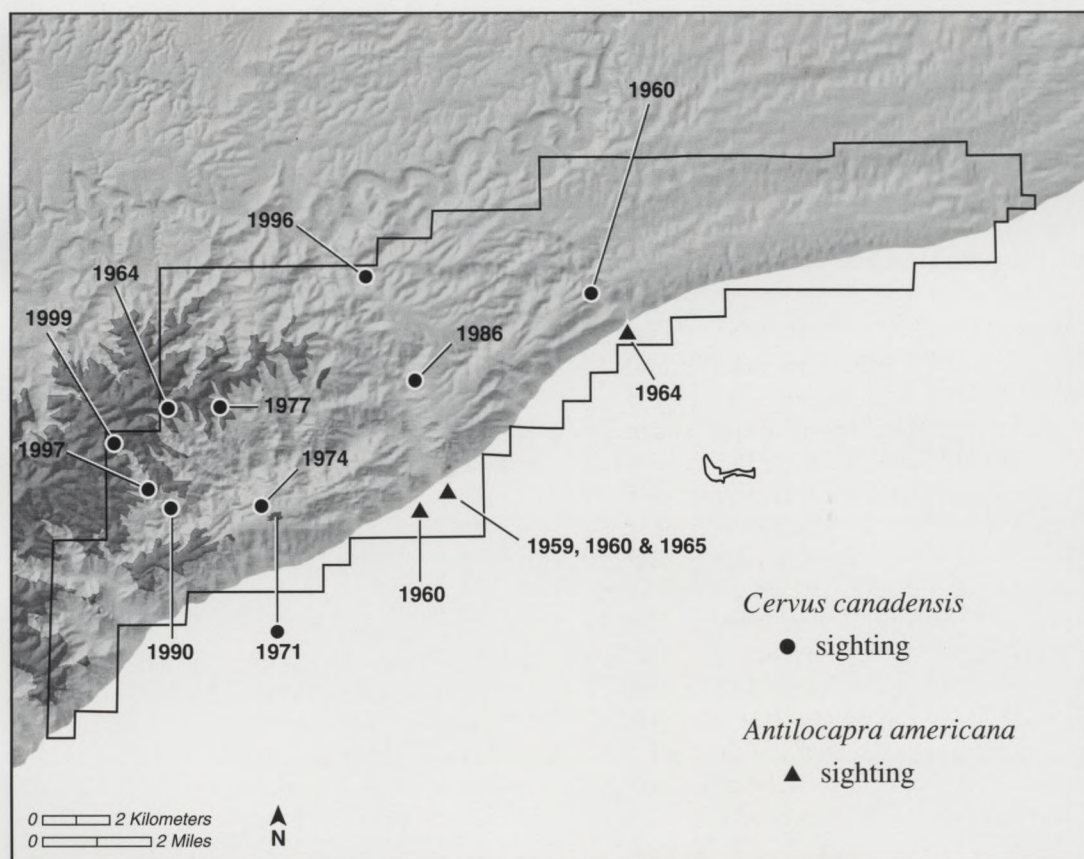


Fig. 78. Distribution of the elk (*Cervus canadensis*) and pronghorn (*Antilocapra americana*) in Carlsbad Caverns National Park. Dates on map correspond to dates in *Additional records*.

March 1993, measured 1.3 m in greatest length, and contained sign of being gnawed by rodents.

Reproduction. Three calves accompanied by four cows and a bull were reported on 6 October 1977.

Taxonomic remarks. As noted above, elk in the park today are descendants of animals belonging to the subspecies *Cervus canadensis nelsoni* V. Bailey, 1935. The subspecies formerly inhabiting the park was *C. c. merriami* Nelson, 1902. Elk in North America were previously known as *C. elaphus*.

Museum specimens (total 1); see record in 1997 below:

- Open Hollow Gulch, T25S, R22E, NE ¼ Sec. 25 [antler collected 11 March 1993] (CACA 1).

Additional records (Fig. 78):

- Rattlesnake Canyon, T25S, R24E, NE ¼ Sec. 5—NW ¼ Sec. 4 (sighting by T. C. Miller on 11 November 1960);
- North Slaughter Canyon, T25S, R23E, NE ¼ Sec. 14 (sighting by KNG on 21 June 1986);

- West Slaughter Canyon (sighting by R. E. Fultz and R. E. Reisch on 23 March 1961 and F. Eichhorst on 6 January 1992) *not plotted*;
- Guadalupe Ridge, T25S, R23E, NE ¼ Sec. 3 (sighting by T. Rohrer and M. Cordova on 8 October 1996);
- 200 yards W of Yucca Cabin, T25S, R23E, W ½ Sec. 28 (sighting by R. J. Heying on 14 October 1971);
- ¼ mi. NW of Yucca Cabin, T25S, R23E, NE ¼ Sec. 29 (sighting by J. R. Yarbrough on 6 January 1974);
- 1 mi. E of Putman Cabin, T25S, R23E, W ½ Sec. 17 (sighting by H. E. Cottingham on 6 October 1977);
- near Putman Cabin (sighting by J. F. Martin and H. V. Rawlings on 28 January 1964);
- ½ mi. up Open Hollow Gulch from West Slaughter Canyon, T25S, R23E, W ½ Sec. 30 (sighting by D. L. Carruth, R. D. Kieffe, and C. Winberg on 17 October 1990);
- Open Hollow Gulch, T25S, R22E, NE ¼ Sec. 25 (dead elk observed by D. M. Roemer on 16 May 1997; same area where antler was discovered in 1993—see *Museum specimens*);
- Open Hollow Gulch, T25S, R22E, NW ¼ Sec. 24 (dead elk observed by D. M. Roemer on 21 April 1999).

Family Antilocapridae *Antilocapra americana* (Ord, 1815) Pronghorn

Pronghorns are animals of open country, and in New Mexico they are most common in grassland habitats (Findley *et al.* 1975; O'Gara 1999). All records of pronghorns in the park are from lowlands along the base of the escarpment (Fig. 78). Several reports from 1959 to 1965 describe pronghorns on park property at mouths of Rattlesnake, Slaughter, and Midnight canyons. Other reports during this period include sightings below Double Canyon and in areas surrounding Rattlesnake Springs, but these records were outside the park's boundary. In the late 1970s, pronghorns were seen south of the park near the mouth of Double Canyon (herd of ten) and below Lefthook Canyon (herd of 15).

In 1987, park ranger K. W. Watson reported two pronghorns on a private ranch near the park's southwest corner. He also re-

ported that the foreman of the ranch regularly saw up to four individuals in the area. In 1998, KNG asked foreman D. K. Colwell about his observations of pronghorns in the area. His most recent sightings were from the early 1990s, and in each instance only a single individual was seen near the park's boundary. In contrast, Colwell remembered seeing up to ten individuals (including young) in the area in the early 1980s (see *Discussion*).

Pronghorns in and around the park in the late 1950s and during subsequent years likely were descendants of animals released near Rattlesnake Springs in 1948 and 1952. During those years, 58 pronghorns (21 males, 37 females) were introduced into Washington Ranch Wildlife Restoration Area (T25S, R24E; Russell 1964). According to Russell, pronghorns were not present west of the Pecos

River in Eddy County by 1938, except perhaps for a few stragglers. Introductions of pronghorns were attempted because reoccupation by natural dispersal was being prevented by fences.

Although no definite specimen of *A. americana* exists from the park, Vernon Bailey collected a cranium in New Mexico in 1901 somewhere along the east base of the Guadalupe Mountains (Findley *et al.* 1975; KNG *pers. observ.* of USNM 110277).

Reproduction. Except for mention of a "very young" individual on 12 June 1960, no information is available regarding reproductive biology of pronghorns in the park.

Taxonomic remarks. The line of demarcation between *Antilocapra americana americana* (Ord, 1815) and *A. a. mexicana* Merriam, 1901 is close to Carlsbad Caverns

National Park (Hall 1981:1108, map 541). The origin of pronghorns introduced near the park in 1948 and 1952 was not reported by Russell (1964), further complicating the subspecific status of pronghorns in the area. The New Mexican specimen collected in 1901 has been assigned to *A. a. americana* by others (Genoways *et al.* 1979:308).

Additional records (Fig. 78):

- ¼ mi. out from mouth of Rattlesnake Canyon, T25S, R24E, NE ¼ Sec. 9 (sighting by R. E. Reisch on 20 April 1964);
- near mouth of Slaughter Canyon (sighting by J. K. Baker on 31 July 1959, D. F. Giese on 17 February 1960, and R. W. Reaves III in April 1965);
- mouth of Midnight Canyon, T25S, R23E, NE ¼ Sec. 26 (sighting by J. R. Patterson and P. F. Spangle on 12 June 1960).

Family Bovidae *Ammotragus lervia* (Pallas, 1777) Aoudad or Barbary Sheep

Aoudads are native to northern Africa and live in rough and rocky terrain of arid and semiarid regions of the continent (Nowak and Paradiso 1983). This exotic species was introduced in the United States for sport hunting. Aoudads observed in the park are descendants of escapees from a ranch in Rio Hondo valley 135 km north-northwest of the park (Dickinson and Simpson 1980). Animals were introduced onto a private game farm in 1940, where some individuals escaped from enclosures a few years later. By 1966 a wild, breeding population of aoudads had expanded its range southward to include the Guadalupe Mountains in Texas (Dickinson and Simpson 1980).

The first recorded sighting of an aoudad in Carlsbad Caverns National Park occurred on 8 May 1959, in a side canyon of North Slaughter Canyon. Today this bovid is firmly established in the park, and sightings are becoming more and more frequent (see *Discussion*). Thus far, all records are from the reef (Fig. 79). From 1991 to 2000, aoudads have been reported in Walnut, Lechuguilla, Nuevo,

South Rattlesnake, Slaughter, West Slaughter, Midnight, Yucca, Lefthook, and Double canyons and along Open Hollow Gulch and Guadalupe Ridge. In 1990 there also was a sighting in the juniper penepain along the Scenic Loop Drive. In the park, as many as 30 individuals have been observed together at one time. The best opportunity to observe aoudads is to scan the high ridges between Midnight Canyon and West Slaughter Canyon while walking up the trail to Slaughter Canyon Cave.

The official policy of the National Park Service is to eliminate aoudads from the park. In 1993 we collected skulls of two animals that were killed by park personnel in Walnut Canyon.

Reproduction. Lambs have been observed on 22 February and juveniles on 3 January, 23 June, and 4 October.

Taxonomic remarks. As noted above, aoudads are native to northern Africa, where six subspecies are recognized (Gray and Simpson 1980). We did not assign a subspecific name to specimens from the park.

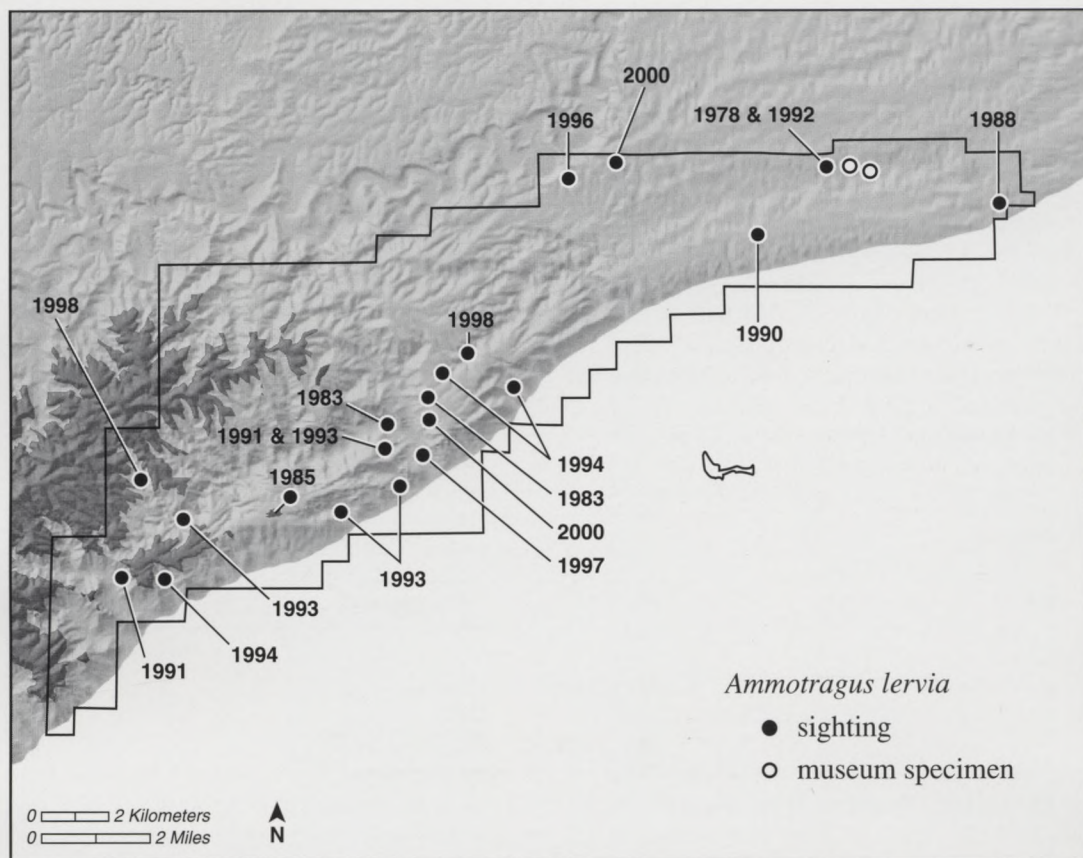


Fig. 79. Distribution of the aoudad (*Ammotragus lervia*) in Carlsbad Caverns National Park. The first reported sighting of *A. lervia* in the park occurred in 1959 somewhere along a side canyon of North Slaughter Canyon; this locality is not plotted on the map. Dates on map correspond to dates in *Additional records*.

Museum specimens (total 3); Fig. 79:

- Walnut Canyon, 200 yards NW of Rock Shelter Exhibit [T24S, R25E, W ½ Sec. 29; Rock Shelter Exhibit is also known as Indian Shelter Exhibit] (CACA 1);
- 1.04 mi. N, 0.94 mi. E Visitor Center, T24S, R25E, NE ¼ Sec. 30 [in Walnut Canyon] (MSB 2).

Additional records (Fig. 79):

- Walnut Canyon, 0.45 mi. NW Whites City, T24S, R25E, N ½ Sec. 34 (sighting by F. Hernandez III on 4 October 1988);
- near corrals in Walnut Canyon, T24S, R25E, N ½ Sec. 30 (sighting by R. A. Wilt on 6 November 1978 and A. Rusk on 12 November 1992);
- along Scenic Loop Drive, 0.87 mi. W, 0.16 mi. S Visitor Center, T24S, R24E, SW ¼ Sec. 36 (sighting by D. A. Ek in 1990);
- 0.26 mi. NW Lechuguilla Cave in Lechuguilla Canyon, T24S, R24E, NW ¼ Sec. 28 (observation of a puma-killed aoudad by D. M. Roemer and G. J. Emmons on 3 May 2000);
- Guadalupe Ridge, T24S, R24E, center of Sec. 29 (sighting by J. M. Richards on 25 June 1996);
- Nuevo Canyon, T25S, R24E, E ½ Sec. 18 (sighting by A. Rusk on 26 March 1994);
- South Rattlesnake Canyon, T25S, R23E, SE ¼ Sec. 12 (observation of dead male by D. M. Roemer on 12 November 1998);
- side canyon of South Rattlesnake Canyon, T25S, R23E, SW ¼ Sec. 12 (sighting by A. Rusk on 16 April 1994);
- next to Ogle Cave in Slaughter Canyon, T25S, R23E, NW ¼ Sec. 24 (sighting by J. M. Richards on 22 February 2000);

- 0.44 mi. N Ogle Cave, T25S, R23E, SW $\frac{1}{4}$ Sec. 13 (sighting by R. McBride in January 1983);
- side canyon of North Slaughter Canyon; side canyon is in E $\frac{1}{2}$ Sec. 11, T25S, R23E (sighting by J. K. Baker and P. F. Spangle on 8 May 1959; this record was not reported by Dickinson and Simpson 1980) *not plotted*;
- Slaughter Canyon, 0.22 mi. N, 0.19 mi. E Slaughter Canyon Cave, T25S, R23E, E $\frac{1}{2}$ Sec. 23 (sighting by C. R. Wadkins and W. C. Robinson on 4 August 1997);
- lower portion of Midnight Canyon (sighting by A. Rusk on 23 January 1993);
- West Slaughter Canyon, T25S, R23E, NW $\frac{1}{4}$ Sec. 23 (sighting by W. F. Van Cott on 23 June 1983);
- between Midnight and West Slaughter canyons, T25S, R23E, SW $\frac{1}{4}$ Sec. 23 (sighting by D. A. Ek on 28 December 1991 and by K. E. Kelly, A. Rusk, and KNG on 22 March 1993);
- Yucca Canyon (sighting by F. Hernandez III on 17 March 1993);
- near Yucca Cabin (sighting by C. G. Ryan on 4 July 1985);
- West Slaughter Canyon, T25S, R23E, Sec. 30 (sighting by J. Cronk on 11 March 1993);
- Lefthook Canyon, T25S, R23E, SW $\frac{1}{4}$ Sec. 31 (sighting by A. Rusk on 23 April 1994);
- Open Hollow Gulch, T25S, R22E, SE $\frac{1}{4}$ Sec. 24 (sighting by D. M. Roemer and R. J. [Beymer] West on 29 May 1998);
- Double Canyon, T25S, R22E, S $\frac{1}{2}$ Sec. 36 (sighting by D. L. Carruth on 19 October 1991).

Extirpated Species

***Cynomys ludovicianus* (Ord, 1815)—Black-tailed Prairie Dog.** According to Bailey (1928), prairie dogs were common in the Pecos River and Black River valleys in the 1920s. He described a colony on the seabed 3.2 km south of Carlsbad Cavern. Although this area lies outside the park (1.3 km from present-day boundary), prairie dogs likely occurred on park property at that time. The most recent sightings of prairie dogs in the vicinity of the park were made in the early 1980s (P. S. West *pers. comm.*). A small colony was regularly observed 1.1 km east of the southeastern corner of Rattlesnake Springs (T25S, R24E, SE $\frac{1}{4}$ Sec. 24). In 1991 and 1993, KNG searched this area and failed to locate a burrow or prairie dog. Populations of *C. ludovicianus* have been drastically reduced over much of their former range because of deliberate eradication by humans (see *Discussion*).

***Canis lupus* Linnaeus, 1758—Gray Wolf.** Gray wolves ranged throughout the Guadalupe Mountains and Pecos River valley before being extirpated in the early 1900s (Bailey 1928; Genoways *et al.* 1979). Only one museum specimen is known from the

Guadalupe Mountains. In 1901 an adult was collected in Texas from the summit of these mountains near the boundary of New Mexico (Genoways *et al.* 1979). Although the precise collecting site of this specimen is unknown, it was probably collected no more than 18 km from Carlsbad Caverns National Park. Gray wolves likely occurred in the park before being extirpated. The loss of this canid from the Guadalupe Mountains was primarily a result of predator-control programs (Genoways *et al.* 1979).

***Ursus arctos* Linnaeus, 1758—Grizzly Bear.** Grizzly bears once were widespread and common in New Mexico (Findley *et al.* 1975), and evidence exists that they occurred in the Guadalupe Mountains (Bailey 1928; Genoways *et al.* 1979). Similar to the gray wolf, grizzly bears likely occurred in the park before being eliminated from this region in the early 1900s. However, unlike the gray wolf, no museum specimen of *U. arctos* exists from the Guadalupe Mountains. Grizzly bears were eradicated from most of their former range because people feared them, and bears occasionally killed livestock (Findley *et al.* 1975; Genoways *et al.* 1979).

***Bos bison* Linnaeus, 1758—American Bison.** Formally common on the eastern plains of New Mexico, bison were gone from the state by the end of the 19th century (Findley *et al.* 1975). The last recorded kills of bison in the Pecos River valley occurred in 1884 and 1885 (Bailey 1928). Before being eradicated from New Mexico, bison likely roamed over park property in lowlands of the seabed. Although no museum specimen or verified record of *B. bison* is known from the park, a partial cranium was collected in the town of Carlsbad in 1949 (KNG *pers. observ.* of MSB 1902).

***Ovis canadensis* Shaw, 1804—Bighorn Sheep.** In the 1920s, bighorn sheep still occurred in several canyons throughout the Guadalupe Mountains, including some in Carlsbad Caverns National Park (Bailey 1928). Bailey mentioned that bighorn sheep inhabited Slaughter Canyon, Rattlesnake Canyon, and probably Walnut Canyon. In fact, a large cave now known as Window Cave (see *Additional records*) was heavily used by these sheep. At the time of Bailey's survey, the number of bighorn sheep inhabiting the Guadalupe Mountains was most likely between 100 and 200 individuals (Gross 1960).

No evidence exists that bighorn sheep occur in the park today. The most recent sighting of this bovid that has been confirmed in

the Guadalupe Mountains occurred on 30 May 1979 (A. Sandoval *pers. comm.*). On this day a wildlife student from Texas Tech University photographed a ewe and lamb in Pup Canyon 45 km northwest of Carlsbad Caverns National Park. This sighting prompted the New Mexico Department of Game and Fish to search for bighorn sheep in this mountain range. Extensive aerial surveys, which included Guadalupe Mountains National Park and Carlsbad Caverns National Park, failed to locate bighorn sheep. Although bighorn sheep may still be present in small numbers in the Guadalupe Mountains, it will become more and more difficult for native bighorn sheep to reoccupy their former range as the exotic aoudad (*Ammotragus lervia*) becomes better established in the Guadalupe Mountains (see *Discussion*).

Museum specimens (total 1); not mapped:

- Big Horn Cave [in West Slaughter Canyon; a horn sheath collected in 1959, which was same year cave was discovered] (CACA 1).

Additional records (not mapped):

- Window Cave in West Slaughter Canyon (Bailey 1928; "the big cave in Slaughter Canyon" described by Bailey on pp. 53 and 54 and referred by him as "Bighorn Cave" on pp. 145 and 149, both refer to Window Cave).

Species with Uncertain Status

***Didelphis virginiana* Kerr, 1792—Virginia Opossum.** Bailey (1928) was first to report Virginia opossums in New Mexico. He stated that a few escaped from captivity in the town of Carlsbad. Since then, 34 additional records have been documented from New Mexico (Bermudez *et al.* 1995). Although most records are associated with the Rio Grande and its tributaries, two records are known from the Guadalupe Mountains. In February 1988, two opossums were trapped near a spring in Last Chance Canyon about 12 km northwest of the park. The origin of these in-

dividuals is unknown. If they represent an established population in the Guadalupe Mountains, then the possibility exists that opossums may eventually be discovered in the mountainous portion of the park. However, because opossums generally occupy wooded habitats with permanent water such as streams, rivers, marshes, and swamps (McManus 1974; Jones *et al.* 1983; Gardner 1999), Rattlesnake Springs is the most likely place for individuals to be discovered in the park. Thus far, opossums have not been reported at Rattlesnake Springs or along the

Pecos River, except for those early reports of escaped individuals near Carlsbad in the 1920s (Bailey 1928; Bermudez *et al.* 1995).

***Cryptotis parva* (Say, 1823)—Least Shrew.** To date, three populations of *C. parva* are known from eastern New Mexico (Hafner and Shuster 1996). The closest population to Carlsbad Caverns National Park occurs at Bitter Lake National Wildlife Refuge along the Pecos River. Measured from Rattlesnake Springs, the park is 145 km south of the wildlife refuge. Hafner and Shuster (1996) believe that other New Mexican populations of *C. parva* may occur south of the refuge in areas with seasonal or permanent standing water along the Pecos River or its tributaries. At the wildlife refuge, least shrews were captured in dense native grasses including alkali sacaton. The collecting sites were dry, but permanent standing water was nearby (D. J. Hafner *pers. comm.*). Habitats similar to those at the refuge occur at Rattlesnake Springs, and the natural spring on this property drains into the Black River, a tributary of the Pecos River. Although we set two pitfall traps at Rattlesnake Springs to capture shrews, they were set in a woodlot of deciduous trees and not in dense, grassy habitats. With additional surveys in appropriate habitats, least shrews might be discovered at the park.

***Myotis yumanensis* (H. Allen, 1864)—Yuma Myotis.** In the past, *M. yumanensis* has been considered part of the mammalian fauna of the park because Baker (1962) stated that skeletal remains of *M. yumanensis* were known from Carlsbad Cavern. Although Baker does not provide specific documentation about the skeletal evidence, his conclusion likely was based on two skulls in the park's museum that were previously labeled *M. yumanensis*. At present, one skull is labeled *M. volans* (CACA 416) and the other *Myotis* sp. (CACA 465). However, a skull collected in the cavern in 1992 (CACA 7909) and another in Lechuguilla Cave in 1995 (CACA 8980) are *M. yumanensis*. Hence, evidence demonstrates that *M. yumanensis* has occurred in the park, but because the age of the skulls is unknown, the current status of this species in the park is not clear.

Based on living animals, *M. yumanensis* is known only from western and northern parts of New Mexico, where it is usually associated with permanent sources of water in deserts, grasslands, and woodlands (Findley *et al.* 1975). To the best of our knowledge, no living individual of *M. yumanensis* is known from southeastern or east-central parts of the state. In Eddy County and southern Chaves County, we have netted along and near the Pecos River and Black River a total of eleven times in 1999 and 2000, and we never captured an *M. yumanensis*, only *M. velifer* ($n = 69$), *T. brasiliensis* (24), *A. pallidus* (9), and *C. townsendii* (7). In New Mexico, the nearest published record of *M. yumanensis* to the park is 183 km west in Doña Ana Co. (Findley *et al.* 1975), but the closest record to the park is 142 km south in Jeff Davis Co., Texas (Schmidly 1977). If *M. yumanensis* is discovered in the park, it likely will be at Rattlesnake Springs.

Because records of *M. yumanensis* from the park are based on skulls of unknown age and because records of living animals do not exist close to the park, we placed *M. yumanensis* in *Species with Uncertain Status*. In contrast, each of the 63 species of mammals listed as contemporary species has been documented by living animals within boundaries of the park in recent years (1949-2000).

Museum specimens (total 2); not mapped:

- New Mexico Room, Carlsbad Cavern [skull collected in 1992] (CACA 1);
- Lechuguilla Cave [in Lechuguilla Canyon; skull collected in 1995] (CACA 1).

***Euderma maculatum* (J. A. Allen, 1891)—Spotted Bat.** Spotted bats occur from southern British Columbia to central Mexico, including 11 states in western United States (Geluso 2000). They have been captured in a variety of habitats ranging from desert scrublands in Texas to montane forests in New Mexico (Easterla 1973b; Findley *et al.* 1975). Until recently, all records of *E. maculatum* in New Mexico were along or west of the Rio Grande, but in 1995, Perry *et al.* (1997) discovered a reproducing population of *E. maculatum* east of the river in the Sacramento Mountains. Lactating females were

captured in an open meadow situated near cliffs and limestone outcrops and surrounded by a mixed coniferous forest. This site is 106 km northwest of Carlsbad Caverns National Park.

Availability of rock cliffs and areas containing ponderosa pine seem to be important factors for *E. maculatum* (Findley *et al.* 1975; Rabe *et al.* 1998; Black and Cosgriff 1999). The rugged, dry canyons of the park with their numerous cliffs and rock outcroppings and presence of ponderosa pines at high elevations on the reef might provide suitable habitat for this species.

***Sylvilagus robustus* (V. Bailey, 1905)—Davis Mountains Cottontail.** The possibility of *S. robustus* inhabiting pine woodland in the western portion of the park is discussed in the species account of *S. audubonii*, the desert cottontail.

Taxonomic remarks. *Sylvilagus robustus* was formerly a subspecies of *S. floridanus*.

***Chaetodipus intermedius* (Merriam, 1889)—Rock Pocket Mouse.** In desert mountains of southern New Mexico, rock pocket mice commonly occur on rocky hillsides containing cacti, agaves, sotol, acacias, and mimosa (Findley *et al.* 1975). Although this habitat is abundant at lower elevations in the Guadalupe Mountains, no record of *C. intermedius* is known from this mountain range in New Mexico (Findley *et al.* 1975). In contrast, Genoways *et al.* (1979) discovered *C. intermedius* common in lowlands along the western edge of the Guadalupe Mountains in Texas. Because Genoways *et al.* (1979) also documented one individual in lowlands along the eastern base of the mountains, *C. intermedius* also may occur farther north at Carlsbad Caverns National Park. Numerous captures on the western side compared to the eastern side may be related to different temperature regimes (see Gennaro 1968). Thus far, the only saxicolous pocket mouse reported from Carlsbad Caverns National Park is *Chaetodipus nelsoni*. Although *C. intermedius* and *C. nelsoni* normally are allopatric, they have been collected together in Texas (Schmidly 1977; Yancey 1997).

***Chaetodipus eremicus* (Mearns, 1898)—Chihuahuan Desert Pocket Mouse.** In New Mexico, the Chihuahuan desert pocket mouse occurs in desert habitats across the southern third of the state (Findley *et al.* 1975). Although this species usually occupies sandy or silty, rock-free soils in New Mexico and elsewhere (Findley *et al.* 1975; Schmidly 1977; Davis and Schmidly 1994), it also inhabits soils containing stones and rocks. For example, 19% (31/160) of individuals captured in the Big Bend area of western Texas were captured on gravelly, rocky, or boulder-strewn substrates (Yancey 1997). Closer to Carlsbad Caverns National Park, Genoways *et al.* (1979) captured *C. eremicus* on rocky soils in lowlands along the base of the eastern escarpment of the Guadalupe Mountains of Texas. Thus, lowland areas with rocky soils and rock-free soils at Carlsbad Caverns National Park should provide suitable habitat for *C. eremicus*.

Taxonomic remarks. This species was formerly considered a subspecies of *C. penicillatus*.

***Castor canadensis* Kuhl, 1820—American Beaver.** Beavers occur along permanent waterways throughout much of New Mexico (Findley 1987), and Bailey (1928) reported them along the Black River in the 1920s. At that time beavers lived in the Black River near Washington Ranch and Rattlesnake Springs. Although beavers have never been documented in permanent pools at Rattlesnake Springs, they might have inhabited them in the past and may become established there in the future.

***Peromyscus truei* (Shufeldt, 1885)—Piñon Mouse.** In New Mexico, *P. truei* is most abundant in pinyon-juniper woodland (Findley *et al.* 1975; Findley 1987). Although no record of *P. truei* was reported from the Guadalupe Mountains of New Mexico by Findley *et al.* (1975), recent trapping confirms that piñon mice do inhabit this part of the state. On 5 July 1999, KG captured five *P. truei* in a pinyon-juniper savanna at 2,025 m (6,640 ft) 11.3 km west of the park.

Piñon mice also occur in the Texas portion of the Guadalupe Mountains (Genoways *et al.* 1979; Cornely *et al.* 1981). Animals were captured in open, wooded areas with grassy understories at elevations of 1,905 m (6,250 ft) and 1,920 m (6,300 ft). Trees included alligator juniper and pinyon pine in one area and just alligator juniper in the other. Because higher summits in Carlsbad Caverns National Park consist of open stands of alligator juniper, pinyon pine, and ponderosa pine and because *P. truei* occurs relatively close to the park's boundaries, the piñon mouse likely occurs in the park.

***Microtus mogollonensis* (Mearns, 1890)—Mogollon Vole.** The Mogollon vole occurs in several mountain ranges in New Mexico, including the Capitan and Sacramento mountains in the southeastern part of the state (Findley *et al.* 1975). Although *M. mogollonensis* is known from the Guadalupe Mountains in Texas, it has not been sufficiently documented on the New Mexican side of this mountain range. In his account of great horned owls (*Bubo virginianus*), Bailey (1928:140 and 146) mentioned that a tooth of the "Guadalupe meadow mouse" (= *Microtus mexicanus guadalupensis*; Bailey 1931) was identified from an owl pellet collected in the region. The pellet was collected either in Carlsbad Cavern, a cave in West Slaughter Canyon, or somewhere along the Pecos River (presumably near the park). We do not know if the tooth was kept as a voucher.

In contrast to poor documentation of this species in the Guadalupe Mountains of New Mexico, *M. mogollonensis* is well documented in the Texas portion of this mountain range (Genoways *et al.* 1979; Wilhelm 1979). At high

elevations in Guadalupe Mountains National Park, voles have been captured in meadows surrounded by conifers; on steep hillsides with small amounts of grass; and on rocky slopes containing agave, sotol, bear grass, and scattered grasses. The lowest record in the park was 1,920 m (6,300 ft). At Carlsbad Caverns National Park, isolated populations of *M. mogollonensis* may exist in western portions of the park. The savanna-like habitat of grasses and conifers may provide suitable habitat. The northern most record of *M. mogollonensis* in Texas is 14.8 km from Carlsbad Caverns National Park.

Taxonomic remarks. The Mogollon vole formerly was referred to as *M. mexicanus*.

***Ondatra zibethicus* (Linnaeus, 1766)—Common Muskrat.** In New Mexico, this semiaquatic rodent lives throughout the state in marshes, ponds, and drainage ditches along major river systems and in montane lakes and ponds (Findley *et al.* 1975; Findley 1987). In the 1920s, Bailey (1928) reported muskrats 6.4 km south of Carlsbad Cavern in permanent pools along the Black River, a tributary of the Pecos River. These pools were <2 km from Rattlesnake Springs. Muskrats still live along the Black River today. On 6 July 1995, KNG discovered a dead individual on Highway 62-180 where it crosses the Black River (Fig. 4). This location is 5.6 km from Rattlesnake Springs, but farther upstream the river is only 0.3 km from the park's boundary. Although the Black River is close to Rattlesnake Springs, muskrats have not been documented on this parcel of land; however, they might have inhabited permanent pools at Rattlesnake Springs in the past and may become established there in the future.

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Appendix 1. Climatological data for Carlsbad Caverns National Park. Yearly precipitation, mean monthly precipitation, and mean surface temperatures are based on data collected from 1973 to 2000 (NOAA 1973-2000). Climatological data for the park are recorded from instruments near the large natural opening of Carlsbad Cavern at a surface elevation of 1,355 m (4,440 ft).

Yearly Precipitation		
Year	Millimeters	Inches
1973	376	14.8
1974	577	22.7
1975	315	12.4
1976	478	18.8
1977	267	10.5
1978	627	24.7
1979	328	12.9
1980	442	17.4
1981	511	20.1
1982	437	17.2
1983	356	14.0
1984	622	24.5
1985	444	17.5
1986	838	33.0
1987	599	23.6
1988	414	16.3
1989	246	9.7
1990 ^a	234	9.2
1991	495	19.5
1992	371	14.6
1993	269	10.6
1994	274	10.8
1995	361	14.2
1996	505	19.9
1997	500	19.7
1998	180	7.1
1999	279	11.0
2000	<u>340</u>	<u>13.4</u>
Arithmetic mean	417	16.4

^aAmount of precipitation estimated for November.

Appendix 1 continued

Mean Monthly Precipitation

Month	Arithmetic mean		Percent of total annual precipitation
	millimeters	inches	
January	10.7	0.42	2.6
February	13.0	0.51	3.1
March	7.1	0.28	1.7
April	14.2	0.56	3.4
May	38.9	1.53	9.3
June	60.5	2.38	14.5
July	53.1	2.09	12.7
August	65.5	2.58	15.7
September	92.7	3.65	22.2
October	33.0	1.30	7.9
November	14.2	0.56	3.4
December	14.7	0.58	3.5

Mean Surface Temperatures

Month	Minimum temperature		Maximum temperature	
	°C	°F	°C	°F
January	0.6	33	12.8	55
February	2.2	36	15.6	60
March	5.6	42	19.4	67
April	8.9	48	23.3	74
May	13.9	57	28.3	83
June	17.8	64	32.2	90
July	18.9	66	32.2	90
August	18.3	65	31.1	88
September	15.0	59	27.8	82
October	10.6	51	23.3	74
November	5.0	41	17.8	64
December	1.1	34	13.3	56

Appendix 2. Plants of Carlsbad Caverns National Park named in text. Common names are arranged alphabetically, and grasses are listed separately at the end. Most scientific names follow Powell (1988, 1994).

Common name	Scientific name
acacia	<i>Acacia</i> spp.
agarito	<i>Berberis trifoliolata</i>
agave	<i>Agave</i> spp.
alligator juniper	<i>Juniperus deppeana</i>
allthorn	<i>Koeberlinia spinosa</i>
Apache plume	<i>Fallugia paradoxa</i>
apple	<i>Pyrus malus</i>
bear grass	<i>Nolina</i> spp.
bigtooth maple	<i>Acer grandidentatum</i> var. <i>brachypterum</i>
broom snakeweed	<i>Gutierrezia sarothrae</i>
bulrush	<i>Scirpus</i> spp.
cane cholla	<i>Opuntia imbricata</i>
catclaw	<i>Acacia greggii</i> , <i>A. roemeriana</i> , and/or <i>Mimosa biuncifera</i>
catclaw acacia	<i>Acacia greggii</i>
catclaw mimosa	<i>Mimosa biuncifera</i> var. <i>biuncifera</i>
chinkapin oak	<i>Quercus muhlenbergii</i>
chokecherry	<i>Prunus serotina</i> subsp. <i>virens</i>
cholla	<i>Opuntia</i> spp.
Christmas cholla	<i>Opuntia leptocaulis</i>
cliff fendlerbush	<i>Fendlera rupicola</i>
cottonwood	<i>Populus deltoides</i> subsp. <i>wislizenii</i>
creosote bush	<i>Larrea tridentata</i>
datil yucca	<i>Yucca baccata</i>
desert ceanothus	<i>Ceanothus greggii</i>
desert willow	<i>Chilopsis linearis</i>
Douglas-fir	<i>Pseudotsuga menziesii</i>
eggleaf silktassel	<i>Garrya ovata</i>
elbowbush	<i>Forestiera pubescens</i>
elm	<i>Ulmus</i> spp.
evergreen sumac	<i>Rhus virens</i> subsp. <i>virens</i>
feather dalea	<i>Dalea formosa</i>
fleabane	<i>Erigeron</i> spp.
fourwing saltbush	<i>Atriplex canescens</i>
fragrant mimosa	<i>Mimosa borealis</i>
fragrant sumac	<i>Rhus trilobata</i> var. <i>pilosissima</i>
frog-fruit	<i>Lippia nodiflora</i>
golden aster	<i>Heterotheca</i> spp.
goldenrod	<i>Solidago</i> spp.
Goodding willow	<i>Salix gooddingii</i>
gray oak	<i>Quercus grisea</i>
honeysuckle	<i>Lonicera albiflora</i> var. <i>dumosa</i>
javelina bush	<i>Condalia ericoides</i>
juniper	<i>Juniperus</i> spp.
lanceleaf sumac	<i>Rhus lanceolata</i>
lechuguilla	<i>Agave lechuguilla</i>
littleleaf lead tree	<i>Leucaena retusa</i>
littleleaf sumac	<i>Rhus microphylla</i>
little walnut	<i>Juglans microcarpa</i>
Louisiana sagewort	<i>Artemisia ludoviciana</i>

Appendix 2 continued

Common name	Scientific name
mariola	<i>Parthenium incanum</i>
mescal bean	<i>Sophora secundiflora</i>
mesquite	<i>Prosopis glandulosa</i>
Mexican buckeye	<i>Ungnadia speciosa</i>
Mexican orange	<i>Choisya dumosa</i>
Mexican vervain	<i>Verbena ciliata</i>
mimosa	<i>Mimosa</i> spp.
mountain mahogany	<i>Cerocarpus montanus</i> var. <i>paucidentatus</i>
netleaf hackberry	<i>Celtis reticulata</i>
New Mexico agave	<i>Agave neomexicana</i>
oak	<i>Quercus</i> spp.
ocotillo	<i>Fouquieria splendens</i>
oreganillo	<i>Aloysia wrightii</i>
pear	<i>Pyrus communis</i>
pecan	<i>Carya illinoensis</i>
pinyon pine	<i>Pinus edulis</i>
plum	<i>Prunus americana</i>
ponderosa pine	<i>Pinus ponderosa</i>
prickly pear	<i>Opuntia</i> spp.
red berry juniper	<i>Juniperus pinchotii</i>
Rocky Mountain juniper	<i>Juniperus scopulorum</i>
Roemer acacia	<i>Acacia roemeriana</i>
Russian olive	<i>Elaeagnus angustifolia</i>
scrub oak	<i>Quercus pungens</i> var. <i>pungens</i>
sedge	<i>Carex</i> spp.
serviceberry	<i>Amelanchier utahensis</i>
shaggy stenandrium	<i>Stenandrium barbatum</i>
silver dalea	<i>Dalea bicolor</i> var. <i>argyraea</i>
skeletonleaf goldeneye	<i>Viguiera stenoloba</i>
soapberry	<i>Sapindus saponaria</i> var. <i>drummondii</i>
soaptree yucca	<i>Yucca elata</i>
sotol	<i>Dasyllirion leiophyllum</i>
Spanish dagger	<i>Yucca treculeana</i>
spikerush	<i>Eleocharis</i> spp.
splitleaf brickellia	<i>Brickellia laciniata</i>
sunflower	<i>Helianthus</i> spp.
tarbush	<i>Flourensia cernua</i>
Texas madrone	<i>Arbutus xalapensis</i> var. <i>texana</i>
tubetongue	<i>Siphonoglossa pilosella</i>
velvet ash	<i>Fraxinus velutina</i>
velvet-leaf gaura	<i>Gaura parviflora</i>
viscid acacia	<i>Acacia neovernicosa</i>
weeping willow	<i>Salix babylonica</i>
white mulberry	<i>Morus alba</i>
wild buckwheat	<i>Eriogonum</i> spp.
wormwood	<i>Artemisia</i> spp.
Wright silktassel	<i>Garrya wrightii</i>

Appendix 2 continued

Common name	Scientific name
(Grasses)	
alkali sacaton	<i>Sporobolus airoides</i>
Bermuda grass	<i>Cynodon dactylon</i>
big bluestem	<i>Andropogon gerardii</i> var. <i>gerardii</i>
black grama	<i>Bouteloua eriopoda</i>
blue grama	<i>Bouteloua gracilis</i>
brome	<i>Bromus</i> spp.
burro grass	<i>Scleropogon brevifolius</i>
bush muhly	<i>Muhlenbergia porteri</i>
cane bluestem	<i>Bothriochloa barbinodis</i> var. <i>barbinodis</i>
cottontop	<i>Digitaria californica</i>
curlyleaf muhly	<i>Muhlenbergia setifolia</i>
feather grass	<i>Stipa neomexicana</i>
grama	<i>Bouteloua</i> spp.
green sprangletop	<i>Leptochloa dubia</i>
hairy grama	<i>Bouteloua hirsuta</i>
hairy tridens	<i>Erioneuron pilosum</i>
Halls panicum	<i>Panicum hallii</i> var. <i>hallii</i>
Indian grass	<i>Sorghastrum nutans</i>
Johnson grass	<i>Sorghum halepense</i>
June grass	<i>Koeleria macrantha</i>
longleaf squirreltail	<i>Elymus elymoides</i>
love grass	<i>Eragrostis</i> spp.
mesa muhly	<i>Muhlenbergia tenuifolia</i>
muhly	<i>Muhlenbergia</i> spp.
Nealley threeawn	<i>Aristida purpurea</i> var. <i>nealleyi</i>
panicum	<i>Panicum</i> spp.
plains bristle grass	<i>Setaria leucopila</i>
plains love grass	<i>Eragrostis intermedia</i>
prairie wedgescale	<i>Sphenopholis obtusata</i> var. <i>obtusata</i>
red grama	<i>Bouteloua trifida</i>
rough tridens	<i>Tridens muticus</i> var. <i>elongatus</i>
sand dropseed	<i>Sporobolus cryptandrus</i>
sandy muhly	<i>Muhlenbergia arenicola</i>
sideoats grama	<i>Bouteloua curtipendula</i>
silver bluestem	<i>Bothriochloa laguroides</i> subsp. <i>torreyana</i>
slim tridens	<i>Tridens muticus</i> var. <i>muticus</i>
Springfield bluestem	<i>Bothriochloa springfieldii</i>
tanglehead	<i>Heteropogon contortus</i>
threeawn	<i>Aristida</i> spp.
tobosa	<i>Hilaria mutica</i>
vine mesquite	<i>Panicum obtusum</i>

Appendix 3. Caves in Carlsbad Caverns National Park mentioned in the text. Elevations represent measurements taken at the entrance to caves and are given in meters and feet above sea level. Elevations are based on park records and are rounded to nearest 50 m and 100 ft. Caves are listed alphabetically.

Cave	Surface elevation	
	meters	feet
Big Horn Cave	1,600	5,200
Carlsbad Cavern		
large opening	1,350	4,400
small opening	1,300	4,300
Chimney Cave	1,300	4,300
Cueva de León	1,350	4,500
Deep Cave	1,800	5,900
Goat Cave	1,450	4,700
Lake Cave ^a	1,600	5,300
Lechuguilla Cave	1,400	4,600
Lost Spider Cave	1,800	5,900
Midnight Goat Cave	1,400	4,600
Ogle Cave	1,450	4,800
Rainbow Cave	1,500	4,900
Recluse Cave	1,500	4,900
Rock Rattler Cave	1,650	5,400
Rockslide Cave	1,400	4,600
Slaughter Canyon Cave ^b	1,450	4,700
Small Cave	1,600	5,200
Spider Cave	1,300	4,300
Window Cave	1,500	4,900

^aLake Cave was named in 1937 but subsequently was called Vandalized Cave. The preferred name is Lake Cave.

^bFor many years this cave was known as New Cave, but in 1993, the cave's original name, Slaughter Canyon Cave, was reinstated.

Appendix 4. Localities where rodents have been collected or sighted in Carlsbad Caverns National Park. Bold-faced numbers in parentheses correspond to circled numbers in Fig. 80. Localities in close proximity to one another are listed together and are represented by the same number. Localities not precise enough to be plotted on the map are listed separately at the end of the appendix and are not numbered. In general, localities are listed from east to west within an area or region.

Localities on reef:

- (1) 0.21 mi. N, 0.31 mi. W Whites City, T24S, R25E, N ½ Sec. 34.
- (2) 0.35 mi. W, 0.51 mi. N Whites City, T24S, R25E, S ½ Sec. 27.
- (3) 1 mi. below wayside #2 exhibit parking area, T24S, R25E, SW ¼ Sec. 27.
- (4) 0.06 mi. N, 0.67 mi. W Whites City, T24S, R25E, NW ¼ Sec. 34.
- (5) 1 mi. W park entrance, Walnut Canyon.
- (6) 0.99 mi. N, 1.25 mi. W Whites City, T24S, R25E, NE ¼ Sec. 28.
- (6) 1.14 mi. N, 1.45 mi. W Whites City, T24S, R25E, NW ¼ Sec. 28.
- (6) 1.18 mi. N, 1.57 mi. W Whites City, T24S, R25E, NW ¼ Sec. 28.
- (7) 1.96 mi. W, 1.17 mi. N Whites City, T24S, R25E, NE ¼ Sec. 29.
- (7) floor of Walnut Canyon, T24S, R25E, NE ¼ Sec. 29.
- (8) 1 mi. below big curve, Walnut Canyon.
- (8) near Indian Shelter Exhibit in Walnut Canyon.
- (9) Bat Cave Draw, 1 mi. E of entrance [entrance = large natural opening of Carlsbad Cavern].
- (10) 0.33 mi. N, 0.04 mi. W Sewage Disposal Ponds, T24S, R25E, SE ¼ Sec. 31.

Localities in and around the large natural opening of Carlsbad Cavern, inside Carlsbad Cavern, and in and around the Visitor Center.

- (11) 0.45 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N ½ Sec. 31.
- (11) Bat Cave Draw, near second shaft.
- (11) by guano shafts.
- (12) 0.05 mi. N, 0.32 mi. E main entrance to Carlsbad Cavern, T24S, R25E, N ½ Sec. 31.
- (13) large natural opening of Carlsbad Cavern; natural entrance; cavern area; Carlsbad Cavern.
- (13) ridge near Carlsbad Cavern.
- (13) Bat Cave in Carlsbad Cavern.
- (13) underground lunchroom in Carlsbad Cavern.
- (13) curio building of the Cavern Supply Company.
- (13) ticket office.
- (13) parking lot near large natural opening of Carlsbad Cavern.
- (13) elevator bridge trail; elevator building trail bridge.
- (13) 0.15 mi. N, 0.12 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31.
- (13) 0.16 mi. N, 0.12 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31.
- (13) Carlsbad Cave [inside house near Carlsbad Cavern].
- (13) residence area; Lee Robinson's garden.
- (13) park headquarters; administration building; headquarters area; women's dorm.
- (13) naturalist office.
- (14) 0.13 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 31.
- (15) 0.28 mi. N, 0.05 mi. E Visitor Center, T24S, R24E, NE ¼ Sec. 36.
- (15) 0.32 mi. N, 0.03 mi. E Visitor Center, T24S, R24E, NE ¼ Sec. 36.
- (16) 0.28 mi. S, 0.04 mi. E Visitor Center, T24S, R24E, SE ¼ Sec. 36.
- (17) Parking lot of Visitor Center, T24S, R24E, NE ¼ Sec. 36.
- (17) Visitor Center, T24S, R24E, NE ¼ Sec. 36.

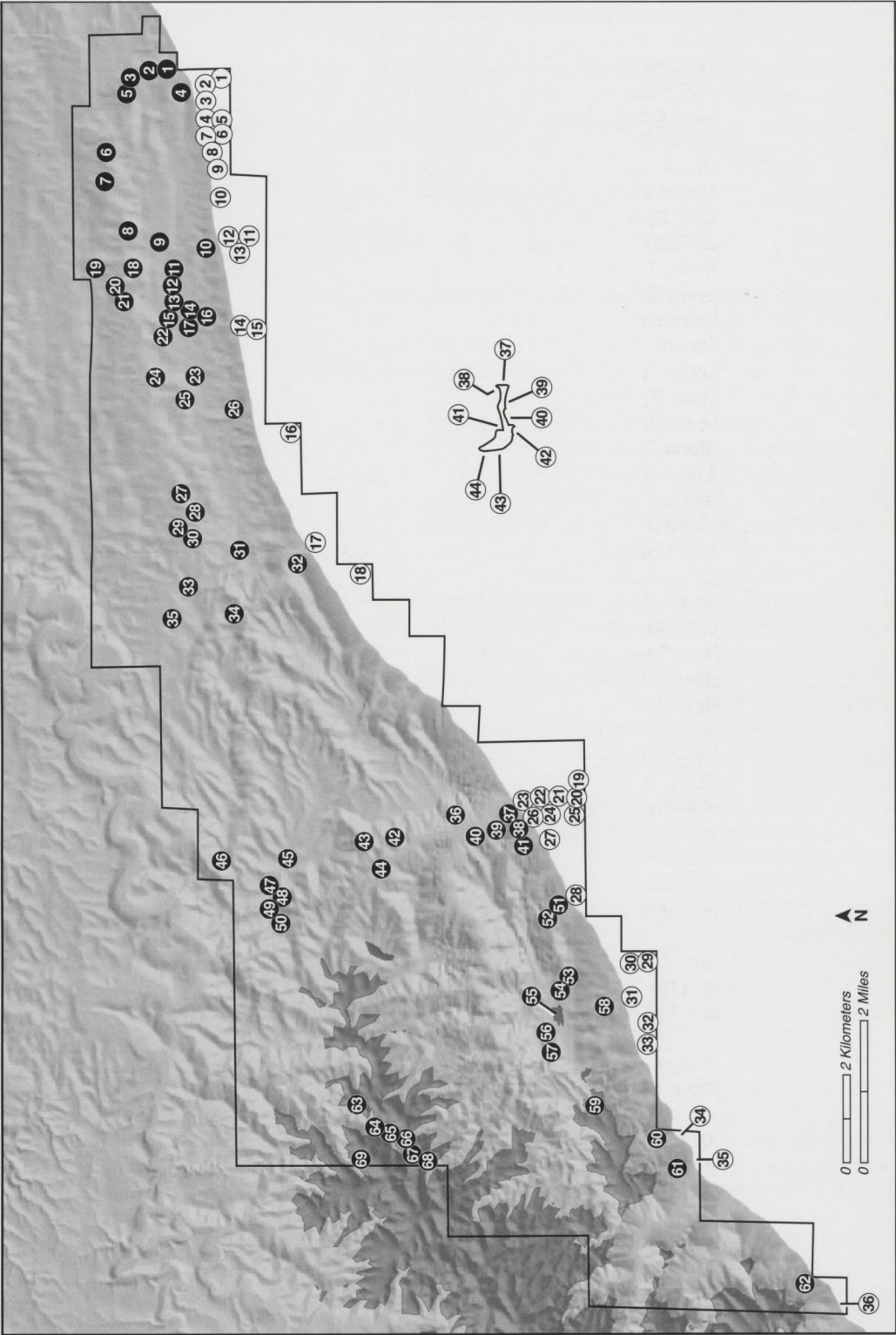


Fig. 80. Localities where rodents have been collected or sighted in Carlsbad Caverns National Park. Localities on the reef are represented by white numbers in black circles and those on the seabed by black numbers in white circles. Circled numbers correspond to bold-faced numbers in Appendix 4 and to italicized numbers listed under *Museum specimens* and *Additional records* in species accounts.

Appendix 4 continued

- (18) 0.67 mi. N, 0.76 mi. E Visitor Center, T24S, R25E, SE ¼ Sec. 30.
- (19) near Grammer Pool, T24S, R25E, NE ¼ Sec. 30.
- (20) 1.0 mi. N, 0.52 mi. E Visitor Center, T24S, R25E, N ½ Sec. 30.
- (21) 0.97 mi. N, 0.37 mi. E Visitor Center, T24S, R25E, NW ¼ Sec. 30.
- (22) Oak Spring, T24S, R24E, NE ¼ Sec. 36.
- (23) 0.77 mi. W, 0.15 mi. S Visitor Center, T24S, R24E, SW ¼ Sec. 36.
- (24) 0.56 mi. W, 0.17 mi. N Oak Spring, T24S, R24E, SW ¼ Sec. 25.
- (25) near Spider Cave, T24S, R24E, NE ¼ Sec. 35.
- (26) face of eastern escarpment, T25S, R24E, NE ¼ Sec. 2.
- (27) 0.34 mi. N, 0.91 mi. E Lowe Spring, T24S, R24E, N ½ Sec. 34.
- (28) 0.71 mi. E, 0.12 mi. N Lowe Spring, T24S, R24E, W ½ Sec. 34.
- (28) Exhibit #13 in Walnut Canyon, 0.70 mi. E, 0.17 mi. N Lowe Spring, T24S, R24E, W ½ Sec. 34.
- (29) 0.47 mi. E, 0.36 mi. N Lowe Spring, T24S, R24E, NE ¼ Sec. 33.
- (30) 0.18 mi. N, 0.37 mi. E Lowe Spring, T24S, R24E, NE ¼ Sec. 33.
- (31) 0.13 mi. E, 0.46 mi. S Lowe Spring, T25S, R24E, NE ¼ Sec. 4.
- (32) 0.43 mi. S, 0.64 mi. E Stone Spring, T25S, R24E, S ½ Sec. 4.
- (33) 0.30 mi. W, 0.30 mi. N Lowe Spring, T24S, R24E, NW ¼ Sec. 33.
- (34) 1 mi. up Rattlesnake Canyon.
- (34) 1.5 mi. up Rattlesnake Canyon.
- (35) 0.73 mi. W, 0.48 mi. N Lowe Spring, T24S, R24E, NE ¼ Sec. 32.

Localities near Slaughter Canyon Cave:

- (36) 0.22 mi. SW Ogle Cave, T25S, R23E, NE ¼ Sec. 23.
- (37) 0.24 mi. S, 0.28 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23.
- (37) 0.24 mi. S, 0.23 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23.
- (38) 0.32 mi. S, 0.19 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26.
- (39) below New Cave [= Slaughter Canyon Cave] in Slaughter Canyon.
- (39) foot trail to Slaughter Canyon Cave, T25S, R23E, SE ¼ Sec. 23.
- (39) 0.18 mi. E New Cave, T25S, R23E, SE ¼ Sec. 23.
- (40) 0.30 mi. N, 0.12 mi. E New Cave, T25S, R23E, NE ¼ Sec. 23.
- (41) face of eastern escarpment, T25S, R23E, NE ¼ Sec. 26.
- (41) 0.39 mi. S New Cave, T25S, R23E, NE ¼ Sec. 26.

- (42) near Clement Ranch, Slaughter Canyon [= Clemond Ranch, T25S, R23E, E ½ Sec. 14; ranch is 0.65 mi. S Goat Cave].
- (43) near Goat Cave, Slaughter Canyon [Goat Cave is in a side canyon of North Slaughter Canyon, T25S, R23E, SE ¼ Sec. 11].
- (44) Middle Slaughter Canyon, T25S, R23E, NW ¼ Sec. 14.

Localities along Guadalupe Ridge:

- (45) 1.12 mi. N, 0.23 mi. W Goat Cave, T25S, R23E, SW ¼ Sec. 2.
- (46) 2.03 mi. N, 0.27 mi. W Goat Cave, T24S, R23E, SW ¼ Sec. 35.
- (47) 1.37 mi. N, 0.65 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3.
- (47) along Guadalupe Ridge, T25S, R23E, Sec. 3.
- (48) 1.23 mi. N, 0.78 mi. W Goat Cave, T25S, R23E, SE ¼ Sec. 3.
- (49) 1.33 mi. N, 0.95 mi. W Goat Cave, T25S, R23E, E ½ Sec. 3.
- (50) 1.22 mi. N, 1.05 mi. W Goat Cave, T25S, R23E, S ½ Sec. 3.

- (51) 0.95 mi. S, 0.90 mi. W New Cave, T25S, R23E, SE ¼ Sec. 27.
- (52) Yucca Canyon, T25S, R23E, S ½ Sec. 27.

Appendix 4 continued

Localities near Yucca Cabin:

- (53) 1.03 mi. E, 0.22 mi. S Longview Spring, T25S, R23E, SE ¼ Sec. 28.
- (54) 0.13 mi. S, 0.72 mi. E Longview Spring, T25S, R23E, SW ¼ Sec. 28.
- (55) inside Yucca Cabin, T25S, R23E, W ½ Sec. 28.
- (55) near Yucca Cabin, T25S, R23E, W ½ Sec. 28.
- (55) 0.03 mi. S, 0.52 mi. E Longview Spring, T25S, R23E, W ½ Sec. 28.
- (56) 0.15 mi. N, 0.25 mi. E Longview Spring, T25S, R23E, NE ¼ Sec. 29 [ravine with Dog Pen Seep].
- (57) 18 yards E Longview Spring, T25S, R23E, E ½ Sec. 29.
- (57) Longview Spring, T25S, R23E, E ½ Sec. 29.

- (58) 0.62 mi. S, 0.61 mi. E Longview Spring, T25S, R23E, NW ¼ Sec. 33.
- (59) 0.29 mi. N, 0.03 mi. W Red Cave, T25S, R23E, NE ¼ Sec. 31.
- (60) 0.57 mi. S, 0.52 mi. W Red Cave, T25S, R23E, SW ¼ Sec. 31.
- (61) 0.95 mi. S, 0.86 mi. W Red Cave, T26S, R23E, NW ¼ Sec. 6.
- (62) 1.76 mi. S, 0.37 mi. W Double Cave, T26S, R22E, NW ¼ Sec. 14.

Localities near Putman Cabin:

- (63) 0.72 mi. E, 0.83 mi. N Putman Cabin, T25S, R23E, SE ¼ Sec. 7.
- (64) 0.51 mi. N, 0.30 mi. E Putman Cabin, T25S, R23E, NW ¼ Sec. 18 [next to Log Cabin Seep].
- (65) Putman Canyon, T25S, R23E, NW ¼ Sec. 18.
- (66) 0.02 mi. N, 0.12 mi. E Putman Cabin, T25S, R23E, SW ¼ Sec. 18.
- (67) near Putman Cabin, T25S, R23E, SW ¼ Sec. 18.
- (67) Knoll of Putman Cabin, T25S, R23E, SW ¼ Sec. 18.
- (67) Putman Cabin, T25S, R23E, SW ¼ Sec. 18 [in shed next to cabin].
- (68) 0.06 mi. S, 0.03 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 18.
- (69) 0.73 mi. N, 0.06 mi. W Putman Cabin, T25S, R23E, SW ¼ Sec. 7.

Localities on seabed:

- (1) 0.59 mi. S, 0.38 mi. W Whites City, T24S, R25E, S ½ Sec. 34.
- (2) 0.17 mi. S, 0.55 mi. W Whites City, T24S, R25E, SW ¼ Sec. 34.
- (3) 0.24 mi. S, 0.82 mi. W Whites City, T24S, R25E, SW ¼ Sec. 34.
- (4) 1 mi. W Whites City, along high line.
- (5) 1.08 mi. W, 0.45 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33.
- (5) 1.10 mi. W, 0.40 mi. S Whites City, T24S, R25E, SE ¼ Sec. 33.
- (6) 0.51 mi. S, 1.35 mi. W Whites City, T24S, R25E, S ½ Sec. 33.
- (7) 1.43 mi. W, 0.26 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33.
- (7) 1.43 mi. W, 0.37 mi. S Whites City, T24S, R25E, S ½ Sec. 33.
- (8) 1.53 mi. W, 0.29 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33.
- (9) 1.79 mi. W, 0.40 mi. S Whites City, T24S, R25E, SW ¼ Sec. 33.
- (10) 0.74 mi. E, 0.21 mi. N Sewage Disposal Ponds, T24S, R25E, SE ¼ Sec. 32.

Localities near Sewage Disposal Ponds:

- (11) 0.12 mi. S, 0.21 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5.
- (11) 0.06 mi. S, 0.14 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5.
- (12) 0.23 mi. N, 0.07 mi. E Sewage Disposal Ponds, T24S, R25E, SW ¼ Sec. 32.
- (12) 0.12 mi. N, 0.05 mi. E Sewage Disposal Ponds, T24S, R25E, SW ¼ Sec. 32.
- (13) 0.08 mi. E Sewage Disposal Ponds, T25S, R25E, NW ¼ Sec. 5.
- (13) 0.09 mi. S, 0.02 mi. E Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6.
- (13) Sewage Disposal Ponds, T25S, R25E, NE ¼ Sec. 6 [in adjacent human-disturbed area].

Appendix 4 continued

- (14) 1.01 mi. W, 0.05 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1.
- (15) 1.15 mi. W, 0.22 mi. S Sewage Disposal Ponds, T25S, R24E, NE ¼ Sec. 1.
- (16) 0.92 mi. S, 0.53 mi. W Chimney Cave, T25S, R24E, SW ¼ Sec. 2.
- (17) 0.57 mi. S, 0.87 mi. E Stone Spring, T25S, R24E, NE ¼ Sec. 9.
- (18) 1.37 mi. S, 0.57 mi. E Stone Spring, T25S, R24E, S ½ Sec. 9.

Localities along Slaughter Canyon Draw:

- (19) 1.24 mi. S, 0.76 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25.
 - (20) 1.24 mi. S, 0.57 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25.
 - (21) ¾ mi. S mouth of Slaughter Canyon, T25S, R23E, SW ¼ Sec. 25.
 - (22) 0.58 mi. S, 0.52 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25.
 - (23) 0.39 mi. S, 0.48 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25.
 - (24) 0.71 mi. S, 0.45 mi. E New Cave, T25S, R23E, NW ¼ Sec. 25.
 - (25) 1.22 mi. S, 0.44 mi. E New Cave, T25S, R23E, SW ¼ Sec. 25.
 - (26) 0.49 mi. S, 0.37 mi. E New Cave, T25S, R23E, NE ¼ Sec. 26.
- (27) 0.52 mi. S New Cave, T25S, R23E, NE ¼ Sec. 26.
 - (28) 1.08 mi. S, 0.79 mi. W New Cave, T25S, R23E, SE ¼ Sec. 27.
 - (29) 1.47 mi. S, 1.39 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33.
 - (30) 1.25 mi. S, 1.32 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 33.
 - (31) 0.96 mi. S, 0.78 mi. E Longview Spring, T25S, R23E, W ½ Sec. 33.
 - (32) 1.44 mi. S, 0.42 mi. E Longview Spring, T25S, R23E, SW ¼ Sec. 33.
 - (33) 1.40 mi. S, 0.23 mi. E Longview Spring, T25S, R23E, SE ¼ Sec. 32.
 - (34) 0.78 mi. S, 0.56 mi. W Red Cave, T26S, R23E, NW ¼ Sec. 6.
 - (35) 1.15 mi. S, 0.85 mi. W Red Cave, T26S, R23E, W ½ Sec. 6.
 - (36) 2.14 mi. S, 0.76 mi. W Double Cave, T26S, R22E, NW ¼ Sec. 14.

Localities at Rattlesnake Springs:

- (37) 0.08 mi. N, 0.64 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23.
- (38) 0.09 mi. N, 0.58 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23.
- (39) 0.08 mi. N, 0.37 mi. E Rattlesnake Spring, T25S, R24E, SE ¼ Sec. 23.
- (39) picnic area at Rattlesnake Springs, T25S, R24E, SE ¼ Sec. 23.
- (40) 0.12 mi. E, 0.06 mi. N Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23.
- (40) 250 meters E, 75 meters N Rattlesnake Spring.
- (41) orchard next to ranger station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23.
- (41) Ranger Station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23.
- (41) front yard of ranger station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23.
- (41) next to ranger station at Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23.
- (42) near water-storage pond, Rattlesnake Springs, T25S, R24E, SW ¼ Sec. 23.
- (42) Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23.
- (43) 0.18 mi. N, 0.18 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23.
- (44) 0.34 mi. N, 0.22 mi. W Rattlesnake Spring, T25S, R24E, SW ¼ Sec. 23.

Localities not plotted in Fig. 80:

Walnut Canyon.

Bat Cave Draw.

Carlsbad Cave.

3 mi. W Whites City.

4 mi. W Whites City.

6 mi. W Whites City.

8 mi. W Whites City.

Rattlesnake Canyon.

Slaughter Canyon.

mouth of Slaughter Canyon.

Putman Canyon.

Rattlesnake Springs.

Rattlesnake Springs Propagation Area.

Appendix 5. Reproductive information for vespertilionid bats at Carlsbad Caverns National Park. Dates of lactation and dates that young were captured in flight are based on data collected from 1973 to 2000. Young are listed only if cartilaginous plates in finger joints were visible to the unaided eye.

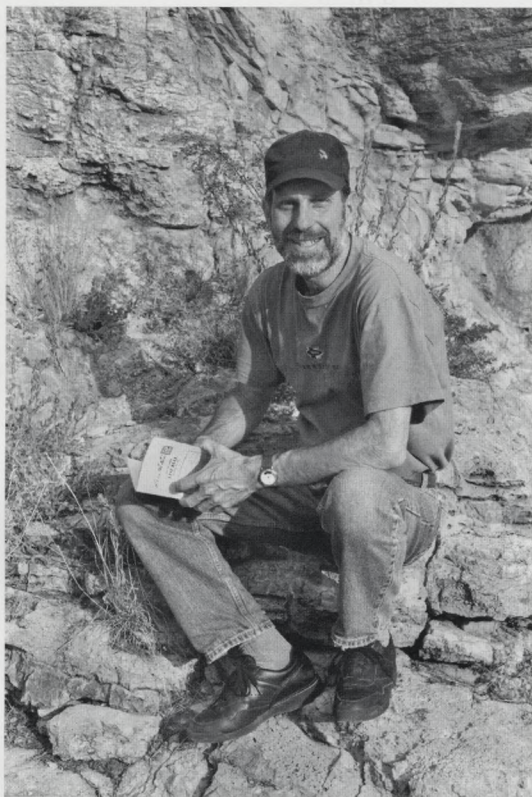
Lactating Females

Species	June	July	August
<i>Myotis velifer</i>	—	9, 10, 17, 23	8
<i>Myotis thysanodes</i>	17, 21, 30	9, 15, 23, 25, 29	10
<i>Myotis californicus</i>	12, 17	—	—
<i>Pipistrellus hesperus</i>	12, 17, 21	9, 10, 11, 23, 25	2, 11
<i>Eptesicus fuscus</i>	—	7, 10, 18, 25	2, 3, 13
<i>Lasiurus borealis</i>	—	9	—
<i>Corynorhinus townsendii</i>	21	7	2
<i>Antrozous pallidus</i>	—	7, 9, 10, 11, 18	—

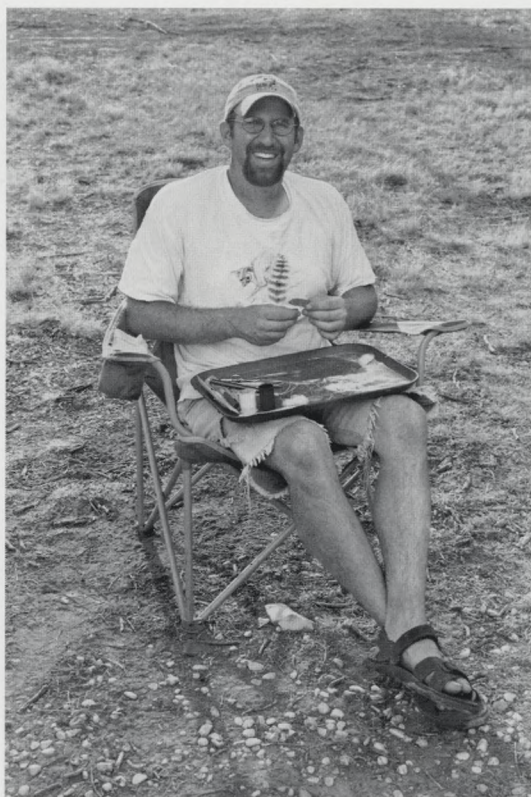
Volant Young

Species	July	August
<i>Myotis velifer</i>	6, 7, 9, 18, 25, 27	5, 7, 9, 10
<i>Myotis thysanodes</i>	15, 29	6, 9, 10, 20
<i>Myotis californicus</i>	25	16
<i>Myotis ciliolabrum</i>	—	11
<i>Pipistrellus hesperus</i>	23, 27	6, 8, 9, 13
<i>Eptesicus fuscus</i>	—	2, 9, 13, 16
<i>Lasiurus borealis</i>	9, 25	—
<i>Antrozous pallidus</i>	27	9, 13, 16

ABOUT THE AUTHORS



Ken in Walnut Canyon.



Keith at Rattlesnake Springs.

Ken Geluso is a professor of biology at the University of Nebraska at Omaha. Although Ken first visited Carlsbad Caverns National Park in 1973, he remembers learning about “the bats” of Carlsbad Cavern while growing up on Long Island, New York in the 1950s. After obtaining a bachelor’s degree at the University of Vermont in 1967, Ken headed west to attend graduate school at the University of Oklahoma. For his master’s research, he studied the distribution of five species of *Peromyscus* in the Black Mesa region of Oklahoma. While at Oklahoma, Ken was introduced to the state of New Mexico by his good friend and fellow graduate student, Troy Best.

In 1969, Ken was accepted into the graduate program at the University of New Mexico and began studying bats under the direction

(continued on next page)

Keith Geluso is a doctoral candidate at the University of New Mexico. For his dissertation, he is studying foraging behaviors and strategies of granivorous rodents under the tutelage of James Brown and Michael Bogan. In 1998, Keith completed his master’s degree at the University of Nevada under the advisement of Jack Hayes. For his thesis, Keith studied effects of dietary quality on metabolic rate and internal morphology of starlings.

Keith’s interests in biology started early. At a young age, he traveled to many parts of the United States on field trips with his dad, Ken Geluso. This exposure to nature led him to pursue a bachelor’s degree in biology at the University of New Mexico. Keith’s interests in biology are broad and include ecology, behavior, physiology, and natural history of mammals and birds.

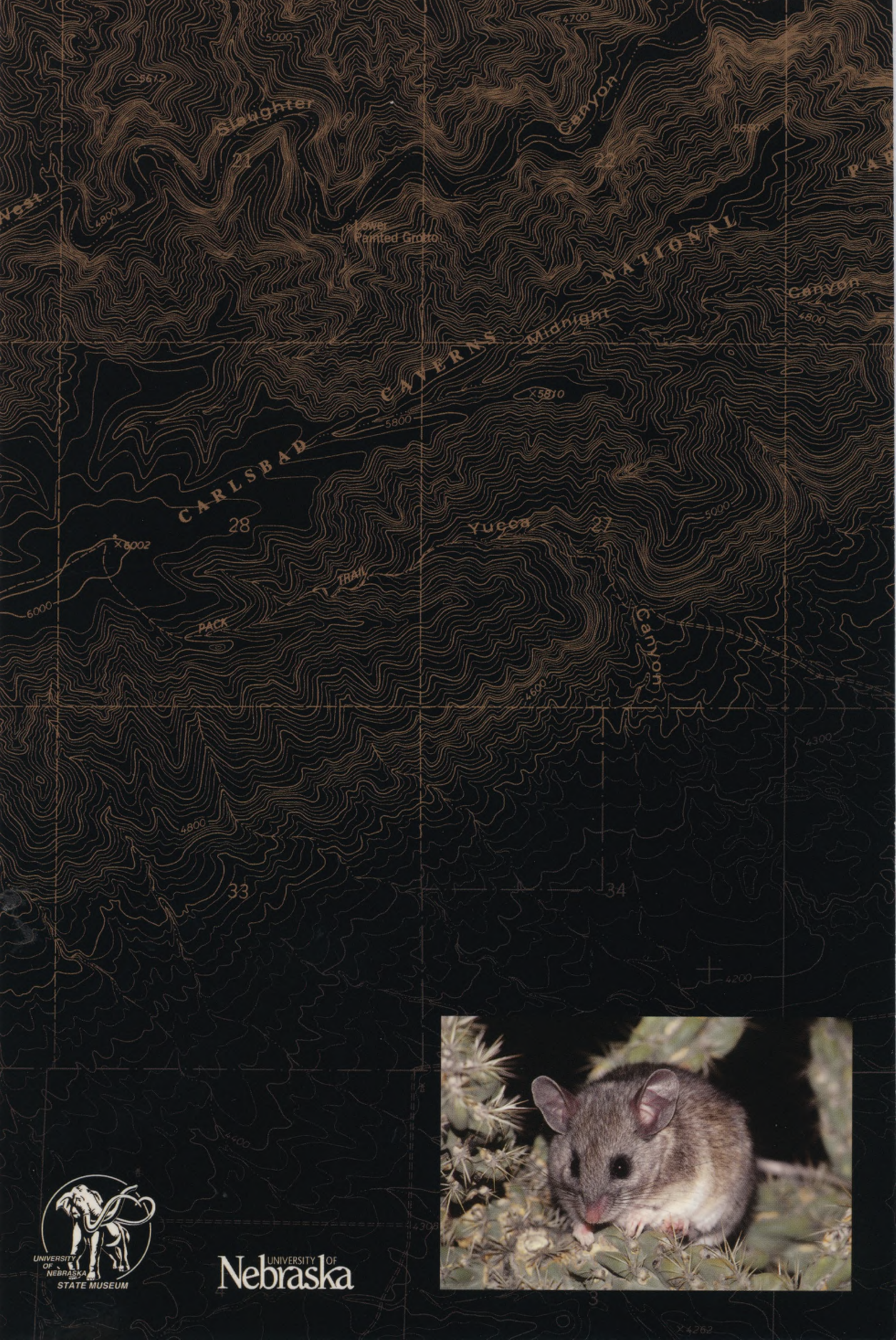
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of Professor James Findley, as many other students had done before (Geluso and Wilson 1997). Ken's research for his dissertation involved an ecophysiological study of insectivorous bats. After receiving his doctorate, Ken began his research at the park and in 1977 was hired as an Assistant Professor at UNO. While pursuing his teaching career, Ken's research has focused on renal form and function in small mammals, effects of pesticides on bats, and the natural history of Nebraskan and New Mexican mammals.

While working on his graduate degrees, Keith also found time to conduct natural history studies of mammals in Nevada, New Mexico, and Nebraska. Most recently he has worked for the U.S. Geological Survey at the Arid Lands Field Station in Albuquerque. While working for this agency, Keith has been involved in a variety of projects that include studying the roosting behavior of little brown bats in the Rocky Mountains, studying foraging movements of long-nosed bats in New Mexico, and conducting mammalian inventories at nine national parks and two national wildlife refuges.



Back cover inset: The cactus mouse (*Peromyscus eremicus*) is one of six species of white-footed mice (*Peromyscus*) inhabiting Carlsbad Caverns National Park. Photograph by Keith Geluso.



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