TEXAS TECH UNIVERSITY
Natural Science Research Laboratory

Occasional Papers

Museum of Texas Tech University Number 386 15 May 2023

Notes on Terrestrial Mammals of the Ocotillo Hills, Eddy County, New Mexico

Jennifer K. Frey, Jason L. Malaney, and Michael T. Hill

Abstract

Little is known about the mammalian fauna of the Pecos Plains in southeastern New Mexico. We surveyed for terrestrial mammals at Living Desert Zoo and Gardens State Park, located on the Pecos Plains in the Ocotillo Hills, Eddy County, New Mexico. Small mammal surveys occurred at five sites that represented the major vegetation types in the area, and other mammals were observed throughout the park. Twenty-three species of mammals were documented in the park. The small mammal community in a riparian woodland was most distinct with highest richness and relative abundance and was dominated by the Hispid Cotton Rat (*Sigmodon hispidus*) and White-footed Deermouse (*Peromyscus leucopus*), but also included Merriam's Pocket Mouse (*Perognathus merriami*) and Western Harvest Mouse (*Reithrodontomys megalotis*). The Eastern White-throated Woodrat (*Neotoma leucodon*) and Lacey's White-ankled Mouse (*Peromyscus laceianus*) dominated two rocky sites, one on a hillside with succulent desertscrub and one on an escarpment dominated by Red-berry Juniper (*Juniperus coahuilensis*). The juniper escarpment site also contained Merriam's Kangaroo Rat (*Dipodomys merriami*). The small mammal communities in two grass-dominated sites had relatively low abundance, with most captures consisting of the Hispid Cotton Rat and Southern Plains Woodrat (*Neotoma micropus*). The small mammal community of the park differed from those in similar ecological settings at Carlsbad Caverns National Park. Results contribute to a better understanding of the mammal fauna of the Chihuahuan Desert region.

Key words: Chihuahuan Desert, diversity, inventory, Living Desert Zoo and Gardens State Park, mammal, New Mexico, Pecos River, protected area, rodents, survey

Introduction

The Chihuahuan Desert region of southeastern New Mexico occurs in the low elevations surrounding the Pecos River (i.e., the Pecos Plains) and extends from Eddy County in the south, northward into Guadalupe County where the desert grades into Great Plains ecosystems. Despite 160 years of formal study of New Mexico mammals, relatively little is known about the mammals occupying this region. The most well-studied mammal fauna is from Carlsbad Caverns National Park (CCNP), Eddy County, which was surveyed by Bailey (1928) and Geluso and Geluso (2004), and the adjacent Guadalupe Mountains National Park (GMNP), Culberson County, Texas, which was surveyed by Genoways et al. (1979). A total of 68 species of mammals are

known to have historically occurred or currently occur at CCNP (Geluso and Geluso 2004). Specimen records from the region have been compiled as part of general monographs of the mammals of New Mexico (Bailey 1931; Findley et al. 1975), Texas (e.g., Bailey 1905; Schmidly and Bradley 2016), and the Trans-Pecos region of Texas (Schmidly 1977). The Chihuahuan Desert of the Trans-Pecos region is biologically unique, but subject to habitat alteration due to human mediated activities, especially livestock grazing and petroleum reserve development that synergistically interact with climate changes.

Outside of CCNP, the Living Desert Zoo and Gardens State Park (LDZGSP) is the only other sizable area of formally protected public land in Eddy County. LDZGSP is located ca 35 km NNE of CCNP, is owned and managed by the state, and it encompasses 224 ha of the Ocotillo Hills west of Carlsbad city limits. The focal point of the park is a developed zoological and botanical complex dedicated to public outreach and education about native Chihuahuan Desert ecosystems (NMSP undated). However, most of the park is undeveloped and provides representation of intact ecological systems of the Chihuahuan Desert. No data are available on the wild mammals of the park. Thus, the purpose of this study was to conduct a survey of the terrestrial wild mammals occurring at the LDZGSP.

METHODS

Study area.—LDZGSP is situated in the Ocotillo Hills, which is a small foothills region composed of limestone and dolomite located adjacent to the Pecos River and the city limits of Carlsbad. The Ocotillo Hills represents the northeastern edge of a large complex of escarpments in western Eddy County that are the ancient remains of a reef that formed along the edge of a sea during the Permian geological era. CCNP and GMNP are both located in a more prominent mountainous portion of the former reef, where elevations range from 1,095 m on the flats to 1,990 m at CCNP and 2,650 m at GMNP. LDZGSP is situated almost completely on the former reef, but it is in a lower portion with a maximum elevation of 1,070 m; low elevations in the adjacent Pecos River valley are 955 m. The topography throughout most of the western portion of the park slopes gently upward from the former seabed to the relatively level or rolling crest of the Ocotillo Hills (Fig. 1). The crest of the Ocotillo Hills runs along a northwest to southeast axis. On the northeastern side of the crest, the escarpment is more dramatic and characterized by a series of deep, rugged, easterly-directed canyons. Another major feature of the park is a long draw (major fork of Calabaza Draw) that extends along the northern and northwestern park boundaries and empties into the Pecos River at the eastern base of the Ocotillo Hills.

The LDZGSP is within the Lower Sonoran Life Zone. The general landcover type of this region is Chihuahuan Mixed Desert and Thorn Scrub (https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.722938/Chihuahuan_Mixed_Desert_and_Thorns crub#:~:text=Summary%3A,northern%20portion%20of%20its%20range), which consists of two subtypes: i) the Creosote Bush (*Larrea tridentata*) scrubland occurs on the flats but does not occur in the park; ii) the foothills transition zone occurs throughout most of the park and is dominated by creosote bush and other thorny shrub species such as Lechuguilla (*Agave lechuguilla*), Ocotillo (*Fouquieria splendens*), Honey Mesquite (*Prosopis glandulosa*), Mimosa, Acacia and Opuntia with grass cover usually less than shrubs. However, most areas of the park were dominated by grass and had sparse shrub cover that varied in composition depending on subtle changes in elevation and aspect. Undisturbed grasslands are now rare in the Chihuahuan Desert region but were once vast prior to 19th century expansionism and 20th century development (Kumar et al. 2013). Only a few steep south-facing slopes had classical Chihuahuan desertscrub vegetation. Further, grasslands on the crest and northeastern-facing slopes contained conspicuous elements of the Upper Sonoran Life Zone, such as Red-berry Juniper (*Juniperus coahuilensis*) and Beargrass (*Nolina*; Bailey 1913, 1928). Historically, the park was subject to disturbances due to roads and vehicles, stone removal from borrow pits, and unregulated livestock grazing, which resulted in erosion and soil depletion (NMSP undated). The developed zoological and botanical park complex is located on an elevated finger of land in the southeastern part of the park, and features native plant and animal exhibits,

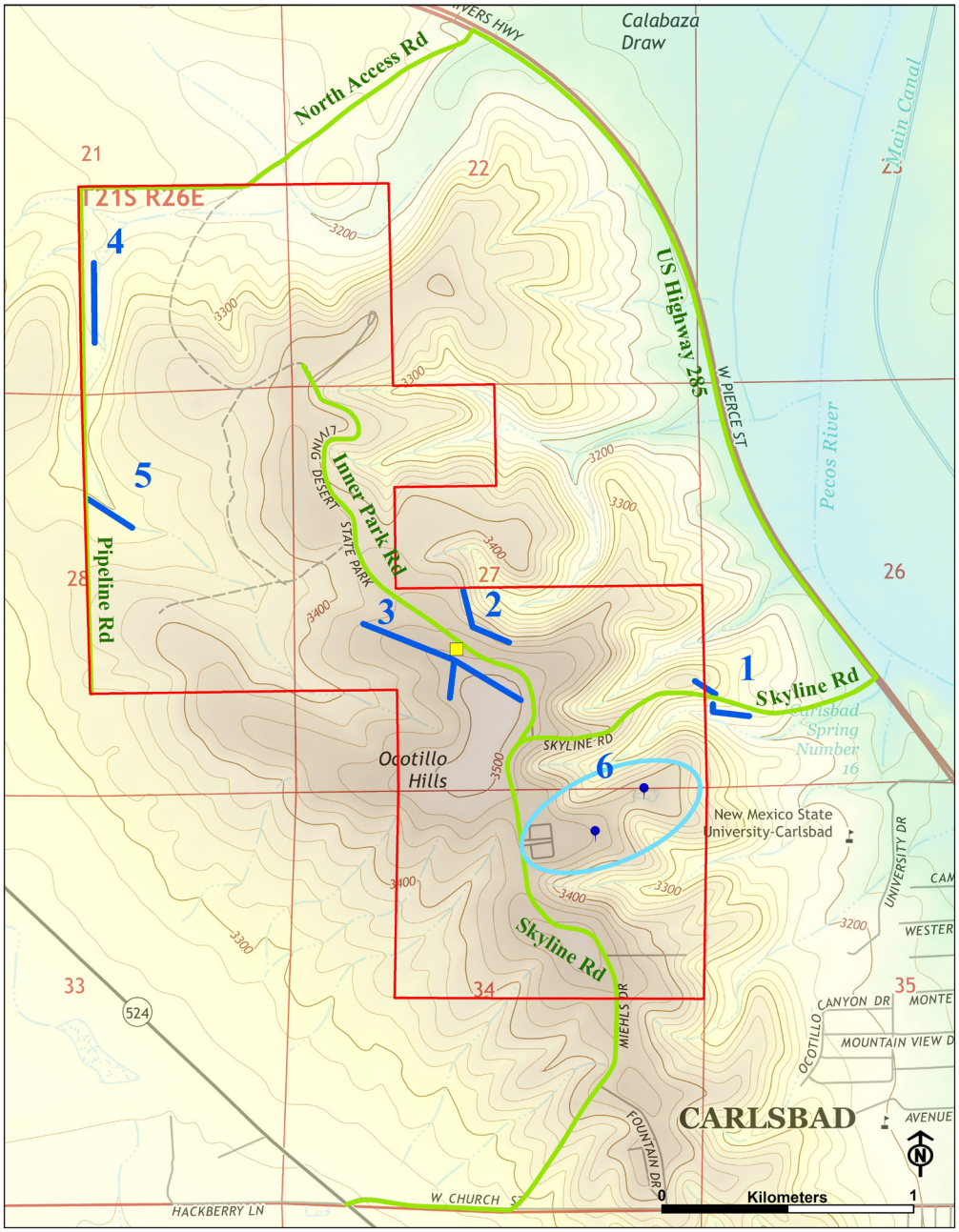


Figure 1. Map showing location of Living Desert Zoo and Gardens State Park (red boundary) in the Ocotillo Hills, Eddy County, which was surveyed for mammals 12–16 May 2008. Map depicts locations of small mammal trapping transects (blue lines) and vehicle survey routes (green lines). Numbers refer to locations described in the Methods and Appendix I. The light blue oval and blue dots labeled 6 represent the developed zoological gardens and artificial ponds, respectively. The yellow box represents location of the base camp.

mature landscaping, two ponds, and various buildings including a visitor's center (Fig. 1).

Field methods.—Surveys were conducted 2–16 May 2008 at five sites chosen to represent the major vegetation types present in the park (Fig. 1, see Appendix I for UTM coordinates). At each site, folding (7.62 cm x 8.89 cm x 22.86 cm) Sherman live traps (model LFATDG; H.B. Sherman, Tallahassee, FL) were set and baited with commercial horse sweet feed (i.e., 3 or 4 grains mixed with molasses) in irregular transects, with traps set approximately every 0.5 to 2 m apart, depending on habitat complexity (i.e., traps spaced closer in more complex environments). Sampling effort was calculated as trap-nights, wherein one trap-night is equivalent to one trap set for one night (e.g., 100 traps set for 2 nights = 200 trap-nights). The total survey effort using Sherman traps was 1,377 trap-nights. Victor gopher traps were used to sample pocket gophers opportunistically. Roads were driven at irregular intervals, both day and night, and mammal observations were recorded (Fig. 1). A predator call was used at irregular intervals during night road surveys. Ten, five-gallon bucket pitfall traps were installed to sample shrews (Appendix I). A handheld global positioning system unit (NAD 83) was used to record survey locations. All mammals captured were identified in the field and either immediately released at the capture location or prepared as museum specimens and followed recommended protocols of the American Society of Mammalogists (Sikes et al. 2016). Representative specimens of each species were prepared as museum voucher specimens and deposited at the Museum of Southwestern Biology, University of New Mexico (MSB).

Analyses.—Relative abundance of small mammals was calculated as the number of individuals captured per 100 trap-nights. Species richness, a metric of species diversity, was calculated as the number of species captured at a location. Principal components analysis was used to compare the composition of species among sites.

Some groups of small mammals, notably deermice (*Peromyscus*) and pocket mice (*Perognathus*), have posed identification difficulties in the region (e.g., Cornely et al. 1981; Brant and Lee 2006). Consequently, voucher specimens at the MSB were used in comparative analyses to aid with species identifications. For *Peromyscus*, standard external measurements (i.e., total, tail, hindfoot, and ear length plus mass) were recorded from a series of 69 reference specimens from Eddy County, including 14 *P. eremicus*, 19 P. *leucopus*, 7 *P. labecula* (formerly *P. maniculatus*), and 29 *P. laceianus* (formerly *P. pectoralis*, Appendix II). Analysis of variance (ANOVA) with post-hoc Student-Newman-Kuels multiple range tests were used to assess univariate patterns of variation among species. Discriminant function analysis (DFA) was used to evaluate the probability of classifying unknown individuals to a known set of individuals of potential species. Statistics were performed with SPSS 10.0 for Windows. Taxonomy and arrangement of mammals follow Wilson and Reeder (2005) and Frey et al. (2004) but are updated to reflect recent taxonomic changes (Malaney et al. 2022). Plant scientific names follow the U.S. Department of Agriculture PLANTS database (http://plants.usda.gov/index.html).

Description of survey locations.—Survey location numbers refer to Fig. 1.

1) Succulent desert hillside: A south-facing hillside dominated by succulent plants was surveyed using 194 trap-nights, 14–16 May 2008 (Fig. 2). Traps were set both south and north of Skyline Road at the eastern park boundary. Slopes were approximately 20–35 degrees, rocky, and had less than 40% vegetation cover. Dominant plants were Lechuguilla, which formed small dense patches of low ground cover, Ocotillo, and prickly pear; grasses, forbs, and low woody sub-shrubs were sparse.

2) Juniper canyon escarpment: The upper escarpments of a canyon on the eastern edge of the Ocotillo Hills was surveyed with 400 trap-nights 12–16 May 2008 (Fig. 3). This site was at the upper end of one of the large east-facing canyons on the east side of the park. Slopes were steep but had abundant ground cover of grasses, forbs, and shrubs; small limestone ridges occurred intermittently. More easterly facing slopes had dense patches of prickly pear, whereas more northerly facing slopes had higher densities of yucca (*Yucca*) and Red-berry Juniper.

3) Grassland/juniper crest: The crest of the Ocotillo Hills was surveyed using 316 trap-nights, 12–16 May 2008 (Fig. 4). Traps were set on level to gentle slopes both along the eastern edge of the escarpment

Figure 2. Photograph of the small mammal survey site (location 1) located on a hillside and dominated by succulent desert vegetation. View is from near the eastern end of the transect looking toward the northeast. Note the road cut of the park entry road that bisects this area. Photo credit Jennifer K. Frey.

Figure 3. Photograph of the small mammal survey site (location 2) located on an escarpment at the upper edge of a canyon where Red-berry Juniper (*Juniperus coahuilensis*) was conspicuous on north-facing slopes. View is from near the center of the transect looking towards the north; note the limestone outcrops. Photo credit Jennifer K. Frey.

Figure 4. Photographs of the small mammal survey site (location 3) located at the crest of the Ocotillo Hills and which was dominated by grassland vegetation with scattered Red-berry Juniper (*Juniperus coahuilensis*). Top: View is from near the eastern end of the transect looking to the southeast towards the developed portion of the zoo illustrating a patch of Upper Sonoran Red-berry Juniper and Beargrass (*Nolina*) association along the northeastern edge of the crest. Bottom: View is from near the center of the transect looking to the south over the crest of the Ocotillo Hills illustrating the open grassland and Prickly Pear (*Opuntia*) association of the top of the crest. Photo credit Jennifer K. Frey.

and over the top of the crest. Soils were composed of rock crumbles and gravel with intermittent large, exposed rocks. Ground cover of grasses ranged from 50 to 75%. The eastern edge of the escarpment was an Upper Sonoran savanna dominated by Red-berry Juniper, but also included Beargrass, tall prickly pear, and Algerita (*Mahonia trifoliolata*). The crest was a more open grassland but included scattered patches of shrubby plants such as Honey Mesquite, Little Leaf Sumac (*Rhus microphylla*), prickly pear, and Catclaw Mimosa (*Mimosa aculeaticarpa*), as well as a few ocotillos and yuccas.

4) Riparian woodland draw: A riparian woodland in a draw was surveyed using 300 trap-nights, 13–16 May 2008 (Fig. 5). The draw was characterized by

Figure 5. Photographs of the small mammal survey site (location 4) located in a riparian draw dominated by lush grass and diverse woody plants. Top: View is near the center of the transect looking across the draw towards the east. Bottom: View is from the bottom of the draw near the center of the transect looking to the south. Photo credit Jennifer K. Frey.

dense, tall shrubs within a matrix of dense grasses that reached up to 80% herbaceous ground cover. Shrubs included large Red-berry Juniper, thickets of Catclaw Mimosa, shrubby Honey Mesquite, Little Leaf Sumac, prickly pear, Cholla (*Cylindropuntia*), and Sotol (*Dasylirion*). Rocks were rare.

5) Grassland/creosote bush valley: A small grassland on relatively deep soils was surveyed using 67 trap-nights, 15–16 May 2008 (Fig. 6). Gopher traps were set in two active pocket gopher burrow systems. Vegetation was composed of dense, tall grasses with scattered Creosote Bush and Red-berry Juniper.

Figure 6. Photograph of the small mammal survey site (location 5) located in a valley dominated by grassland vegetation interspersed with Creosote Bush (*Larrea tridentata*). View is from near the western edge of the transect looking to the east. Photo credit Jennifer K. Frey.

RESULTS AND DISCUSSION

Survey efforts documented 23 species of mammals in the park. Across the trapping transects (Table 1), 169 individuals from nine species of rodents were captured, and another 14 species of rodents, carnivores, and ungulates were documented via other methods. Relative abundance of small mammals documented on transects was within the range of variation reported for the former reef at CCNP (Geluso and Geluso 2004). The riparian woodland draw (location 4) had the highest relative abundance, highest species richness, and most distinctive small mammal community (Table 1, Fig. 7). The high relative abundance was due mainly to captures of Hispid Cotton Rats (*S. hispidus*) that depend on tall, dense grass. Additionally, the White-footed Deermouse (*Peromyscus leucopus*), which is typically associated with low-elevation riparian and shrubby grassland vegetation, was found in highest abundance at this site. Six of the nine species of small mammals were captured at this location, including the only captures of Merriam's Pocket Mouse (*Perognathus merriami*) and Western Harvest Mouse (*Reithrodontomys megalotis*). Presence of *R. megalotis* is notable because it also requires tall, dense herbaceous vegetation (Webster and Jones 1982). At CCNP, *S. hispidus*, *P. leucopus*, and *R. megalotis* were most common in lower elevation grassy areas (Geluso and Geluso 2004). Several species of larger mammals were observed only at this location, including the Desert Cottontail (*Sylvilagus audubonii*), Bobcat (*Lynx rufus*), and Striped Skunk (*Mephitis mephitis*). Most (7/10; 70%) observations of Mule Deer (*Odocoileus hemionus*) were at this site.

Table 1. Relative abundance (captures per 100 trap-nights) and richness (number of species) of small mammals captured in Sherman live-trap transects at Living Desert Zoo and Gardens State Park, Eddy County, New Mexico, during May 2008.

			Species[1]											
No.	Name	Total trap-nights	DIME	PGME	REME	NELE	NEMI	PEER	PELE	PELA	PE??	SIHI	Total relative abundance	Richness
1	Succulent desert hillside	194	0	0	0	5.67	0	1.03	0	4.12	1.55	0	12.37	3
2	Juniper canyon escarpment	400	0	0	0	7.00	0	0	0.75	3.00	0.50	0.25	11.50	4
3	Grassland/juniper crest	416	0.24	0	0	0.72	1.68	0	0.24	0.72	0.72	2.16	6.49	6
4	Riparian woodland draw	300	0	0.33	1.33	1.67	1.00	0	1.33	0	1.33	17.00	24.00	6
5	Grassland/creosote bush valley	67	0	0	0	0	1.49	0	0	0	0	2.99	4.48	2
	Total	1,377	0.08	0.08	0.34	3.95	0.84	0.17	0.67	1.93	1.01	5.12	14.19	9

[1]Species codes: DIME, Merriam's Kangaroo Rat (*Dipodomys merriami*); PGME, Merriam's Pocket Mouse (*Perognathus merriami*); REME, Western Harvest Mouse (*Reithrodontomys megalotis*); NELE, White-toothed Woodrat (*Neotoma leucodon*); NEMI, Southern Plains Woodrat (*Neotoma micropus*); PEER, Cactus Mouse (*Peromyscus eremicus*); PELE, White-footed Deermouse (*Peromyscus leucopus*); PELA, Lacey's White-ankled Mouse (*Peromyscus laceianus*); PE??, unidentified juvenile deermouse (*Peromyscus* spp.); SIHI, Hispid Cotton Rat (*Sigmodon hispidus*).

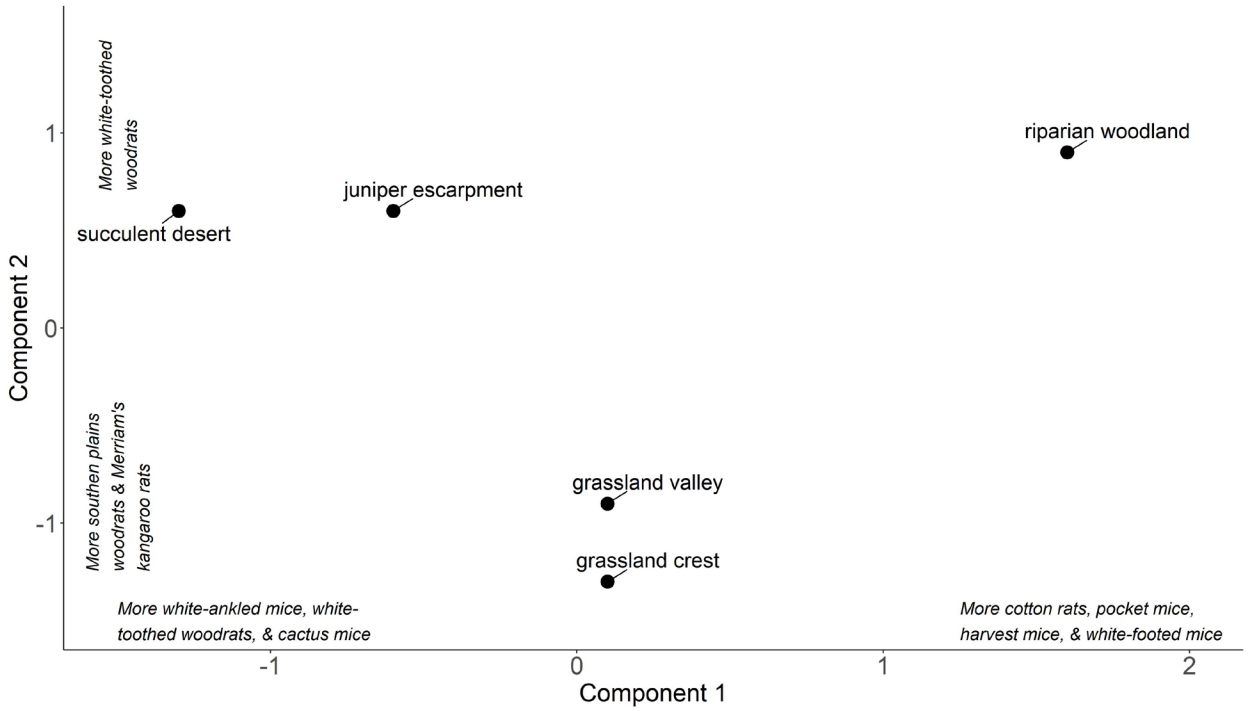


Figure 7. Scatter plot of small mammal community composition (i.e., relative abundance of each small mammal species) on principal components 1 and 2 in May 2008 in the Ocotillo Hills, Eddy County, New Mexico. Axis gradients are indicated in italics. Principal component 1 accounted for 83.6% of the variation and principal component 2 accounted for 15.5% of the variation.

The two rocky sites, the succulent desert hillside site (location 1) and juniper canyon escarpment site (location 2), had similar mammalian communities (Fig. 7). Both had moderate species richness and moderate relative abundance (Table 1) and were dominated by relatively high abundances of the Eastern White-throated Woodrat (*Neotoma leucodon*) and Lacey's White-ankled Mouse (*P. laceianus*), which are both commonly associated with rocky areas, especially *P. laceianus* (Findley et al. 1975; Geluso and Geluso 2004). However, these sites differed in composition of the less abundant species. The only other species documented at the succulent desert hillside location was the Cactus Mouse (*Peromyscus eremicus*). This species is typical of rocky areas within arid, sparsely vegetated desertscrub and hence this was the only location where the species was expected to occur. In contrast, the small mammal community at the juniper canyon escarpment included *S. hispidus*, which is primarily associated with grassland, and *P. leucopus*, which is often found in arid grasslands (Findley et al. 1975).

The two grassland dominated sites, the grassland/juniper crest (location 3) and grassland/creosote bush valley (location 5), had similar small mammal communities (Fig. 7). Both sites were characterized by low overall relative abundance of small mammals, but *S. hispidus* and the Southern Plains Woodrat (*N. micropus*), typical grassland species, had the greatest number of captures (Table 1). The grassland/juniper crest site differed in having a higher diversity of species due to the presence of another grassland species (*P. leucopus*), plus the presence of several species more typical of rocky areas (*N. leucodon*, *P. laceianus*) and Merriam's Kangaroo Rat (*Dipodomys merriami*), which was not found at any other site. *Dipodomys merriami* is usually associated with level Chihuahuan desertscrub and grassland (Findley et al. 1975). Hence, the occur-

rence of *D. merriami* at this site is consistent with its known habitat affiliations. Overall, the low richness at the grassland/juniper site may have been due to the reduced sampling efforts (Table 1). Despite the lack of captures, *P. leucopus* is expected to also occur in that biotic community type as it was captured in similar vegetation in other survey efforts in the region (Bailey 1924; Geluso and Geluso 2004).

Geluso and Geluso (2004) concluded that the distribution of several species of small mammals at CCNP had changed between Vernon Bailey's survey in 1924 and their survey in the 1990s. Specifically, they noted that *P. leucopus*, *N. micropus*, *D. merriami,* and *Dipodomys spectabilis* (Banner-tailed Kangaroo Rat) occurred on the former seabed and reef in the 1920s but were not captured on the former reef during the 1990s. In contrast, we captured *P. leucopus*, *N. micropus*, and *D. merriami* on the former reef at LDZGSP, indicating the former reef continues to provide habitat for these species and that there has not been a wholesale change in small mammal distributions across the region. All four species are associated with the Lower Sonoran life zone, which occurs principally at lower elevations and is dominated by arid Chihuahuan desertscrub and semidesert grassland (Bailey 1913, 1928). The Upper Sonoran life zone occurs at higher elevations, is relatively cooler and more mesic, and dominated by species such as junipers and oaks (*Quercus*). At CCNP, the transition between the Lower and Upper Sonoran zones is 1,524 m (5,000 ft) on southern aspects, 1,372 m (4,500 ft) on gentle southern aspects, and 1,219 m (4,000 ft) on northern aspects (Bailey 1928). Due to differences in overall elevations, nearly the entirety of LDZGS is within the Lower Sonoran zone, whereas almost all the former reef at CCNP is within the Upper Sonoran zone. Thus, occurrence of these four species is expected at LDZGSP, but not throughout the majority of the former reef at CCNP. The terms reef and seabed, although useful for conveying information about geology and topography, do not describe discrete habitats for small mammals.

We offer two explanations for why the Gelusos' failed to record the four species (*P. leucopus*, *N. micropus*, *D. merriami,* and *D. spectabilis*) on the former reef that Bailey had previously documented in 1924. First, it is possible some of these species continue to persist on the former reef at CCNP but were not captured. Bailey captured these species near the entrance to the cavern (i.e., Carlsbad Cavern) on a bench of long limestone ridges at the top of the escarpment of the former reef (Bailey 1928). While the former reef near Carlsbad Caverns is almost entirely within the Upper Sonoran zone, Bailey (1928) described warm south-facing aspects of the ridges as containing Lower Sonoran plant associations. Thus, pockets of Lower Sonoran habitat for these species were limited to localized patches on the ridges. Total sampling effort on the former reef during the Geluso and Geluso (2004) study was similar to ours (2,052 trap-nights versus 1,377 trap-nights, respectively), but their efforts primarily focused on rocky, steep, and high-elevation areas, none of which are typical habitat for these species. Therefore, it is possible some of these species were present on the former reef at CCNP but not documented by Geluso and Geluso (2004).

Second, at CCNP the escarpment of the former reef is rocky, and has a steep southern aspect causing it to be within the Lower Sonoran zone (Bailey 1928). *Peromyscus leucopus*, *N. micropus*, *D. merriami,* and *D. spectabilis* are generally associated with grassy areas of gentle topography, and hence the steep, rocky escarpment, while in the Lower Sonoran zone, is not the preferred habitat for these species (Bailey 1928). Thus, the escarpment likely serves as a strong filter barrier limiting colonization and metapopulation dynamics of these species in small patches of lower Sonoran habitat on the ridges. In such situations, local extirpations can cause intermittently vacant habitat. During Bailey's surveys in 1924, the area around Carlsbad Cavern was overgrazed by livestock and he remarked that Apache Plume (*Fallugia paradoxa*), a secondary forage after primary forage is removed, had been nearly eliminated by livestock grazing and only persisted on rocky sites inaccessible to ungulates. In 1943, 75% of CCNP was severely overgrazed and inadequate management of livestock persisted (NPS 1943). Excessive livestock grazing can cause profound ecosystem changes and local species extirpations (Frey and Malaney 2009). Although CCNP and LDZGNP are both now largely free from livestock grazing, the sheer escarpment at CCNP likely prevents recolonization of these species into vacated habitat. Similarly, annual differences and inter-annual trends in climate can drastically alter

habitats. Climate data from Eddy County indicate that temperatures were at least 1°C cooler during Bailey's survey compared to the mid-1990s and mid-2000s. Similarly, precipitation during Bailey's survey was during a relatively wet period (despite 1924 being exceptionally dry) but the mid-1990's experienced below average precipitation and mid-2000's experienced above average precipitation. Consequently, desertscrub and semidesert grasslands along with their mammalian communities likely fluctuated in response to differing climates across these different periods. Further, *D. spectabilis* was subject to poisoning campaigns (Oakes 2000) that caused extirpation of black-tailed prairie dogs (*Cynomys ludovicianus*) from CCNP (Bailey 1928; Geluso and Geluso 2004). Taken together, marginal habitat, changing grazing pressure, shifting climates, and localized extirpations may have synergistically contributed to Geluso and Geluso (2004) failing to detect these species.

Finally, the regional presence of desertscrub and semidesert grassland associated *P. leucopus*, *N. micropus*, *D. merriami,* and *D. spectabilis* is notable because despite a century of landscape and vegetation changes due to overgrazing, development, and climate shifts, pockets of intact Chihuahuan Desert environments remain. These remnants are important for conservation but also for monitoring change. Specimen-based sampling and other field-based surveys are in decline (Malaney and Cook 2018). Without spatiotemporally continuous sampling and survey efforts, our collective ability to understand when and how both individual species and community-level changes manifest is compromised. This study provides some key insights into local and regional mammalian communities but demonstrates that we still have a lot to learn about desertscrub and semidesert grassland mammalian faunas and, more broadly, the Chihuahuan Desert.

SPECIES ACCOUNTS

ORDER RODENTIA
Family Sciuridae

***Ictidomys parvidens* (Mearns 1896)**
Rio Grande Ground Squirrel

Ictidomys parvidens was formerly classified as *Spermophilus mexicanus* (Helgen et al. 2009). These ground squirrels were observed at several locations including beside Skyline Road at the eastern boundary of the park, near the crest of the Ocotillo Hills near the junction of Skyline Road and the Inner Park Road (UTM 13-567758N-3590049E), and along the pipeline road at the riparian woodland draw (location 4; UTM 13-567091N-3591276E). These records are somewhat unusual because all others from New Mexico apparently were taken from Lower Sonoran vegetation on the flats. In New Mexico, *I. parvidens* is restricted to southern Lea County, and areas near the Pecos River Valley north to central Chaves County (Findley et al. 1975; Choate 1997; Geluso and Geluso 2004).

Family Geomyidae

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

Cratogeomys castanops has been documented from numerous locations in Eddy County (Findley et al. 1975). In New Mexico, this species typically is associated with grasslands on relatively deep soils with few rocks. At CCNP the yellow-faced pocket gopher occurred in relatively deep, friable soils on the flats, whereas Botta's pocket gopher (*Thomomys bottae*) usually occurred in shallow, rocky soils on the former reef (Geluso and Geluso 2004). At the grassland/creosote bush valley (location 5), gopher mounds were prevalent in an area with relatively deep soils with few rocks. Attempts were made to capture gophers this site but were unsuccessful. However, the excavated burrows were almost certainly constructed by *C. castanops* because they were very large (i.e., a human hand could be easily inserted into the burrow; *T. bottae* is smaller bodied and

makes narrower burrows) and piles of fresh-cut grass were stored in each burrow system, which is unique to this species (Davidow-Henry et al. 1989). Thus, *C. castanops* can occur on the former reef in areas of deep soil within the Lower Sonoran Zone. This species may be of conservation concern in New Mexico because distribution and abundance has been reduced (Findley et al. 1975). This species was formerly placed in the genus *Pappogeomys* (Demastes et al. 2002).

Family Heteromyidae

***Dipodomys merriami* Mearns 1890**
Merriam's Kangaroo Rat

A single *Dipodomys merriami* was captured and collected (MSB 344059) during this study at the grassland/juniper crest (location 3). The capture location had a southwestern (more arid) aspect, gravelly soil, sparse grass, and few shrubs, which was an uncommon condition in the park. At CCNP, Bailey (1928) described *D. merriami* as common in the valleys and on the ridges of the former seabed. However, Geluso and Geluso (2004) only documented it on the flats and speculated that it had disappeared or was only sparsely distributed on the former reef. Our record demonstrates that this species continues to occupy the former reef in pockets of suitable habitat.

***Perognathus merriami* J. A. Allen 1892**
Merriam's Pocket Mouse

In Eddy County, two species of small, short-tailed pocket mice (genus *Perognathus*) have been documented, the Silky Pocket Mouse (*P. flavus*) and Merriam's Pocket Mouse (*P. merriami gilvus*), and a third, the Plains Pocket Mouse (*Perognathus flavescens copei*), is possible based on its overall geographic range (Choate et al. 1991). *Perognathus merriami* has been treated as a species or a subspecies of *P. flavus* (Wilson 1973). However, recent genetic and morphological studies have supported *P. merriami* as a species distinct from *P. flavus*, although hybridization between the two forms may occur in Eddy County (Lee and Engstrom 1991; Best and Skupski 1994; Brant and Lee 2006). Identification of the three species is difficult because *P. merriami* and *P. flavus* are morphologically similar, and *P. merriami gilvus* is intermediate in some characters between *P. flavus* and *P. flavescens copei*.

A single pocket mouse was captured and collected (MSB 344036) from the riparian woodland draw (location 4) in an open area lacking shrubs, with dense grasses on relatively deep soil. It was a pregnant female with 4 embryos measuring 6 mm crown-rump length, which also were collected (MSB 344037–344039, 344056). The specimen was referred to the *flavus*/*merriami* group (rather than the *flavescens*/*apache* group) on basis of having: 1) greatly inflated bullae; 2) a relatively small, narrow interparietal with a pentagonal shape with rounded anterior corners; 3) the premaxillae extended distinctly beyond the nasals posteriorly (Merriami 1889; Frey 2007); and 4) the pelage lacking a distinct lateral line (Hall 1981). The specimen was further identified as *P. merriami* on basis of pelage color, external measurements, and cranial characters. Typical of *P. merriami*, the dorsal pelage was orangish grading uniformly to a darker shade mid-dorsally, and the pale post-auricular patches were small and relatively indistinct (Anderson 1972; Best and Skupski 1994; Frey 2007). In pelage color, the specimen resembled a series of *P. flavescens copei* in the MSB from eastern New Mexico. However, the individual differed from a series of pocket mice in the MSB collected from CCNP, which had a pinkish dorsal hue tinged with black and distinct, large, pale post-auricular patches; both features are typical of *P. flavus*. Based on external measurements (total length = 123, tail length = 60, hindfoot = 17, ear length = 6, mass = 9.5 g), the specimen was similar to *P. merriami* in overall large size, proportionately long tail (ca 49% of total length), and short ears (Anderson 1972; Bryant and Lee 2006; Frey 2007). Measurements of the skull were typical of *P. merriami* including a large interorbital breadth (4.88) and the relationship of the mastoid breadth (11.66) and interorbital breadth as depicted in a diagram by Anderson (1972: Fig. 308). However, the relationship of the interparietal length (2.31) to interparietal breadth (2.92) was more nearly square (ratio of the length to breadth of the interparietal = 79.1) as in *P. flavus*, rather than more rectangular (i.e., having a smaller length to breadth ratio) as in *P. merriami*. The specimen was unusual in having an interparietal that was narrower than any reported for *P. flavus* or *P. merriami* by Brant and Lee (2006).

Specimens examined.—Perognathus flavescens copei (*n*=17): New Mexico; Chaves County, 7 mi E Hagerman, T14S, R27E (14896); 3 mi N, 9 mi W

Caprock (29778, 29779, 29780, 29781, 29782, 29784); Lea County, 7 mi N, 15 mi W Jal, T24S, R34E, Sec 14 (14894, 14895); 1.5 mi S, 3.5 mi E Knowles at Texas state line (69486); Quay County, 2 mi S, 0.5 mi E Logan, T13N, R33E, Sec 23 (13046); Roosevelt County, 3.3 mi S of Tolar (29775, 29776, 29777); Union County, 4 mi S Clayton, Perico Creek, T25N, R35E (12647, 12648, 12649). *Perognathus flavus* (*n*=19): New Mexico; Eddy County, Carlsbad Cavern National Park, 1.24 mi S, 0.76 mi E New Cave (63846); Carlsbad Cavern National Park, 1.24 mi S, 0.57 mi E New Cave (63852, 63853, 63854); Carlsbad Cavern National Park, 0.49 mi S, 0.37 mi E New Cave (63887, 63888); Carlsbad Cavern National Park, 0.71 mi S, 0.45 mi E New Cave (63895); Carlsbad Cavern National Park, 0.8 mi E sewage disposal ponds (63940); Carlsbad Cavern National Park, 1.24 mi S, 0.76 mi E New Cave (63846); Carlsbad Cavern National Park, 0.96 mi S, 0.78 mi E Longview Spring (63983, 63984, 63985); Carlsbad Cavern National Park, 0.18 mi N, 0.18 mi W Rattlesnake Spring (64053); Carlsbad Cavern National Park, 0.32 mi N, 0.03 mi E visitor center, T24S, R24E, NW ¼ Sec 36 (65043); Carlsbad Cavern National Park, 0.92 mi S, 0.53 mi W Chimney Cave, T25S, R24E, SW ¼ Sec 2 (65046, 65047); Carlsbad Cavern National Park, 0.09 mi S, 0.02 mi E sewage disposal ponds, T25S, R25Em NE ¼ Sec 6 (65059); Carlsbad Cavern National Park, 1.37 mi S, 0.57 mi E Stone Spring, T25S, R24E, S1/2 Sec 9 (65063); Carlsbad Cavern National Park, 1.47 mi S, 1.39 mi E Longview Spring, T25S, R23E, SE ¼ Sec 33 (65071).

Family Cricetidae

Reithrodontomys megalotis (Baird 1857)
Western Harvest Mouse

In New Mexico, *Reithrodontomys megalotis* may be expected in any area that is dominated by tall, dense herbaceous vegetation (Bailey 1931), which is often afforded by ungrazed riparian areas. At LDZGSP, *R. megalotis* was captured only in the riparian woodland draw, where it was fairly abundant. One voucher specimen was collected (MSB 344051). Similarly, at CCNP the only captures of *R. megalotis* on the former reef were in a grassy draw (Geluso and Geluso 2004).

Neotoma leucodon Merriam 1894
Eastern White-throated Woodrat

This species, also called the White-toothed Woodrat, includes populations east of the Rio Grande that were formerly recognized as *N. albigula* (Planz et al. 1996; Edwards et al. 2001). *Neotoma leucodon* has been document from numerous locations in Eddy County (Findley et al. 1975; Geluso and Geluso 2004). It typically is associated with rocky areas in deserts, grasslands, and woodlands (Findley et al. 1975). At CCNP this was the most common woodrat captured and it was found in a variety of vegetation types on the former reef and flats. At LDZGSP, this was the second most abundant mammal, and it was captured at all locations except the grassland/creosote bush valley. In most instances, this species was captured in rocky situations, and it was the most common species captured at sites with extensive rock (i.e., juniper canyon escarpment, succulent desert hillside). Occasionally the species was captured in non-rocky areas in traps set at the base of large shrubs, such as at the grassland/juniper crest (location 3) and riparian woodland draw (location 4). Five voucher specimens were collected (MSB 344032, 344044–344047), all from the juniper canyon escarpment (location 2).

Neotoma micropus Baird 1855
Southern Plains Woodrat

Neotoma micropus has been documented at numerous locations in Eddy County (Findley et al. 1975; Geluso and Geluso 2004). This woodrat is associated with desert and plains grasslands. At CCNP, Geluso and Geluso (2004) only captured this species on the flats and speculated that it had disappeared from the former reef where it had historically occurred. Our captures of *N. micropus* at LDGZSP indicate that the species continues to occupy the former reef. This woodrat species was captured in all three locations dominated by grass and lacking a large rocky component (i.e., grassland/juniper crest, riparian woodland draw, grassland/creosote bush valley). Only *S. hispidus* was more numerous in the grassland/juniper crest (location 3) and grassland/creosote bush valley (location 5). Three voucher specimens were collected, two from location 3 (MSB 344041, 344048) and one from the riparian woodlands draw (location 4; MSB 344052).

***Peromyscus eremicus* (Baird 1857)**
Cactus Deermouse

Peromyscus eremicus occurs throughout the Chihuahuan Desert in New Mexico where it usually is associated with rocky areas and hot environments (Gennaro 1968; Findley et al. 1975). In eastern New Mexico, the species is known only from southern Eddy County (Findley et al. 1975). *Peromyscus eremicus* was considered uncommon (only three captured) during a mammal survey at CCNP (Geluso and Geluso 2004). At LDZGSP, two *P. eremicus* were captured and collected (MSB 344035, 344067) at the succulent desert hillside (location 1) where it co-occurred with the more abundant *P. laceianus* (Table 1). Within LDZGSP this species likely is relatively uncommon and restricted to small areas of steep south-facing hillsides that provide the hot, desertscrub vegetation preferred by this species. External measurements of reference samples of deermice from Eddy County are in Figure 8 and characters useful for identifying species of deermice occurring at LDZGSP are summarized in Table 2.

***Peromyscus leucopus* (Rafinesque 1818)**
White-footed Deermouse

In the American Southwest, *P. leucopus* typically is associated with low elevation riparian and grassland biotic community types (Findley et al. 1975). *Peromyscus leucopus* was captured most commonly in the riparian woodland draw where it was the only species of deermouse captured. However, the species also occurred at lower abundance in other grass-dominated sites, including the juniper canyon escarpment (location 2) and grassland/juniper crest (location 3), where it co-occurred with the more numerous *P. laceianus*. Two voucher specimens were collected, one from location 2 (MSB 344066) and one from location 3 (MSB 344050).

***Peromyscus laceianus* V. Bailey 1906**
Lacey's White-ankled Deermouse

Also known as Northern White-ankled Deermouse, *Peromyscus laceianus* is known in New Mexico from the Guadalupe Mountains in southeastern Eddy County north through the lowlands between the Sacramento Mountains and Pecos River to northeastern Lincoln County (Findley et al. 1975; Geluso 2004). Geluso's (2004) study served to highlight how poorly surveyed and little known was the mammal fauna of southeastern New Mexico. In New Mexico, this mouse is associated with rocky areas at low and mid elevations, including both the former seabed and reef at CCNP (Geluso 2004; Geluso and Geluso 2004). At CCNP, the species was the most common and widespread species of deermouse. Similarly, at LDZGSP *Peromyscus laceianus* was the most common deermouse and was the third most abundant mammal captured. It was particularly common in rocky areas at the succulent desert hillside (location 1) and juniper canyon escarpment (location 2), but the species also occurred in association with large shrubs at the grassland/juniper crest (location 3). A total of 14 voucher specimens were collected, 7 from location 1 (MSB 344054, 344055, 344057, 344058, 344061–344063), 5 from location 2 (MSB 344030, 344031, 344034, 344043, 344064), and 2 from location 3 (MSB 344042, 344065).

***Sigmodon hispidus* Say and Ord 1825**
Hispid Cotton Rat

Sigmodon hispidus has been documented from numerous locations in Eddy County (Findley et al. 1975; Geluso and Geluso 2004). This species is associated with desert and plains grasslands and other low elevation community types where grasses provide cover (Findley et al. 1975). At CCNP, only 3 of 84 *S. hispidus* were captured on the former reef, all from canyon bottoms. In contrast, at LDZGSP *S. hispidus* was the most common species captured and was found at all sites except the succulent desert hillside (location 1), which probably reflects the well-developed grassland vegetation found throughout the park. Five voucher specimens were collected, two from location 3 (MSB 344033, 344049) and three from location 4 (MSB 344053, 344060, 344068). *Sigmodon hispidus* is prone to dramatic population fluctuations with peaks occurring in ideal conditions (Cameron and Spencer 1981). There was exceptionally high relative abundance of *S. hispidus* in the riparian woodland draw (location 4), where tall, dense grasses and thorny shrubs provided an excellent source of food and cover. Because cotton rats have a relatively large body size and can obtain high densities, areas such as the riparian woodland draw can serve as important habitats for vertebrate predators.

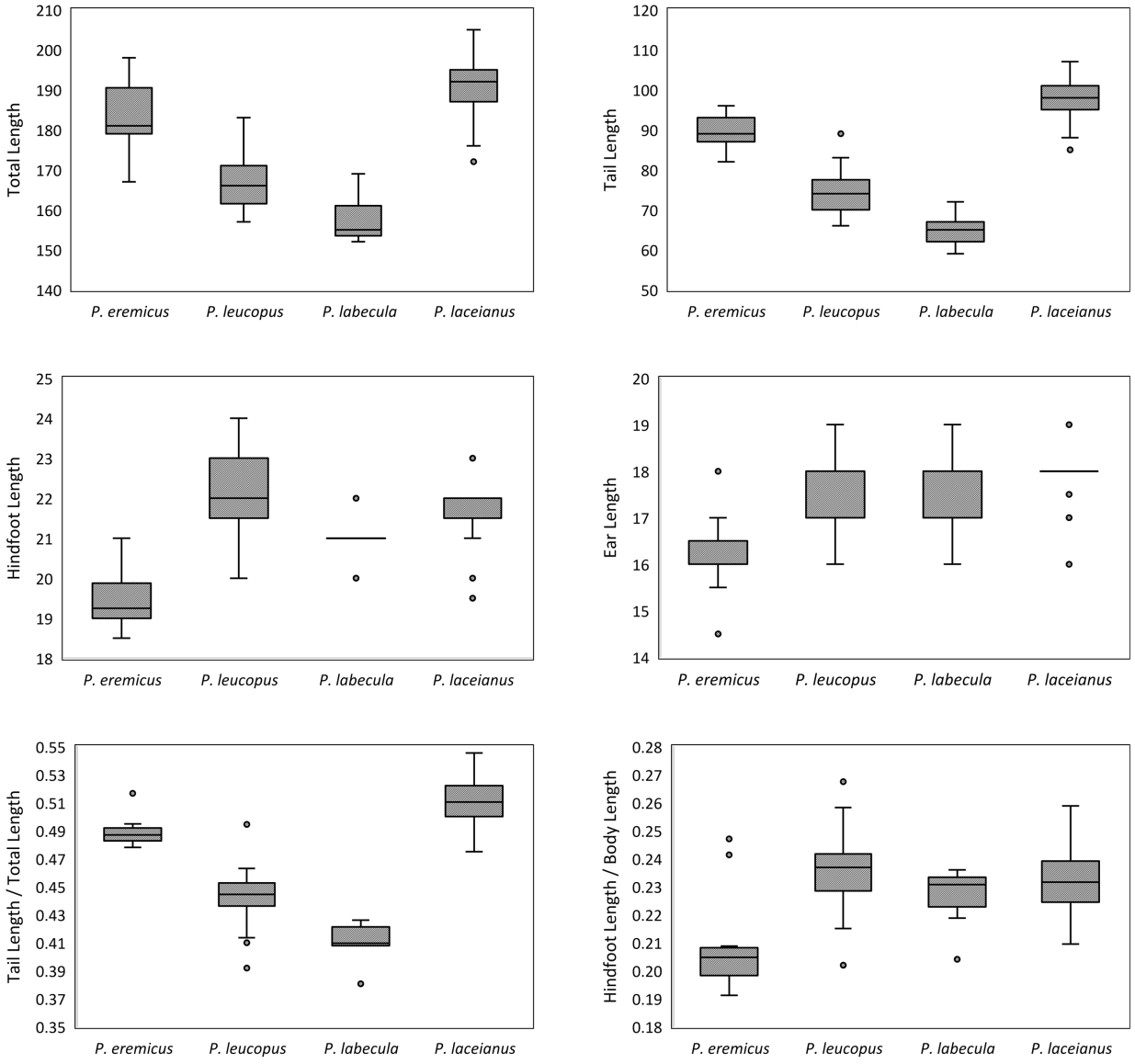


Figure 8. External measurements and ratios for reference specimens (see Appendix II) of four species of deermice from Eddy County, New Mexico, in the Museum of Southwestern Biology: *Peromyscus laceianus* (n = 29), *P. eremicus* (n = 14), *P. leucopus* (n = 19), *P. labecula* (n = 7; formerly *P. maniculatus*). Black bars represent medians, boxes represent quartiles, circles represent outliers, and asterisks represent extreme outliers.

Table 2. Characters useful for identifying deermice (genus *Peromyscus*) at Living Desert Zoo and Gardens State Park, Eddy County, New Mexico and adjacent regions of the Chihuahuan Desert. See also Figure 8.

	Species			
Character	*P. eremicus*	*P. labecula*	*P. laceianus*	*P. leucopus*
Penis	thick		very thin	
Pectoral mammae	absent	present	present	present
Nasals and premaxillae ca. equal in length or premaxillae extend noticeably beyond nasals	longer premaxillae	equal	equal	equal
Color of hind leg just above ankle	white/cream	gray	white	gray
Wash of orange on sides between dark dorsal and ventral colors	present, extensive	absent	present, slight	absent
Tail length in relation to body length	longer	shorter	longer	shorter
Typical total length	>178	<161	>185	161–175
Typical tail length	85–95	<68	>95	70–77
Typical hindfoot length	19–20	21	21.5–22	21.5–23
Typical ear length	16–16.5	17–18	18	17–18

Family Erethizontidae

***Erethizon dorsatum* (Linnaeus 1758)**
North American Porcupine

The distinctive fecal pellets (i.e., peanut-shaped and consisting of sawdust-like material) of *Erethizon dorsatum* were observed in the riparian woodland draw (location 4) and the grassland/creosote bush valley (location 5). Museum and observation records of this species are available from near the Pecos River and former reef west of the river (Findley et al. 1975; Geluso and Geluso 2004). At CCNP, *E. dorsatum* was most commonly observed in canyon bottoms, near springs, and in rocky shelters (Geluso and Geluso 2004).

ORDER LAGOMORPHA
Family Leporidae

***Lepus californicus* Gray 1837**
Black-tailed Jackrabbit

Lepus californicus has been documented from numerous locations in Eddy County (Findley et al. 1975; Geluso and Geluso 2004). The species typically occupies grasslands, scrublands, and woodlands in areas with level or rolling terrain. At CCNP this jackrabbit was observed in a variety of vegetation types on the former seabed and reef, especially in the juniper peneplain. Similarly, *L. californicus* was commonly observed throughout LDZGSP in areas with gentle terrain, including the grassland/juniper crest (location 3), riparian woodland draw (location 4), grassland/creosote bush valley, and along the inner park road, north access road, and pipeline road.

***Sylvilagus audubonii* (Baird 1857)**
Desert Cottontail

Sylvilagus audubonii has been documented from numerous locations in Eddy County (Findley et al. 1975; Geluso and Geluso 2004). In New Mexico, this cottontail typically is associated with relatively arid environments that afford shrubby cover on relatively level or rolling terrain. At CCNP, the species was observed in a wide variety of vegetation types both on the former seabed and reef (Geluso and Geluso 2004). At LDZGSP, however, *S. audubonii* was only observed near the riparian woodland draw and along the north access road. *Sylvilagus audubonii* may have been more abundant in this area of the park because of the heavy shrub cover provided by the draw.

ORDER CARNIVORA
Family Felidae

***Lynx rufus* (Schreber 1777)**
Bobcat

Lynx rufus was observed in the riparian woodland draw (UTM 13-565998N-3591983E). Previously, park staff reported that there had been a single unverified report of *L. rufus* in the park. *Lynx rufus* may be most common in undisturbed areas that afford cover and an abundance of cottontails and other vertebrate prey species.

Family Canidae

***Canis latrans* Say 1823**
Coyote

Park staff did not report *Canis latrans* as present in LDZGSP. However, the distinctive howls of *Canis latrans* were heard west of our base camp on two nights, which confirms the presence of this species. *Canis latrans* may be most common in grasslands on relatively level or rolling terrain where cottontails and jackrabbits are abundant. These environments are more common in areas adjacent to the park, but also dominate much of the western portion of the park.

***Urocyon cinereoargenteus* (Schreber 1775)**
Common Gray Fox

Park staff reported that *Urocyon cinereoargenteus* occasionally was captured in the developed part of the zoo. No *Urocyon cinereoargenteus* were documented during this survey. At CCNP, this species was relatively common on the former reef in vegetation similar to those at LDZGSP (Geluso and Geluso 2004).

Family Mustelidae

***Taxidea taxus* (Schreber 1777)**
American Badger

The distinctive diggings of *Taxidea taxus* (Harrison 2015) were observed at the grassland/creosote bush valley (location 5), and within park boundaries along the north access road (UTM 13-566452N-3592253E). *Taxidea taxus* utilizes a variety of vegetation types but is most common in grasslands and meadows where there is a high density of burrowing rodents. The indication of digging by *T. taxus* at the grassland/creosote bush valley was in an area with a high density of pocket gopher burrows.

Family Mephitidae

***Conepatus leuconotus* (Lichtenstein 1832)**
White-backed Hog-nosed Skunk

A dead *Conepatus leuconotus* was found adjacent to the LDZGSP that had been killed on U.S. Highway 285 at the mouth of a major canyon that extends into the park (UTM 13-568517N-3591376E). Sign (rooted soil at the base of shrubs) attributed to this species was observed at the top of the juniper canyon escarpment (location 2). *Conepatus leuconotus* primarily utilizes warm grasslands, scrublands, and woodlands, although at CCNP most observations were in canyons on the former reef (Geluso and Geluso 2004). The species is of conservation concern due to declines in distribution and abundance throughout parts of its range (Meaney et al 2006).

***Mephitis mephitis* (Schreber 1776)**
Striped Skunk

A *Mephitis mephitis* was observed adjacent to the pipeline road near the riparian woodland draw (location 4; UTM 13-565983N-3592165E). *Mephits mephitis* uses a wide variety of vegetation types at all but the highest elevations in New Mexico, but are apparently most common in grasslands, woodlands, and human modified environments. At CCNP, most observations of skunks were of this species (Geluso and Geluso 2004).

Family Procyonidae

***Bassariscus astutus* (Lichtenstein 1830)**
Ringtail

Bassariscus astutus has been documented from numerous locations in western Eddy County (Findley et al. 1975). The species is primarily associated with rocky areas in rugged terrain and canyons at moderate elevations, especially in areas dominated by scrublands and woodlands. At CCNP, most observations of *B. astutus* were from canyons, although some were in the juniper peneplain and other vegetation types (Geluso and Geluso 2004). Staff of LDZGSP reported occasionally capturing *B. astutus* in the developed zoo portion of the park. In addition, abundant scat attributed to this species was observed around the edge of the escarpment at the developed part of the zoo and at the juniper canyon escarpment (location 2).

***Procyon lotor* (Linnaeus 1758)**
Northern Raccoon

Museum records of *Procyon lotor* are available from a few scattered locations in Eddy County (Findley et al. 1975). *Procyon lotor* is typically associated with perennial water, but may occasionally be found far from water (Findley et al. 1975; Frey 2003). *Procyon lotor* can take advantage of food sources provided by humans, which can alter their typical pattern of distribution, abundance and habitat use. At CCNP, *P. lotor* was frequently observed at trash cans until raccoon-proof cans were installed, and most recent observations were from developed portions of the park (Geluso and Geluso 2004). At LDZGSP, park staff reported that *P. lotor* was commonly captured in the developed portion of the zoo. Due to the absence of water, raccoons are not expected to be common in other areas of the park.

ORDER ARTIODACTYLA
Family Cervidae

***Odocoileus hemionus* (Rafinesque 1817)**
Mule Deer

Odocoileus hemionus occurs throughout western Eddy County (Findley et al. 1975). At CCNP, *O. hemionus* was observed in a variety of vegetation types both on the former seabed and reef. At LDZGSP, *O. hemionus* was commonly observed at the riparian woodland draw (location 4) and elsewhere along that draw, including the upper end of the draw near the grassland/creosote bush valley (location 5). Hoof prints of *O. hemionus* were observed at the gravel pit at our base camp, and a dead juvenile *O. hemionus* was observed on US Highway 285 near the mouth of a small canyon that extends into the park (UTM 13-568207N-3592281E), and a shed antler found in the park was collected (MSB 344040).

ACKNOWLEDGMENTS

We thank Steve Cary, Ken Britt, and staff of Living Desert Zoo and Gardens State Park for facilitating this study. We thank the Museum of Southwestern Biology for access to specimens and three anonymous reviewers for helpful comments. We thank Kenneth Geluso and Keith Geluso for their studies of mammals at Carlsbad Caverns National Park, which has provided an important foundation for understanding the mammal fauna of Eddy County, New Mexico.

LITERATURE CITED

Anderson, S. 1972. Mammals of Chihuahua taxonomy and distribution. Bulletin of the American Museum of Natural History 148:153–410.

Bailey, V. 1905. Biological survey of Texas. North American Fauna 25:1–222.

Bailey, V. 1913. Life zones and crop zones of New Mexico. North American Fauna 35:1–100.

Bailey, V. 1928. Animal life of the Carlsbad Cavern. Monographs of the Museum of Natural History, University of Kansas 3:1–415.

Bailey, V. 1931 (=1932). Mammals of New Mexico. North American Fauna 53:1–412.

Best, T. L., and M. P. Skupski. 1994. *Perognathus merriami*. Mammalian Species 473:1–7.

Brant, J. G., and T. E. Lee, Jr. 2006. Morphological analysis of *Perognathus flavus* and *P. merriami* (Rodentia: Heteromyidae). The Southwestern Naturalist 51:79–86.

Cameron, G. N,, and S. R. Spencer. 1981. *Sigmodon hispidus*. Mammalian Species 158:1–9.

Choate, L. L. 1997. The mammals of the Llano Estacado. Special Publications, Museum of Texas Tech University 40:1–240.

Choate, L. L., R. W. Manning, J. K. Jones, Jr., C. Jones, and T. R. Mollhagen. 1991. Records of mammals from the Llano Estacado and adjacent areas of Texas and New Mexico. Occasional Papers, Museum of Texas Tech University 138:1–11.

Cornely, J. E., D. J. Schmidly, H. H. Genoways, and R. J. Baker. 1981. Mice of the genus *Peromyscus* in Guadalupe Mountains National Park, Texas. Occasional Papers, Museum of Texas Tech University 74:1–35.

Davidow-Henry, B. R., J. K. Jones, Jr., and R. R. Hollander. 1989. *Cratogeomys castanops*. Mammalian Species 338:1–6.

Demastes, J. W., T. A. Spradling, M. S. Hafner, D. J. Hafner, and D. L. Reed. 2002. Systematics and phylogeography of pocket gophers in the genera *Cratogeomys* and *Pappogeomys*. Molecular Phylogenetics and Evolution 22:144–154.

Edwards, C. W., C. F. Fulhorst, and R. D. Bradley. 2001. Molecular phylogenetics of the *Neotoma albigula* species group: further evidence of a paraphyletic assemblage. Journal of Mammalogy 82:267–279.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque.

Frey, J. K. 2003. Distributional records and natural history notes for uncommon mammals on the Llano Estacado of eastern New Mexico. New Mexico Journal of Science 43:1–24.

Frey, J. K. 2004. Taxonomy and distribution of the mammals of New Mexico: An annotated checklist. Occasional Papers, Museum of Texas Tech University 240:1–32.

Frey, J. K. 2007. Key to the rodents of New Mexico. Final report to New Mexico Department of Game and Fish, Santa Fe, 24 June 2007.

Frey, J. K. and J. L. Malaney. 2009. Decline of the meadow jumping mouse (*Zapus hudsonius luteus*) in two mountain ranges in New Mexico. The Southwestern Naturalist 44:31–44.

Geluso, K. 2004. Distribution of the white-ankled mouse (*Peromyscus pectoralis*) in New Mexico. The Southwestern Naturalist 47:283–288.

Geluso, K. N., and K. Geluso. 2004. Mammals of Carlsbad Caverns NP, New Mexico. Bulletin of the University of Nebraska State Museum 17:1–180.

Gennaro, A. L. 1968. Northern geographic limits of four desert rodents of the genera *Peromyscus*, *Perognathus*, *Dipodomys*, and *Onychomys* in the Rio Grande Valley. The American Midland Naturalist 80:477–493.

Genoways, H. H., R. J. Baker, and J. E. Cornely. 1979. Mammals of the Guadalupe Mountains National Park, Texas. Pages 271–340 in Biological investigations in the Guadalupe Mountains National Park, Texas (H. H. Genoways and R. J. Baker, eds). National Park Service, Proceedings and Transactions Series 4:1–442.

Hall, E. R. 1981. The mammals of North America. Wiley & Sons, New York.

Harrison, R. L. 2015. A comparison of sign searches, live-trapping, and camera-trapping for detection of American badgers (*Taxidea taxus*) in the Chihuahuan Desert. Western North American Naturalist 75:387–395.

Helgen, K. M., F. R. Cole, L. E. Helgen, and D. E. Wilson. 2009. Generic revision in the Holarctic ground squirrel Genus *Spermophilus*. Journal of Mammalogy 90:270–305.

Lee, T. E., Jr., and M. D. Engstrom. 1991. Genetic variation in the silky pocket mouse (*Perognathus flavus*) in Texas and New Mexico. Journal of Mammalogy 72:273–285.

Malaney, J. L., and J. A. Cook. 2018. A perfect storm for mammalogy: declining sample availability in a period of rapid environmental degradation. Journal of Mammalogy 99:773–788.

Malaney, J. L., J. L. Dunnum, and J. A. Cook. 2022. Checklist of New Mexico mammals. New Mexico Museum of Natural History and Science Bulletin 87:357–365.

Meaney, C. A., A. K. Ruggles, and G. P. Beauvais. 2006. American Hog-nosed Skunk (*Conepatus leuconotus*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/americanhognosedskunk.pdf [accessed 19 September 2019].

Merriam, C. H. 1889. Revision of the North American pocket mice. North American Fauna 1:1–29.

New Mexico State Parks [NMSP]. Undated. Living Desert Zoo and Gardens State Park management and development plan.

Oakes, C. L. 2000. History and consequence of keystone mammal eradication in the desert grasslands: The Arizona black-tailed prairie dog (*Cynomys ludovicianus arizonensis*). Unpublished dissertation, University of Texas at Austin.

Schmidly, D. J. 1977. The mammals of Trans-Pecos Texas, including Big Bend National Park and Guadalupe Mountains National Park. Texas A&M University Press, College Station.

Schmidly, D. J., and R. D. Bradley 2016. The Mammals of Texas, 7th ed. University of Texas Press, Austin.

Sikes, R. S., and the Animal Care and Use Committee of the American Society of Mammalogists. 2016. 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. Journal of Mammalogy 97:633–688.

United States Department of Interior National Park Service (NPS). 1943. Wildlife conditions in National Parks 1941. U.S. Government Printing Office.

Webster, W. D., and J. K. Jones, Jr. 1982. *Reithrodontomys megalotis*. Mammalian Species 167:1–5.

Wilson, D. E. 1973. The systematic status of *Perognathus merriami* Allen. Proceedings of the Biological Society of Washington 86:175–192.

Wilson, D. E. and D. M. Reeder. 2005. Mammal species of the World: a taxonomic and geographic reference, 3rd ed. Johns Hopkins University Press, Baltimore, Maryland.

Addresses of authors:

JENNIFER K. FREY

Department of Fish, Wildlife and Conservation Ecology
New Mexico State University
P.O. Box 30003, MSC 4901
Las Cruces, NM 88003-8003 USA
jfrey@nmsu.edu

JASON L. MALANEY

New Mexico Museum of Natural History and Science
1801 Mountain Road NW
Albuquerque, NM 87104 USA
Jason.Malaney@state.nm.us

MICHAEL T. HILL

2219 Sea Foam St. NW
Albuquerque, NM 87120 USA
neomexicanus@gmail.com

APPENDIX I

Universal Transverse Mercator coordinates (Zone 13S) of locations surveyed for mammals at Living Desert Zoo and Gardens State Park. Location numbers correspond to small mammal trapping sites as described in the text and mapped in Figure 1.

Location Number	Name	Point Description	Easting	Northing	Elevation (m)
1	Succulent Desert Hillside	End transect north of Skyline Rd.	0568438	3590283	1,011
		Start transect north of Skyline Rd.	0568494	3590239	960
		End transect south of Skyline Rd.	0568495	3590210	1,021
		Start transect south of Skyline Rd.	0568633	3590155	941
2	Juniper Canyon Escarpment	North end of transect	0567517	3590633	1,044
		Middle of transect	0567559	3590504	1,047
		South end of transect	0567691	3590438	1,044
3	Grassland/juniper Crest	North end of transect	0567136	3590506	1,054
		End of perpendicular transect	0567449	3590242	1,064
		Center of transect	0567487	3590375	1,053
		South end of transect	0567711	3590228	1,064
4	Riparian Woodland Draw	South end of transect	0566029	3591816	1,178
		Middle of transect	0566034	3591809	984
		North end of transect	0566045	3591934	986
5	Grassland/Creosote Bush Valley	Gopher traps and near west end transect	0566051	3590971	1,003
	Base Camp		0567507	3590399	1,056
	Pitfall trap		0566715	3591453	1,035
	Pitfall trap		0566715	3591442	1,035
	Pitfall trap		0566714	3591431	1,035
	Pitfall trap		0566712	3591412	1,035
	Pitfall trap		0566711	3591402	1,035
	Pitfall trap		0566709	3591390	1,035
	Pitfall trap		0566709	3591380	1,035
	Pitfall trap		0566708	3591368	1,035
	Pitfall trap		0566708	3591359	1,035
	Pitfall trap		0566708	3591347	1,035

APPENDIX II

Specimens (n = 69) of adult deermice (*Peromyscus*) from Eddy County, New Mexico, in the Museum of Southwestern Biology used for comparison with mice captured at Living Desert Zoo and Gardens State Park. Numbers are catalog numbers.

Peromyscus eremicus (14).—2 mi N, 13 mi W Carlsbad; T21S, R23E (8108, 8109, 8110, 8111, 8113, 8114, 8115, 8116, 8117, 8118, 8119, 8120); Carlsbad Cavern National Park, 0.39 mi S, 0.48 mi E New Cave (63722); Carlsbad Cavern National Park, 1.15 mi W, 0.22 mi S, sewage disposal ponds (63743).

Peromyscus leucopus (19).—2 mi N, 13 mi W Carlsbad; T21S, R23E (8125); Blue Springs, E bank of Blue Springs, near head of (60271, 60272); Blue Springs, 100 yrds S head of Blue Springs (60273); Carlsbad Cavern National Park, 1.10 mi W, 0.40 mi S Whites City (63714); Carlsbad Cavern National Park, 0.39 mi S, 0.48 mi E New Cave (63721); Carlsbad Cavern National Park, 0.08 mi N, 0.37 mi E Rattlesnake Spring (63727); Carlsbad Cavern National Park, 1.08 mi W, 0.45 mi S Whites City (63764); Carlsbad Cavern National Park, Rattlesnake Springs near water storage pond (63781); Carlsbad Cavern National Park, 0.06 mi S, 0.14 mi E sewage disposal ponds (63800); Carlsbad Cavern National Park, 1.24 mi S, 0.57 mi E New Cave (63862, 63863, 63864, 63865); Carlsbad Cavern National Park, 0.08 mi N, 0.64 mi E Rattlesnake Spring (63910, 63911, 63912); Carlsbad Cavern National Park, 0.08 mi E sewage disposal ponds (63941, 63942).

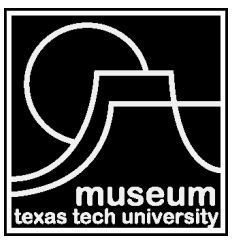
Peromyscus labecula (7).—Carlsbad Cavern National Park, 1.10 mi W, 0.40 mi S Whites City (63711); Carlsbad Cavern National Park, 0.06 mi S, 0.14 mi E sewage disposal ponds (63793, 63795); Carlsbad Cavern National Park, 1.24 mi S, 0.57 mi E New Cave (63866); Carlsbad Cavern National Park, 0.05 mi N, 0.32 mi E main entrance to Carlsbad Caverns (63967); Carlsbad Cavern National Park, 0.08 mi E sewage disposal ponds (63939); Carlsbad Cavern National Park, 0.51 mi S, 1.35 mi W Whites City (63951);

Peromyscus laceianus (29).—Carlsbad Cavern National Park, women's dorm (45745); Guadalupe Mts., Black Canyon at Gunstock Rock (60396, 60397, 60398, 60399, 60401, 60402); Carlsbad Cavern National Park, 0.45 mi E main entrance to Carlsbad Caverns (63899); Carlsbad Cavern National Park, 0.28 mi N, 0.05 mi E visitor center (63918); Carlsbad Cavern National Park, 1.0 mi N, 0.52 mi E visitor center (63946); Carlsbad Cavern National Park, 0.34 mi N, 0.91 mi E Lowe Spring (63957); Carlsbad Cavern National Park, 0.05 mi N, 0.32 mi E main entrance to Carlsbad Caverns (63963); Carlsbad Cavern National Park, 0.06 mi N, 0.67 mi W Whites City (63976); Carlsbad Cavern National Park, 0.62 mi S, 0.61 mi E Longview Spring (63986); Carlsbad Cavern National Park, 0.57 mi S, 0.52 mi W Red Cave (63996); Carlsbad Cavern National Park, 0.18 mi N, 0.37 mi E Lowe Spring (63999); Carlsbad Cavern National Park, 0.52 mi S New Cave (64002); Carlsbad Cavern National Park, 0.39 mi S New Cave (64004); Carlsbad Cavern National Park, 1.12 mi N, 0.23 mi W Goat Cave (64048); Carlsbad Cavern National Park, 2.03 mi N, 0.27 mi W Goat Cave (64049); Carlsbad Cavern National Park, 0.43 mi S, 0.64 mi E Stone Spring (64051); Carlsbad Cavern National Park, 0.95 mi S, 0.90 mi W New Cave (64072); Carlsbad Cavern National Park, Oak Spring (64079); Carlsbad Cavern National Park, 0.29 mi N, 0.03 mi W Red Cave, T25S, R23E, NE ¼ Sec 31 (65049); Carlsbad Cavern National Park, visitor center, T24S, R24E, NE 1/4 Sec 36 (65067); Carlsbad Cavern National Park, 0.48 mi N, 0.73 mi W Lowe Spring, T24S, R24E, NE ¼ Sec 32 (65072); Carlsbad Cavern National Park, 0.58 mi S, 0.52 mi E New Cave, T25S, R23E, NW ¼ Sec 25 (66642); Carlsbad Cavern National Park, 1.14 mi N, 1.45 mi W Whites City, T24S, R25E, NW ¼ Sec 28 (66646); Carlsbad Cavern National Park, 2.14 mi S, 0.76 mi W Double Cave, T26S, R22E, NW ¼ Sec 14 (66649).

Publications of the Museum of Texas Tech University

Institutional subscriptions to Occasional Papers are available through the Museum of Texas Tech University, attn: NSRL Publications Secretary, Box 43191, Lubbock, TX 79409-3191. Individuals may also purchase separate numbers of the Occasional Papers directly from the Museum of Texas Tech University.

Series Editor: Robert D. Bradley
Production Editor: Lisa Bradley



ISSN 0149-175X

Museum of Texas Tech University, Lubbock, TX 79409-3191