



An annotated checklist of mammals of the Lake Meredith National Recreation Area, Texas, USA

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Abstract: Mammals of Lake Meredith National Recreation Area (Hutchinson, Moore and Potter counties, Texas) were surveyed between March 2002 and October 2003 as a part of the larger inventory of vertebrate animals of this protected area. Both Sherman and Tomahawk traps were used to catch small and medium-size mammals (for a total 330 trap-nights). Pit-fall traps, gopher live traps, Trailmaster™ cameras, mist-nets (for bats), and spotlight surveys were also utilized. The study detected 29 (72.5%) of the 39 mammalian species previously confirmed for Lake Meredith, and provided confirmed records for four other species (*Cryptotis parva*, *Notiosorex crawfordi*, *Dasypus novemcinctus*, and *Sciurus niger*). Four additional species were recorded in the adjacent area. This manuscript compares the 2002–2003 study with the three mammal inventories previously undertaken in the area (Blair 1954; Killebrew 1979; Yancey et al. 1998).

Key words: mammals, Texas Panhandle, Rolling Plains, Lake Meredith, inventory

INTRODUCTION

This mammal study of Lake Meredith National Recreation Area (LMNRA) was undertaken in 2002–2003 as a part of the larger project to inventory all vertebrate animals within the recreation area, and also in the adjacent Alibates Flint Quarries National Monument (AFQ). This study's objective was to inventory the mammal populations, and to detect any changes that have occurred in species composition since the previous studies. Due to logistic and access issues all mammal trapping was done in LMNRA, and only limited number of observations came from AFQ.

The first mammal study in the general area was probably that by Blair (1954) at the Bugbee Ranch, Hutchinson County (14.5 km east of Stinnett, and 27 km north-northwest of the northeastern limits of LMNRA),

between 6 June and 12 July 1950. Killebrew (1979) erroneously reported that Blair's study took place in the Bugbee area of LMNRA. Therefore, Killebrew's study in 1978–1979 was the first detailed mammalian inventory of LMNRA and AFQ. Some opportunistic collecting by West Texas A&M University (WTAMU) mammalogy class occurred in 1979 and 1984–1986 (WTAMU collection). It was followed by a mammal inventory by Texas Tech University (TTU) team from July 1991 through July 1992 (Yancey et al. 1998). My study was conducted between March 2002 and October 2003.

The most comprehensive mammalian study to date was that by Killebrew (1979) who trapped most of the accessible sites in LMNRA: McBride Canyon, Fritch Fortress-Cedar Canyon, Spring Canyon, Bugbee, Blue West-Chimney Hollow, Plum Creek, Saddlehorse Canyon, and Bonita Creek, as well as Alibates Flint Quarries. Killebrew used a combination of snap traps (including Victor spear traps for gophers), Harpoon traps (for moles), and live traps (large Sherman, Havahart, and custom-made gopher life traps), Conibear and suitcase traps for aquatic mammals, and baited pit-fall traps for shrews. He also searched for small mammals under rocks, debris, tree bark, trash piles, and in buildings. Although Killebrew (1979) used mist-nets and searched old buildings, rock faces, and under tree bark to detect bats, all of his bat specimens were collected with a shotgun. Larger mammals (medium size) were caught with baited Tomahawk traps, Victor leg traps, and Conibear traps; additional observations were collected during daytime excursions and spotlight searches at night. Tracks, signs, and scats were also noted. Many small mammals that were caught alive were toe-clipped in a case of recapture. Killebrew (1979) reported the total effort of 6,280 trap nights, but he did not differentiate by trap type. Specimens collected by Killebrew were deposited with WTAMU. Yancey et al. (1998) used Sherman traps of unspecified size, baited with oatmeal, specialized gopher traps, mist-nets, and firearms, but

also recorded direct observations, and mammal tracks and signs. Specimens from Yancey et al. (1998) study are in the Collection of Recent Mammals at Texas Tech University. Methods used during my 2002–2003 study are discussed in the “Materials and Methods” section.

MATERIALS AND METHODS

Study Area

Lake Meredith National Recreation Area lies in the Texas Panhandle (Potter, Moore, and Hutchinson counties) within the western extension of the Rolling Plains (Figure 1). The recreation area consists of the Lake Meredith (4,000 ha), a reservoir created in 1962–1968 by damming the Canadian River, and 18,216 ha of uplands, steep slopes (45–60% gradient), arid plains, and wetlands adjacent to the lake. Alibates Flint Quarries National Monument (555 ha of uplands) abuts LMNRA in the northeastern part of Potter County. The Canadian River had carved a narrow, steep-walled canyon 60 to 90 m deep and up to 3.3 km wide through the recreation area, and its tributary streams had created a rough and broken topography, known as the Canadian River Breaks (National Park Service 2001). The climate is semi-arid

with considerable seasonal variations in temperature, from the average of -7°C in winter to 33°C in summer. Seventy percent of the annual rainfall (ca. 500 mm) falls between April and September, although 60–65% of the total precipitation evaporates because of persisting winds of ca. 20 km/h, often reaching 50–60 km/h in early spring (National Park Service 2001). According to Texas Water Development Board online information (2009) the area experienced several droughts as well as wetter years between 1940 and 2004. The average precipitation values for 1977–1978, 1991–1992, and 2002–2003 were 554, 595, and 442 mm respectively, and these differences were not statistically significant.

Oil and gas exploration and development have been actively pursued in the vicinity of LMNRA and AFQ since the late 1920s, well before the creation of these federally protected areas. In the early 2000s there were 170 active oil and gas wells, 64 km of active access roads, 167 km of abandoned roads, and 6 km of oil and gas pipelines in the recreation area (National Park Service 2001). Despite this disturbance, the vegetation of LMNRA and AFQ remains in mostly good condition (Nesom and O’Kennon 2005) compared to similar vegetation types

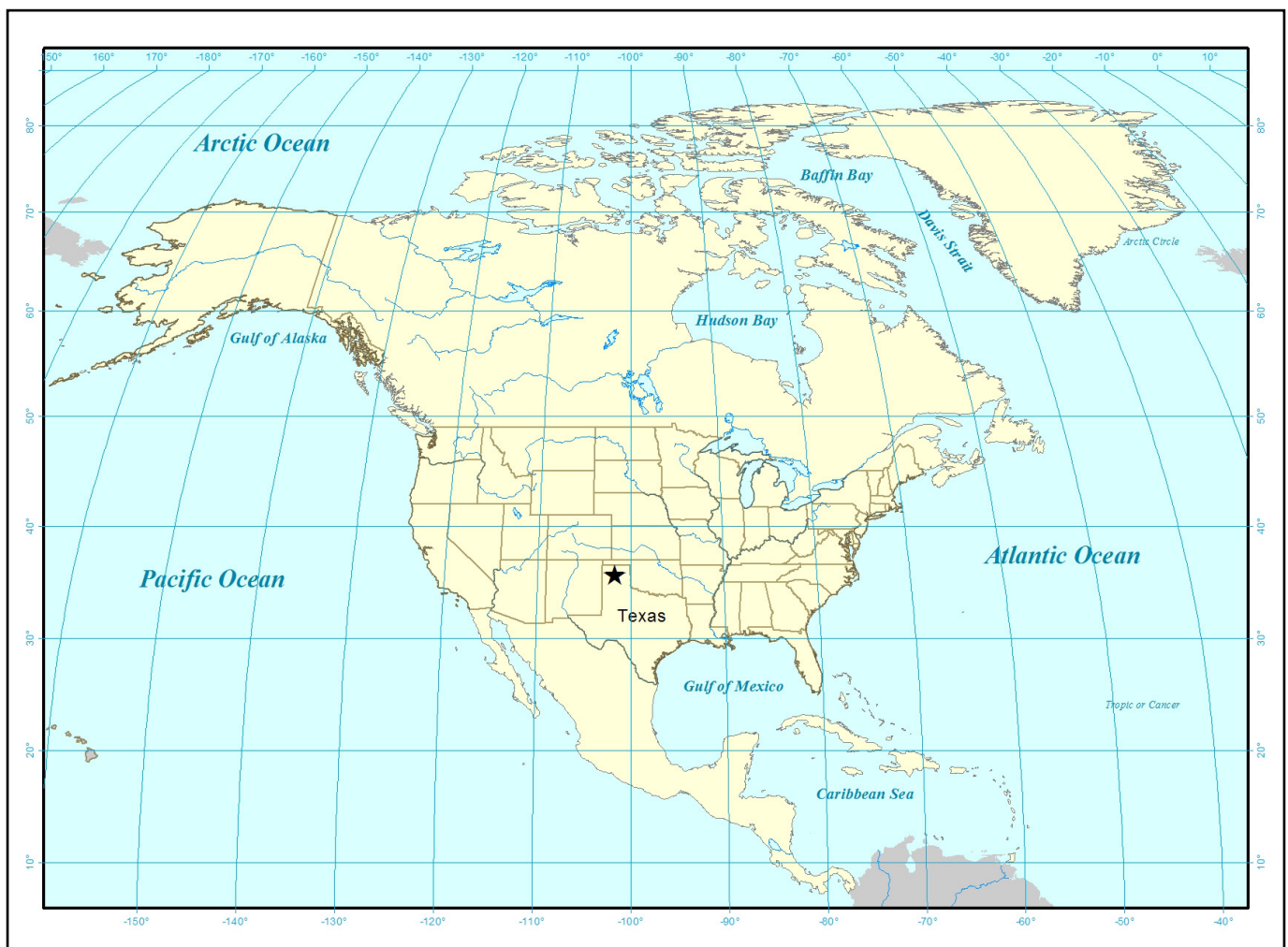


Figure 1. Geographic location of the Lake Meredith National Recreation Area (star) in the State of Texas, United States of America, North America (ESRI base map).

outside the protected areas. Nesom and O’Kennon (2005) recognized four main habitats: rocky slopes and uplands, sandy areas, riparian areas, and marsh. There is also a man-modified borrow area at the northeast end of LMNRA (Figure 2). All of the vegetation information provided below is from Nesom and O’Kennon (2005)

Rocky slopes consist of red sandstone, gravel, Dolomite caprock and few gypsum outcrops. These slopes are dominated by Broom Snakeweed (*Gutierrezia sarothrae*), Small Soapweed Yucca (*Yucca glauca*), Woolly Locoweed (*Astragalus mollissimus*), White Sagebrush (*Artemisia ludoviciana*), Featherplume (*Dalea formosa*), Sideoats Grama (*Bouteloua curtipendula*), and Blue Grama (*B. gracilis*), with scattered One-seeded Juniper (*Juniperus monosperma*), and Honey Mesquite (*Prosopis glandulosa*).

Sandy areas: sandhills, and sandy valley bottoms are dominated by Sand Sagebrush (*Artemisia filifolia*), Annual Buckwheat (*Eriogonum annuum*), Small Soapweed Yucca, Sand Dropseed (*Sporobolus cryptandrus*), Purple Sandgrass (*Triplasis purpurea*), Witchgrass (*Panicum capillare*), and scattered Honey Mesquite and patches of Chickasaw Plum (*Prunus angustifolia*). Sandflats are dominated by grasses, especially Vine Mesquite (*Panicum obtusum*) and Western Wheatgrass (*Pascopyrum smithii*), with Sand Dropseed, Streambed Bristlegrass (*Setaria leucopila*), and Sideoats Grama in lesser abundance.

Riparian areas include cottonwood woodlands and hackberry-soapberry dry woodlands. Dominant trees and shrubs are Plains Cottonwood (*Populus deltoides* var. *monilifera*), Chickasaw Plum, Netleaf Hackberry (*Celtis reticulata*), Western Soapberry (*Sapindus drummondii*), Common Hoptree (*Ptelea trifoliata*), Fragrant Sumac (*Rhus aromatica*) and willows (*Salix* sp.). Herbaceous species are represented by grasses, e.g., Switchgrass (*Panicum virgatum*), Indian Grass (*Sorghastrum nutans*), Canada Wild-rye (*Elymus canadensis*), and Little Bluestem (*Schizachyrium scoparium*). Common Reed (*Phragmites australis*) and Southern Cattail (*Typha domingensis*) grow in the wettest areas. Varying lake levels have encouraged the encroachment of non-native Salt Cedar (*Tamarix ramosissima*) in the floodplain (National Park Service 2001).

Marshes are common at the south end of Lake Meredith, along the Canadian River, and immediately below Sanford Dam (Sanford Marsh). These marshes are dominated by Southern Cattail and Common Threesquare (*Schoenoplectus pungens*) in areas of deeper water, with Common Reed around the edges.

The borrow area at the north end of Lake Meredith NRA, between North Canyon and Hwy 1319, had large amounts of rock and soil removed ca. 1962–1968 for the construction of Sanford Dam. This area is now

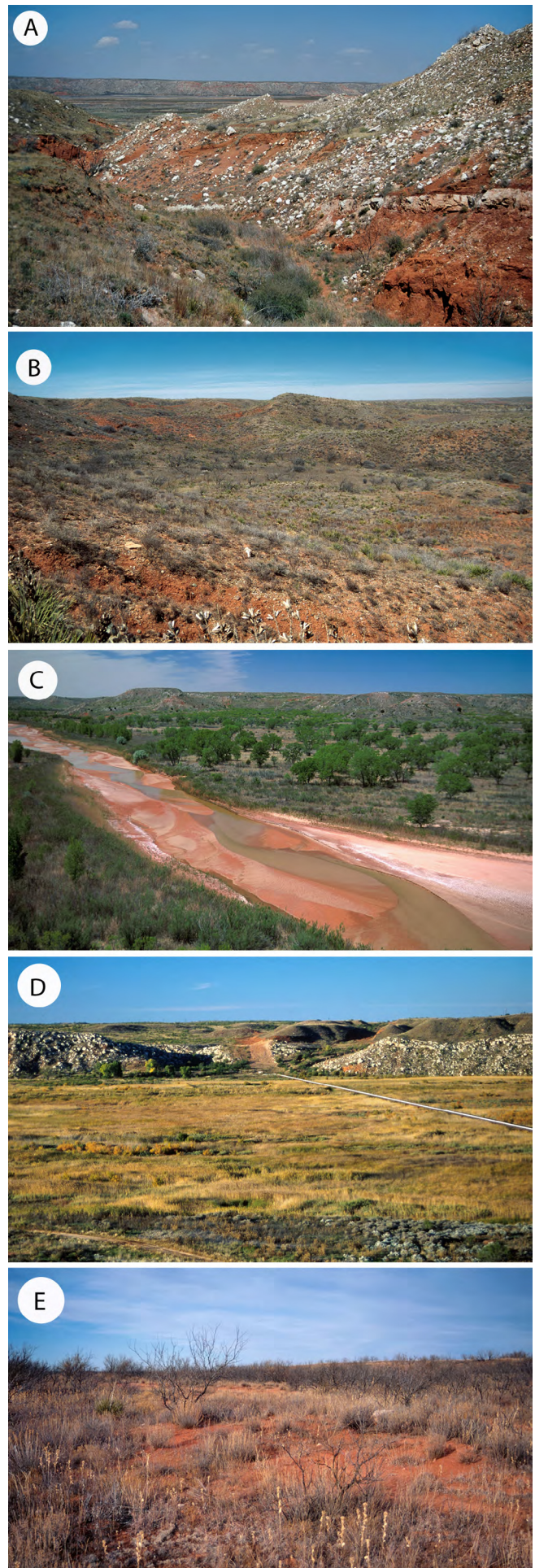


Figure 2. Habitats of Lake Meredith National Recreation Area, Texas. **A:** Rocky slopes, **B:** Sandy areas, **C:** Riparian habitats, **D:** Marsh, **E:** The borrow area. Photographs by Michael Patrikeev.

relatively flat, consistently scraped down to a level of reddish sandstone and sandy clay, and naturally revegetated over the last 40–50 years. Honey Mesquite is the dominant shrub-small tree of the borrow area. Other common species are Broom Snakeweed, White Heath Aster (*Symphotrichum ericoides*), Yellow Bluestem (*Bothriochloa ischaemum*), Sideoats Grama, and Sand Dropseed (Nesom and O’Kennon 2005).

Hunting of game species (*Sylvilagus audubonii* and *S. floridanus*, *Lepus californicus*, *Canis latrans*, *Procyon lotor*, and *Odocoileus hemionus* and *O. virginianus*) is legally permitted in LMNRA, but not in AFQ.

Methods

The 2002–2003 study followed the methods suggested by the US National Park Service (National Park Service 2000). At the request of the USNPS no lethal means of collecting were used (i.e., no snap traps, harpoon traps, firearms, etc.), and every attempt was made to reduce mortality in live-trapped animals. Although several species of rodents and shrews were collected, in-hand identification of rodents and bats, positive visual identification of larger mammals, and photographic evidence were deemed sufficient (National Park Service 2000), and the majority of captured mammals were subsequently released.

Small and medium-size mammals were trapped at mammal trapping stations (National Park Service 2000), and by individually placed Sherman traps. Each trapping station consisted of two Tomahawk and four Sherman traps each: one large Tomahawk trap (6 × 6 × 24 inch = 15.2 × 15.2 × 61 cm), baited with meat and vegetable food-stuffs, one small Tomahawk trap (5 × 5 × 16 inch = 12.7 × 12.7 × 40.6 cm), baited with a combination of meat or fish, and apples, peanut butter, carrots, and cracked corn, one large (4 × 5 × 15 inch = 10.2 × 12.7 × 38.1 cm) Sherman and three small (3 × 3 × 9 inch = 7.6 × 7.6 × 22.9 cm) Sherman traps, baited with peanut butter and oats. The original design called for pitfall traps at these stations also, but due to weather conditions (see below) pitfall traps were run separately. The mammal stations were at least 150 m apart, and individual Sherman traps 20–30 m apart. Trapping sessions of 2–3 nights/site were deemed sufficient to capture small mammals at each site.

Fourteen mammal stations were run in the northernmost section of LMNRA (Hutchinson County) during 22–24 October 2002, and three additional mammal stations and 24 individual small Sherman traps in northern, central and southern sections of the park (Hutchinson and Potter Counties) during 12–23 April 2003. In October 2002 continuous rains prompted to delay pitfall-trap surveys until November to prevent drowning of captured animals. Pitfall traps consisted of 3.78 liter food cans (1 gallon cans, #10), and were used in 4 locations at the north end of LMNRA 1–11 November 2002 (10 m apart, 30 pitfall traps per location). In total, Tomahawk

and Sherman traps were run for 330 trap-nights (large and small Tomahawk traps for 42 trap-nights each, large Sherman traps for 69, and small Shermans for 177), and pitfalls for 1,200 trap-nights. The majority of captured small mammals were identified and released; some were photographed, but a few (shrews and rodents) were collected as voucher specimens. Capture rates were calculated according to the size of species and the type of trap, i.e., larger species, such as *Neotoma*, were not expected in small Sherman traps, whereas smaller rodents such as *Peromyscus* and *Reithrodontomys*, were unlikely to trigger large Tomahawk traps; if large traps caught smaller species and vice versa then those types of traps were included in capture rate calculations.

Pocket-gophers (Geomyidae) required specialized traps described in Baker and Williams (1972). These traps are made of pieces of PVC pipe with a trigger mechanism based on a rat snap-trap, and were placed directly into an excavated gopher tunnel. Traps for the current study were custom-made in the lab of Dr. Robert Dowler (Angelo State University). Trapping of gophers is time consuming, but necessary for positive identification. Due to time constraints, only two areas were sampled for gophers (April 2003): sandy soils at the North End grasslands (Hutchinson County) and red clay-loam and rocky soils in Bates Canyon (Potter County).

Bat surveys in LMNRA/AFQ presented a challenge, because of strong persistent winds. Mist-netting on windy nights was impractical because swinging nets could be easily detected and avoided by bats. Four separate mist-netting sessions were attempted in 2002: at Sanford Marsh on 4 September, at Mullinaw Crossing on 16 September, at a water source in Plum Creek Valley on 24 September, and at the foot of Bultaco Hill (Rosita Meadows) on 26 September. Caves, cavities, and old structures possibly used by bats were not thoroughly searched, and the only known sizeable cave (at the base of Bultaco Hill) was vandalized by fire in 2002.

Ten Trailmaster™-modified Canon all-weather automatic film cameras with TM-550 sensors/trigger mechanisms were employed to detect carnivorous and omnivorous mammals between 6 September 2002 and 20 June 2003. The cameras and sensors were mounted on two-inch (5.1 cm) wooden stakes next to a bait station. Each bait station was centered on a metal pipe (1 m long, and 5 cm in diameter) driven into the ground. A piece of raw meat or chicken was placed in a cricket cage attached to a top of the pipe; other food items (cracked corn, apples, and canned fish) were placed around the base of the pipe. When warm-blooded wildlife investigates the bait, an infrared sensor activates the camera to takes a photograph. At selected camera stations, canned sardines were substituted for beef or chicken bait.

Large and medium-size mammals were also sought

during spotlight surveys. Three surveys were carried out on 13 and 15 March, and 26 June 2002, but proved ineffective. Although LMNRA possesses an extensive network of unpaved roads, paved roads are few and relatively short (with the exception of Bates Canyon Road). Many unpaved roads cut deep into the substrate thus obstructing vision and many could only be navigated at crawling speed (10 km/hour). The extensive Saddle Horse Canyon-Mullinaw-Devil's Canyon road system could not be surveyed because the only access point (Mullinaw Crossing) remained impassable during the 2002 and 2003 field seasons.

Other night road surveys were conducted after dark by slowly driving roads and looking for mammals crossing roadways. Most of these searches were undertaken on rainy or warm and humid nights (to pursue the herpetological component of this inventory), but searches for *Perognathus* pocket mice were carried out on dry and moonless nights. If small mammals were detected then an attempt to identify or catch them was made. Photographs were taken when possible and practical. A total of 24 night searches were conducted: 13 in 2002 (between 28 April and 8 August), and 11 in 2003 (25 April to 16 July).

Visual encounters involved systematic and opportunistic searches such as turning rocks, logs, and other debris, or looking into rock crevices and cracks in structures. A few rodents were found under coverboards (chipboard and roofing tin) used for sampling amphibians and reptiles. Signs of mammalian presence: tracks, scats, feeding signs (e.g., in beaver and porcupine), and all road-killed mammals were noted.

I also examined mammal specimens and records from Collection of Recent Mammals at Texas Tech University (TTU), and study skins from West Texas A&M University, Canyon (WTAMU). Taxonomy and common names of mammals follow Manning et al. (2008). Voucher specimens (skulls and/or skins) from this study were deposited with Angelo State University (ASU). The following permits governed research activities conducted during this project: 1) NPS Scientific Research and Collecting Permit # Lake Meredith NRA-2002-SCI-0001; 2) Texas Park and Wildlife Department Scientific Collections Permit # SPR-0102-193.

GIS coordinates of all sampling stations were provided in Patrikeev (2004). The following abbreviations related to transportation network are used in the text: US 287 (US Interstate Highway 287), SH (State Highway), FM (Farm to Market roads, Texas Department of Transportation).

Data analysis

I used Jaccard similarity coefficient (J), and also Simpson Index (SI) to compare all four mammal studies conducted at LMNRA and the vicinity. $J = a/(a +$

$b + c)$, where J = Jaccard similarity coefficient, a = number of species shared by surveys, b = number of species unique to the first survey, and c = number of species unique to the second survey (Jaccard 1901). Simpson Index is expressed as a negative logarithm that increases with the number of species, $SI = -\ln \sum n(n-1)/N(N-1)$, where n = number of individuals of each species and N = total number of individuals in the dataset (Simpson 1949; Lim and Engstrom 2004). Inconsistencies in sampling effort in Blair (1954), Killebrew (1979), and Yancey et al. (1998) precluded a more complex analysis. The indices were calculated for each of the four studies, and species recorded outside of the administrative boundaries of the two protected areas were included. In calculating Jaccard similarity coefficients I omitted species with missing values from pair-wise comparisons (e.g., lagomorphs and deer unreported in Blair 1954). For SI, I used "1" for species abundance when a species was recorded only as "present", and "2" if it was deemed "common", but without numeric values. For prairie dogs I used number of colonies instead of individuals. In calculating Simpson index I omitted lagomorphs and deer from all four studies, because of inconsistencies with reporting, failure to identify to species, or omission. I also calculated SI for all small mammals that were trapped (insectivores and rodents), although the actual number of animals caught by Killebrew (1979) was likely greater than the number of study skins in the WTAMU collection.

RESULTS AND DISCUSSION

The 2002–2003 study detected 29 species of mammals in LMNRA, including four previously unreported species, and four additional species from neighboring lands (Table 1): 2 Soricidae, 1 Talpidae, 1 Vespertilionidae, 1 Dasypodidae, 3 Leporidae, 4 Sciuridae, 1 Geomyidae, 3 Heteromyidae, 1 Castoridae, 7 Cricetidae, 1 Erethizontidae, 2 Canidae, 1 Procyonidae, 1 Mustelidae, 1 Felidae, 2 Cervidae, and 1 Antilocapridae.

One species was caught in large Tomahawk traps, three species in small Tomahawks, five species in large Shermans, six species in small Shermans, two species in pitfall traps, one species in gopher traps, and one species in mist-nets; Trailmaster™ cameras recorded three species, spotlight surveys detected three species, other night surveys eight species, coverboards three species, visual day-time encounters 13 species; tracks and signs were recorded for up to 16 species; finally four species were recorded as roadkills, or otherwise dead. Details are summarized in Table 2.

Overall catch rate for live-traps during the 2002–2003 study was 20/100 trap-nights. Sixty-six individuals of 10 species, all rodents, were captured (330 trap-nights/all traps combined): *Peromyscus leucopus*, 28; *Onychomys*

Table 1. Mammalian species detected by the present study, Yancey et al. (1998) and Killebrew (1979) in Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument, and by Blair (1954) at Bugbee Ranch, east of Stinnett. Number of trapped and roadkilled is shown in bold and other observed specimens in normal font; relative species abundance is given where applicable. Legend: (+) present, (-) absent, (A) anecdotal, (C) collected, but no details given (no specimens found in the examined collections), (S) signs (tracks, scat, dens, nests and other signs of activity), (*) outside LMNRA and AFQ, (#) roadkilled or found dead, (^) tracks could not be identified to species, (tn) trap-nights, (&) difficult to distinguish between the two species by visual signs alone.

Species	This Study, 2002–2003	Yancey et al. 1998	Killebrew 1979	Blair 1954
<i>Didelphis virginiana</i>	-	A	A	1
<i>Cryptotis parva</i>	2 (0.17/100 tn)	-	-	5
<i>Notiosorex crawfordi</i>	1 (0.08/100 tn)	-	-	2
<i>Scalopus aquaticus</i>	S	1 , S	3 , S	12
<i>Eptesicus fuscus</i>	-	-	C	9
<i>Lasiurus borealis</i>	-	-	2	1
<i>Antrozous pallidus</i>	1	-	2	-
<i>Corynorhinus townsendii</i>	-	-	2	-
<i>Dasypus novemcinctus</i>	2 [#] , 1	-	-	-
<i>Sylvilagus audubonii</i>	>25 [*]	2	3	?
<i>Sylvilagus floridanus</i>	>25 [*]	2	C	?
<i>Lepus californicus</i>	>25	?	C (0.1–0.9/km)	?
<i>Xerospermophilus spilosoma</i>	1 (0.65/100 tn), >6	+	3 (≥2/ha)	3
<i>Ictidomys tridecemlineatus</i>	2 [*]	-	C (≥2/ha)	1
<i>Cynomys ludovicianus</i>	2 colonies [*]	1 colony [*]	1 , 1 colony	2 colonies
<i>Sciurus niger</i>	2, S	-	A, S	1
<i>Geomys bursarius</i>	3 , S	-	5 (3.8–10/ha)	21
<i>Cratogeomys castanops</i>	-	2	9 (5.4–8/ha)	-
<i>Perognathus flavescens</i>	-	-	-	6
<i>Perognathus flavus</i>	3 , >6	21	-	> 4
<i>Chaetodipus hispidus</i>	1 (0.56/100 tn), 1 [*]	16	2 (2–2.5/ha)	2
<i>Dipodomys ordii</i>	8 (0.7–7.8/100 tn), >50	17	40 (2–88.9/ha)	113
<i>Castor canadensis</i>	S	-	S	-
<i>Reithrodontomys megalotis</i>	3 (1.7/100 tn)	3	-	1
<i>Reithrodontomys montanus</i>	-	5	-	1
<i>Peromyscus leucopus</i>	28 (11.4/100 tn)	90	> 21 (av. 2–20/ha)	35
<i>Peromyscus maniculatus</i>	2 (0.8/100 tn), 1	5	> 13 (av. 2–20/ha)	2
<i>Onychomys leucogaster</i>	10 (4.1/100 tn)	2	3 (4–8/ha)	10
<i>Sigmodon hispidus</i>	1 (0.3/100 tn)	34	> 7 (24–281.4/ha)	4
<i>Neotoma leucodon</i>	5 (1.5/100 tn), S	14	7 (4–14/ha)	-
<i>Neotoma micropus</i>	6 (7/100 tn), >5, S	3	3 (2–7/ha)	16
<i>Ondatra zibethicus</i>	-	-	5	5
<i>Mus musculus</i>	-	3	4	2
<i>Erethizon dorsatum</i>	2 [#] , 1, S	1 [*]	S	1 [#]
<i>Canis latrans</i>	>10	+	+	S
<i>Urocyon cinereoargenteus</i>	S? [^]	-	1	-
<i>Bassariscus astutus</i>	-	-	1	-
<i>Procyon lotor</i>	>5, 1 [#] , S	-	C	?
<i>Taxidea taxus</i>	S, 1 [*] , 2 [#]	-	+	1
<i>Mephitis mephitis</i>	-	-	1	6
<i>Felis rufus</i>	S	-	S	S
<i>Odocoileus hemionus</i>	>20	+	0.06–0.12/km ²	-
<i>Odocoileus virginianus</i>	>25	?	0.06–2.3/km ²	+
<i>Antilocapra americana</i>	>25 [*]	-	>25	-

leucogaster, 10; *Dipodomys ordii*, 8; *Neotoma micropus*, 6; *Neotoma leucodon*, 5; *Reithrodontomys megalotis*, 3; *Peromyscus maniculatus*, 2; *Chaetodipus hispidus*, 1; *Sigmodon hispidus*, 1; *Xerospermophilus spilosoma*, 1. Pitfall trap catch rate was very low: 0.25/100 trap-nights, with only 3 individuals of 2 shrew species caught (*Cryptotis parva*, 2; *Notiosorex crawfordi*, 1). Interestingly, *Perognathus flavus* was never captured in life traps or pit-falls during this study, but was caught by hand during night searches (Table 1). Record of species by site and the site coordinates are provided in Tables 3 and 4 respectively.

Annotated checklist of the mammals of Lake Meredith National Recreation Area and the vicinity (including species not found in 2002–2003 study)

Didelphis virginiana Kerr, 1792 (Didelphimorphia: Didelphidae)

Virginia Opossum

One collected at Sanford Dam on 18 September 1986 (TTU 47798); anecdotal reports from riparian areas (Killebrew 1979, Yancey et al. 1998); Blair (1954) caught a female with young east of Stinnett.

Table 2. Mammalian species detected in Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument by specific methods in the present study, 2002–2003. Legend: (LT) large Tomahawk trap, (ST) small tomahawk trap, (LS) large Sherman trap, (SS) small Sherman trap, (PF) pitfall traps, (GT) gopher traps, (MN) mist-nets, (TC) Trailmaster™ cameras, (SP) spotlight surveys, (NR) night road surveys, (CV) coverboards, (VD) visual daytime encounters, (TS) tracks and signs, (RK) roadkilled or found dead, (*) recorded outside the protected areas; (#) difficult to distinguish between the two species by visual identification alone; (^) impossible to distinguish between two or more species by tracks or signs alone.

Species	LT	ST	LS	SS	PF	GT	MN	TC	SP	NR	CV	VD	TS	RK
<i>Cryptotis parva</i>					x									
<i>Notiosorex crawfordi</i>					x									
<i>Scalopus aquaticus</i>													x	
<i>Antrozous pallidus</i>							x							
<i>Dasyopus novemcinctus</i>												x		x
<i>Sylvilagus audubonii</i> [#]									x	x		x		
<i>Sylvilagus floridanus</i> [#]									x	x		x		
<i>Lepus californicus</i>										x		x	x	
<i>Xerospermophilus spilosoma</i>			x									x		
<i>Ictidomys tridecemlineatus</i>												x		
<i>Cynomys ludovicianus</i>												x		
<i>Sciurus niger</i>												x	x	
<i>Geomys bursarius</i>						x							x	
<i>Perognathus flavus</i>										x				
<i>Chaetodipus hispidus</i>				x						x				
<i>Dipodomys ordii</i>			x	x				x	x				x	
<i>Castor canadensis</i>													x	
<i>Reithrodontomys megalotis</i>				x							x?			
<i>Peromyscus leucopus</i>			x	x				x?			x			
<i>Peromyscus maniculatus</i>				x							x			
<i>Onychomys leucogaster</i>			x	x										
<i>Sigmodon hispidus</i>		x												
<i>Neotoma leucodon</i>		x	x										x?	
<i>Neotoma micropus</i>	x	x						x	x			x	x	
<i>Erethizon dorsatum</i>												x	x	x
<i>Canis latrans</i>												x	x	
<i>Urocyon cinereoargenteus</i> [^]													? [^]	
<i>Vulpes velox</i> [^]													? [^]	
<i>Procyon lotor</i>								x					x	x [*]
<i>Taxidea taxus</i>										x [*]			x	x [*]
<i>Felis rufus</i>													x	
<i>Odocoileus hemionus</i>												x	x [^]	
<i>Odocoileus virginianus</i>												x	x [^]	
<i>Antilocapra americana</i>												x [*]		

Cryptotis parva (Say, 1823) (Insectivora: Soricidae)
Least Shrew

Possibly widespread in the Canadian River Valley, but only two captures in 2002: both from Sanford Marsh (Hutchinson County) on 1 November 2002. One skull was deposited with the Angelo State University (ASU 14356). Blair (1954) collected five from the floodplain of Bugbee Ranch.

Notiosorex crawfordi (Coues, 1877) (Insectivora: Soricidae)
Desert Shrew

Only one specimen obtained in this study: in upland mesquite savanna between Sanford-Yake and Cedar Canyon on 13 November 2002 (ASU 14357). Blair (1954) collected two on Bugbee Ranch, Hutchinson County. Known from elsewhere in Moore and Hutchinson counties (Davis and Schmidly 1994).

Scalopus aquaticus (Linnaeus, 1758) (Insectivora: Talpidae)
Eastern Mole

Positively identified mole tunnels were found in riparian grasslands east of Devil's Canyon in January 2002; the tunnels are hard to see in dense grass. Yancey et al. (1998) collected one specimen at Big Blue Creek, and observed tunnels in Bates Canyon and Spring Canyon; Killebrew (1979) collected this species in riparian habitats at Blue Creek, Plum Creek and Spring Canyon. Blair (1954) caught 12 in sandy floodplain and stabilized sand dunes at Bugbee Ranch.

Lasiurus borealis (Muller, 1776) (Chiroptera: Vespertilionidae)
Eastern Red Bat

Killebrew (1979) collected two in cottonwood trees at Bonita Creek (mislabelled "*Lasiurus cinereus*"; no longer in WTAMU collection); Blair (1954) collected one at Bugbee Ranch, also in a cottonwood grove.

Table 3. Distribution summary by site (see Table 4 for coordinates): from 1978–1979 (a), 1991–1992 (b), and 2001–2003 (c) studies, and opportunistic collection by WTANU faculty and students (d). Legend: (1) Alibates Flint Quarries NM, (2) Bates Canyon, (3) Big Blue Creek, (4) Big Canyon, (5) Blue West, (6) Bonita Creek, (7) Bugbee Canyon, (8) Cas Johnson Road, (9) Chicken Creek, (10) Devil's Canyon, (11) Dolomite Point grasslands, (12) Fritch Fortress-Cedar Canyon, (13) McBride Canyon, (14) Mullinaw Crossing, (15) North Canyon, (16) North End, (17) Plum Creek, (18) Rosita Meadows, (19) Saddlehorse Canyon, (20) Sanford Marsh, (21) Sanford-Yake, (22) Spring Canyon. (x) small prairie dog town at this location succumbed to plague in 2001, (*) old signs, (?) identification uncertain, e.g., where a species cannot be identified by sight alone.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<i>Didelphis virginiana</i>																					d	
<i>Cryptotis parva</i>																					c	c
<i>Notiosorex crawfordi</i>																					c	
<i>Scalopus aquaticus</i>		b	a, b							c							a					a, b
<i>Lasiurus borealis</i> ¹						a																
<i>Antrozous pallidus</i>						a												c				
<i>Corynorhinus townsendii</i>						a						d										
<i>Eptesicus fuscus</i> ²																						
<i>Dasypus novemcinctus</i>									c		c					c						
<i>Sylvilagus audubonii</i>	c?	c?			a			c?		c?	c?	a, c?	b		c?		c?					a
<i>Sylvilagus floridanus</i>			b			c?	b, c?				c?	c?		c?			c?	c?			b	
<i>Lepus californicus</i> ²	a, c	c			c			c		c	c	c				c		c		c		
<i>Xerospermophilus spilosoma</i>	a, c					a		a			c	a		c?		c	c?	c				b
<i>Ictidomys tridecemlineatus</i> ²	a																					
<i>Cynomys ludovicianus</i> ³																					x	
<i>Sciurus niger</i>			c			a?			c								a?				c	
<i>Geomys bursarius</i>	a	c			a	a	a			c?	c?		a			c	a		a		a, c?	
<i>Cratogeomys castanops</i>	a		b		a	a						a	b				a		a		b	
<i>Perognathus flavus</i>		b	b								c	b	b			c	b, c				b	b
<i>Chaetodipus hispidus</i>		b	c		a, b		b					b					a, b				b	b, c
<i>Dipodomys ordii</i>	a, c	b, c			a, c			c			c	a, b, c	a, b	c		c	a, b, c	c	a			a, b
<i>Castor canadensis</i>						a, c			a					c*						a		
<i>Reithrodontomys megalotis</i>											c?		b					c		c?	c?	b
<i>Reithrodontomys montanus</i>					b		b						b								b	
<i>Peromyscus leucopus</i>	a, c	b, c	b		a	a	b					b	a, b	c	c	c	a, b	c	a		b, c	a, b, c
<i>Peromyscus maniculatus</i>						a	b					b	a			c	a	c	a		b	a
<i>Onychomys leucogaster</i>							b					a	a		c	c						b
<i>Sigmodon hispidus</i>	a	b	b		b	a	a, b					b	b								b	a, b
<i>Neotoma leucodon</i>	a	b	b		c		b, c					b, c	a, b, c				a	c			b	a, c
<i>Neotoma micropus</i>	c				c		b				c	a	b, c				a				b, c	c
<i>Ondatra zibethicus</i>																				a		
<i>Mus musculus</i>							a, b						a				a				b	b
<i>Erethizon dorsatum</i> ⁴							c		c		c										b, c	c
<i>Canis latrans</i> ⁵	c	c	c		c		c			c			c	c		c	c				c	c
<i>Urocyon cinereoargenteus</i>													c?								c?	a
<i>Bassariscus astutus</i>																			a			
<i>Procyon lotor</i> ²			c		c		c		c					c						c	c	
<i>Taxidea taxus</i> ²									c					c								
<i>Mephitis mephitis</i> ⁶												a?	a									
<i>Felis rufus</i> ⁷									c													
<i>Odocoileus hemionus</i> ⁵	a, c				c			c					c								c	c
<i>Odocoileus virginianus</i> ²	a, c	c				c			c		c			c			c	c		c		
<i>Antilocapra americana</i> ²																						

Footnote: Killebrew (1979) likely observed species and collected specimens at additional locations throughout the park, but did not provide specifics in his report. 1 - two WTAMU specimens (# 603 and 604) mislabelled *Lasiurus cinereus* were lost or discarded; 2 - Killebrew (1979) reported this species in LMNRA, but no specific locations were provided; 3 - Killebrew (1979) reported a colony from North Turkey Creek within LMNRA; that location was not visited in either 1991-92 or 2001-03; 4 - signs reported by Killebrew (1979) from LMNRA, but locations were not specified (probably from Bonita Creek); 5 - Both Killebrew (1979) and Yancey et al. (1998) reported these species as common, but did not specify locations; 6 - "was noted in virtually every recreation area at the lake and was particularly abundant around picnic areas where they were observed foraging in trash cans" (Killebrew 1979); the only specimen was from McBride area; 7 - Killebrew (1979) noted that tracks were "more numerous in areas remote from picnic and camping sites"

Table 4. Estimated centroids of locations mentioned in the text and Table 3.

Site	Latitude	Longitude
Hutchinson County		
Borger	35°40'24"N	101°23'30"W
Bugbee Canyon	35°43'44"N	101°35'42"W
Bugbee Ranch	35°49'42"N	101°16'53"W
Cedar Canyon	35°28'37"N	101°45'42"W
Fritch	35°38'17"N	101°35'56"W
Fritch Fortress	35°40'60"N	101°35'39"W
North Canyon	35°43'28"N	101°34'37"W
North End grasslands	35°44'05"N	101°33'18"W
Sanford Marsh	35°43'02"N	101°32'49"W
Sanford-Yake	35°41'39"N	101°33'31"W
Spring Canyon	35°43'40"N	101°33'15"W
Stinnett	35°49'34"N	101°26'35"W
Moore County		
Big Blue Creek	35°42'55"N	101°39'36"W
Blue West	35°40'47"N	101°38'10"W
Blue West Road	35°41'16"N	101°40'11"W
Fourways	35°41'27"N	101°57'50"W
Potter County		
Alibates Flint Quarries	35°34'54"N	101°40'39"W
Bates Canyon	35°34'25"N	101°41'56"W
Big Canyon	35°32'12"N	101°46'57"W
Bonita Creek	35°28'08"N	101°47'26"W
Bultaco Hill	35°27'49"N	101°49'43"W
Cas Johnson Road	35°33'23"N	101°40'52"W
Chicken Creek	35°28'37"N	101°45'42"W
Chimney Hollow	35°35'07"N	101°40'47"W
Devils Canyon	35°33'25"N	101°46'15"W
Dolomite Point grasslands	35°35'49"N	101°40'22"W
McBride Canyon	35°32'53"N	101°44'15"W
Mullinaw Crossing	35°31'47"N	101°46'02"W
Plum Creek	35°36'06"N	101°44'44"W
Rosita Meadow	35°28'05"N	101°50'40"W
Saddle Horse Canyon	35°29'39"N	101°47'32"W

Antrozous pallidus (LeConte, 1856)

(Chiroptera:Vespertilionidae)

Pallid Bat

One was mist-netted at the foot of Bultaco Hill, Rosita Meadows on 26 September 2002; 2 collected by Killebrew (1979) at Bonita Creek.

Corynorhinus townsendii (Cooper, 1837)

(Chiroptera:Vespertilionidae)

Townsend's Big-eared Bat

Killebrew (1979) deemed this species the most common bat in LMNRA, and collected two specimens at Bonita Creek on 15 July 1979. Additional specimen was collected in McBride Canyon on 10 June 1986 by N.J. Hildreth.

Eptesicus fuscus (Beauvois, 1796)

(Chiroptera:Vespertilionidae)

Big Brown Bat

Unspecified number of specimens was collected by Killebrew (1979) among cottonwood trees at Lake Meredith (these specimens are no longer in WTAMU collection). This species was common at Bugbee Ranch, 9 specimens (Blair 1954).

Dasyopus novemcinctus Linnaeus, 1758 (Cingulata:

Dasyopodidae)

Nine-banded Armadillo

One was caught by hand at the Chicken Creek on 31 October 2003. Additionally, two withered shells were found east of Bugbee and at Dolomite Point in January and June 2002 respectively. Killebrew (1979) and USNPS staff cited anecdotal reports (e.g., of roadkills). Most likely, *Dasyopus* wanders into the study area in summer from the counties in the east and in the south, but lacking adaptations for the extremes of cold weather (Davis and Schmidly 1994) it cannot survive severe winters in LMNRA. Photo of an armadillo shell (Figure 3) is probably the first documented record for Hutchinson County.

Sylvilagus audubonii (Baird, 1858) (Lagomorpha:

Leporidae)

Desert Cottontail

Sylvilagus floridanus (J.A. Allen, 1890) (Lagomorpha:

Leporidae)

Eastern Cottontail

Field identification of *S. audubonii* and *S. floridanus* is unreliable, and no methods to catch or kill *Sylvilagus* were employed in this study. *S. audubonii* seemingly occupies open sandy areas in the Canadian River Valley and the uplands, while *S. floridanus* inhabits riparian thicket, and brushy canyons. Blair (1954) reported similar habitat preferences, though both species undoubtedly overlap. Yancey et al. (1998) collected *S. audubonii* west of Fritch and in McBride Canyon, and observed it in Spring Canyon. Killebrew (1979) collected *S. audubonii* in Blue West, Cedar Canyon and Spring Canyon. Yancey et al. (1998) collected *S. floridanus* in Bugbee Canyon and Big Blue Creek. Killebrew (1979) reported the following density of *Sylvilagus* sp.: 0.3–0.4/km in AFQ, and 0.01–1.8/km in LMNRA.

Lepus californicus Gray, 1837 (Lagomorpha: Leporidae)

Black-tailed Jackrabbit

Uncommon to common and widespread in uplands and sandy areas. Killebrew (1979) defined this species' habitat as "prairie-mesquite grasslands", and reported densities of 0.1/km in AFQ, and 0.1–0.9/km in LMNRA.

Xerospermophilus spilosoma Bennett, 1833

(Rodentia: Sciuridae)

Spotted Ground Squirrel

Uncommon (or under-recorded), but widespread in sandy areas along the Canadian River, and in the adjacent uplands. One was captured at the North End in May 2003, and four large young photographed at a burrow entrance in Rosita Meadows on 12 August 2002 (Figure 3); this species was also observed in AFQ. Yancey et al. (1998) reported *X. spilosoma* in Spring Canyon, and Killebrew (1979) collected it at Bonita Creek, Cas Johnson

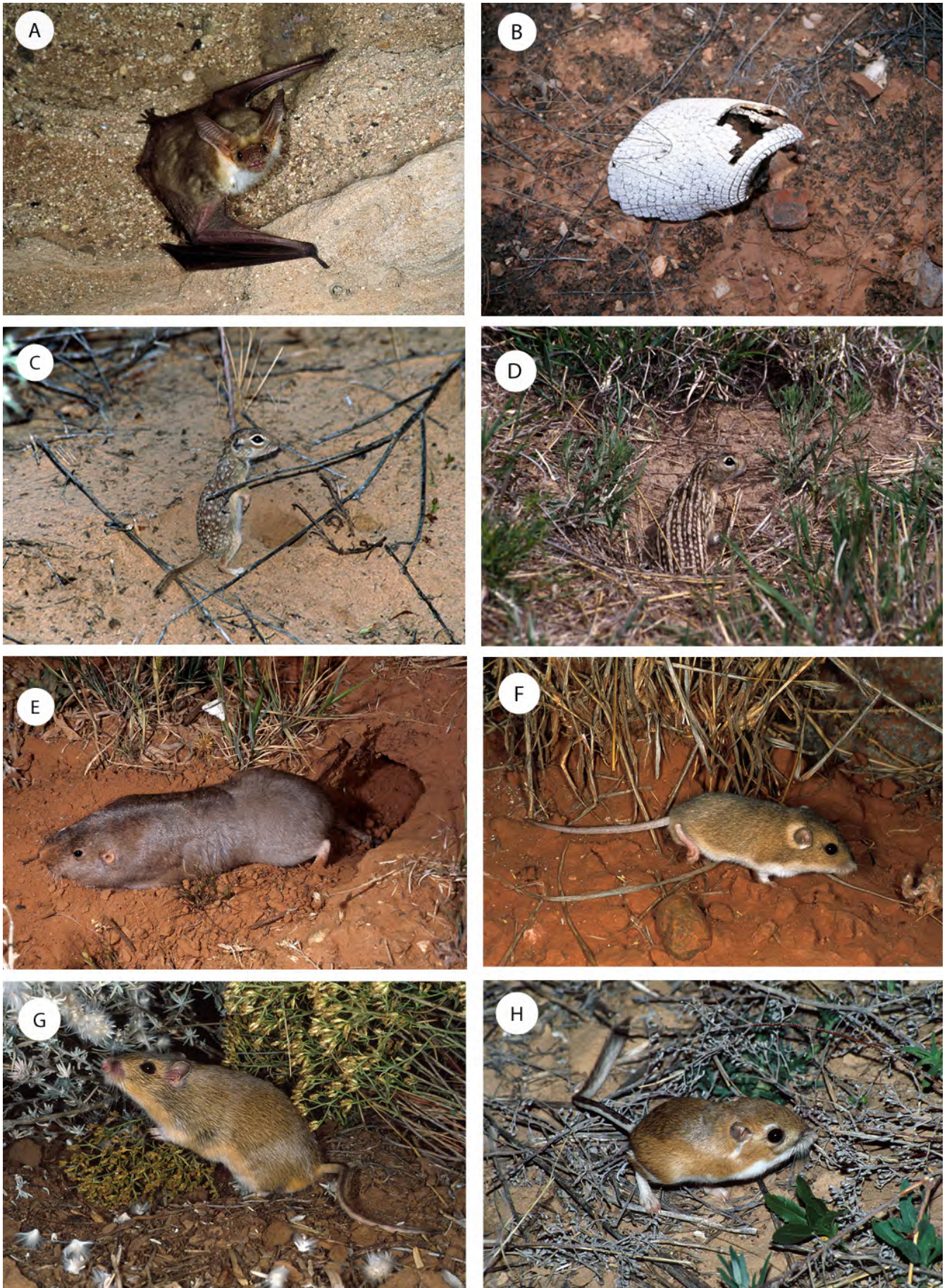


Figure 3. Mammals found in Lake Meredith National Recreation Area, Texas: **A:** *Antrozous pallidus*, **B:** *Dasypus novemcinctus* (withered shell), **C:** *Xerospermophilus spilosoma*, **D:** *Ictidomys tridecemlineatus*, **E:** *Geomys bursarius*, **F:** *Perognathus flavus*, **G:** *Chaetodipus hispidus*, **H:** *Dipodomys ordii*. Photographs by Michael Patrikeev.

Road and Fritch Fortress. Killebrew reported density of 2/ha in mesquite grasslands of Fritch Fortress-Cedar Canyon, and of *Spermophilus sp.*: 5.4–6.3/ha in mesquite grassland, and 6.1–23.8/ha in prairie grassland. Blair (1954) collected 3 in Bugbee Ranch.

Ictidomys tridecemlineatus (Mitchill, 1821)

(Rodentia: Sciuridae)

Thirteen-lined Ground Squirrel

Killebrew (1979) recorded this species throughout LMNRA (“practically everywhere”), and in AFQ, but none were found there in 1991–1992 (Yancey et al. 1998) or 2002–2003. One *I. tridecemlineatus* was observed and photographed at the intersection of Plum Creek Road and FM 1913 (Moore County) north of LMNRA on 2 May and 13 July 2003 (Figure 3). Killebrew (1979) reported finding both *Xerospermophilus spilosoma* and *Ictidomys tridecemlineatus* at densities of 5.4–6.3/ha in mesquite grassland, 6.1–23.8/ha in prairie grassland. One *I. tridecemlineatus* was collected in deep sands near Stinnett (Blair 1954).

Cynomys ludovicianus (Ord, 1815) (Rodentia: Sciuridae)

Black-tailed Prairie Dog

C. ludovicianus was absent from LMNRA and AFQ in 2002–2003; a small colony at the Sanford-Yake campground succumbed to plague in 2000 (J. Rancier pers. comm.). In August 2001, another small colony remained on private lands by Fritch Fortress Road near LMNRA, but no animals were present by January 2002 although J. Rancier (pers. comm.) found a roadkill west of Fritch in summer 2002. A new colony established in a mesquite pasture north of Blue West Road, just outside LMNRA, in 2003 (30–40 mounds counted on 28 April 2003). *C. ludovicianus* was common in the study area and on the adjacent ranches in the late 1970s, e.g., Killebrew (1979) reported a colony occupying several hundred hectares in LMNRA and collected a specimen at North Turkey Creek.

Sciurus niger Linnaeus, 1758 (Rodentia: Sciuridae)

Fox Squirrel

Rare; confined to riverine habitats and planted trees. Blair (1954) collected one east of Stinnett, but Killebrew (1979) and Yancey et al. (1998) did not observe any in LMNRA; Killebrew cited anecdotal reports of squirrel nests at Plum Creek, Bonita Creek and in the LX ranch. In 2002–2003 *S. niger* was observed twice: in planted trees at Sanford-Yake on 4 May 2003, and in riparian woods of Big Blue Creek on 5 June 2003. Additionally, a nest was seen in cottonwoods at Chicken Creek in May 2002.

Geomys bursarius (Shaw, 1800) (Rodentia: Geomyidae)

Plains Pocket Gopher

This species occurs throughout LMNRA and AFQ (Killebrew 1979). According to Davis and Schmidly (1994) *G. bursarius* favors sandy soils, but in 2002–2003

I caught *G. bursarius* in both sandy and clay-loam soils. Killebrew (1979) collected 5 specimens at Bonita Creek, Bugbee Canyon, McBride Canyon and Sanford Dam, and reported densities of 3.8/ha in uplands, sandy areas, and the borrow, and 10/ha in riparian habitats. None was found by Yancey et al. (1998). Blair (1954) collected 21 *G. bursarius* in deep sands of Bugbee Ranch.

Cratogeomys castanops (Baird, 1852) (Rodentia:

Geomyidae)

Yellow-faced Pocket Gopher

None found in the 2002–2003 study. According to Davis and Schmidly (1994) and Yancey et al. (1998), *C. castanops* occurs in calcareous, clay and clay-loam soils, occupying sandy soils where *G. bursarius* is absent. Killebrew (1979) collected nine *C. castanops* (AFQ, Blue West, Bonita Creek, Cedar Canyon, Plum Creek, Saddle Horse Canyon) in deeper mellower soils and also around cliff bases and lower uplands. Yancey et al. (1998) collected two. Killebrew (1979) reported densities of 5.4–8/ha in riparian habitats.

Perognathus flavus Baird, 1855 (Rodentia: Heteromyidae)

Silky Pocket Mouse

Specific identity of *Perognathus* from LMNRA is problematic because the study area lies in the zone of contact between closely related *P. flavus* and *P. merriami*. Schmidly (2004) showed only *P. flavus* for Hutchinson, Moore and Potter counties. Two recent studies of small *Perognathus* (Brant and Lee 2006; Coyner et al. 2010) have not included any specimens from within the 100 km radius of LMNRA. According to Coyner et al. (2010), *P. flavus* occurs to the west and to the north and *P. merriami* to the north, east and south of LMNRA. Both species were found in Cimarron County, Oklahoma 110 km north from the study area. Blair (1954) collected both species at Bugbee Ranch, east of Stinnett (4 *P. flavus* and 13 *P. merriami*), and Yancey et al. (1998) obtained 22 *P. flavus* in live traps in LMNRA. One specimen collected during the latter study by J.R. Goetze is labeled “*P. merriami*” (TTU 59865), but it was not mentioned under that name in Yancey et al. (1998). Interestingly Killebrew (1979) did not collect any *Perognathus* in LMNRA. I caught none in Sherman traps or pitfalls, but infrequently encountered *Perognathus* on paved and unpaved roads during night searches, and caught two by hand (Plum Creek Canyon and near Big Blue Creek). Although Brant and Lee (2006) reported significant differences in five cranial and two external measurements between *P. flavus* and *P. merriami*, most of these differences are < 1 mm, and one would need to examine a large series of specimens to detect these differences. I prefer to follow Schmidly (2004) and treat all *Perognathus* from LMNRA as *P. flavus* at this time while acknowledging that a future molecular or morphometric study of the LMNRA *Perognathus*

may prove that either or both *P. flavus* and *P. merriami* inhabit the study area.

Chaetodipus hispidus Baird, 1858 (Rodentia: Heteromyidae)
Hispid Pocket Mouse

Rare in 2002–2003: only one was caught in Spring Canyon on 24 October 2002, and another observed by Big Blue Creek, north of LMNRA on 15 May 2003. Blair (1954) and Killebrew (1979) also collected two *C. hispidus* each: in Bugbee Ranch, and at the Blue West and Plum Creek respectively. Such paucity of records contrasts the Yancey et al. (1998) study when 20 specimens were collected in LMNRA. Perhaps populations of this species undergo cyclic fluctuations.

Dipodomys ordii Woodhouse, 1853 (Rodentia: Heteromyidae)
Ord's Kangaroo Rat

Common and widespread, and was frequently observed during night road searches, e.g., 7/km on the Dolomite Point Road (4 and 28 May 2003). Trapping proved less effective in October 2002 (0.7/100 trap-nights) than in April 2003 (7.8/100). Four out of seven *D. ordii* caught 12–13 April 2003 were recently weaned juveniles. In the late 1970s, Killebrew (1979) collected 40 specimens and reported densities of up to 88.9/ha in McBride Canyon, although lower elsewhere, from 3/ha (riparian) to 36.6–66.2/ha (sandy areas and upland). Yancey et al. (1998) collected 15 in LMNRA, and Blair (1954) 113 at Bugbee Ranch. *D. ordii* is most common in grasslands and mesquite savanna on sandy soils, but also occurs on clay and loam soils.

Castor canadensis Kuhl, 1820 (Rodentia: Castoridae)
North American Beaver

Limited to the Canadian River and its tributaries. Killebrew (1979) reported *C. canadensis* from the river, Bonita and Chicken Creeks, and Sanford Marsh, e.g., five dams per ca. 400 m of Bonita Creek. No beaver signs were found in 1991–1992 (Yancey et al. 1998), and in 2002–2003 fresh signs of *C. canadensis* activity (felled trees, dams, lodges, and runways) were found only along Bonita Creek, and older signs upstream from the Mullinaw Crossing (Figure 4).

Reithrodontomys megalotis (Baird, 1858) (Rodentia: Cricetidae)
Western Harvest Mouse

Only three were captured during this study, all in the Rosita Meadows on 23 April 2003; also three were collected by Yancey et al. (1998) in McBride and Spring Canyons. Blair (1954) collected one at Bugbee Ranch.

Reithrodontomys montanus (Baird, 1855) (Rodentia:

Cricetidae)
Plains Harvest Mouse

None in 2002–2003, but Yancey et al. (1998) caught five in Bugbee and McBride canyons, and at the Blue West. According to Yancey et al. (1998) *R. montanus* favors more xeric and upland habitats than *R. megalotis*. One was collected in Bugbee Ranch by Blair (1954). Interestingly, Killebrew (1979) did not collect either *Reithrodontomys* during his study.

Peromyscus leucopus (Rafinesque, 1818) (Rodentia: Cricetidae)
White-footed Mouse

Very common; perhaps the most common rodent in the Texas Panhandle (Jones et al. 1988) including LMNRA (Yancey et al. 1998). Killebrew (1979) reported densities from as low as 4/ha at Plum Creek to 38.9–55.3/ha in sandy areas, with estimates of 74.8/ha in McBride Canyon, and even 196.2/ha in AFQ! Blair (1954) collected 35 at Bugbee Ranch; Yancey et al. (1998) and Killebrew (1979) collected 99 and 21 specimens respectively. My study is in accord with the previous findings: a total of 28 captured, 11.4/100 trap nights (one specimen in ASU, 14361), and at least seven found under coverboards. *P. leucopus* was recorded in all habitats in LMNRA. Pregnant females caught in Spring Canyon and Sanford Marsh produced litters of 7 young each on 24 and 25 October 2002.

Peromyscus maniculatus (Wagner, 1845) (Rodentia: Cricetidae)
Deer Mouse

Less common than *P. leucopus*. In the late 1970s Killebrew (1979) collected 13 specimens and reported densities from 4 to 58.3/ha, though as high as 241.4/ha in AFQ. He noted higher numbers in rock slopes, and lowest in sandy areas. Blair (1954) caught only two at Bugbee Ranch. In more recent studies Yancey et al. (1998) caught 5 *P. maniculatus* (Appendix 1), compared to 99 *P. leucopus*, and I trapped only two *P. maniculatus* (0.8/100 trap-nights), and found one under a coverboard in McBride Canyon. A pregnant female caught in LMNRA on 23 October 2002 produced a litter of 7 in captivity (ASU 14364–14371).

Onychomys leucogaster (Wied-Neuwied, 1841) (Rodentia: Cricetidae)
Northern Grasshopper Mouse

Killebrew (1979) reported densities of 4 to 8/ha, but collected only two specimens: at Cedar and McBride canyons; Yancey et al. (1998) also collected two (Bugbee Creek and Spring Canyon). Ten were caught during this study (4/100 trap-nights): seven in the little bluestem-sage-yucca grassland on sandy soils at the North End, and three in dense mesquite in the borrow area (one

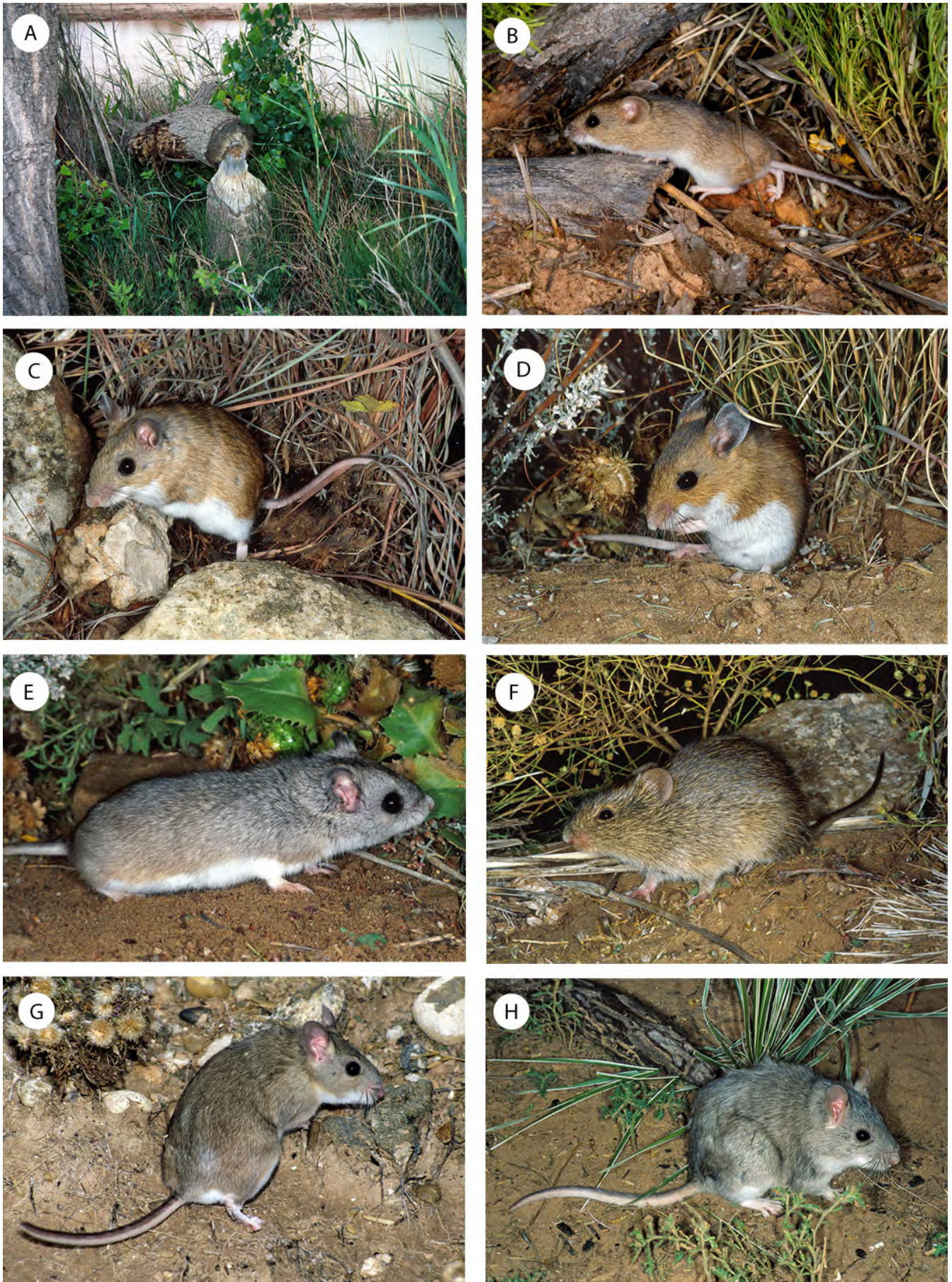


Figure 4. Mammals found in Lake Meredith National Recreation Area, Texas: **A:** Tree felled by *Castor canadensis*, **B:** *Reithrodontomys megalotis*, **C:** *Peromyscus leucopus*, **D:** *Peromyscus maniculatus*, **E:** *Onychomys leucogaster*, gray phase, **F:** *Sigmodon hispidus*, **G:** *Neotoma leucodon*, **H:** *Neotoma micropus*. Photographs by Michael Patrikeev.

deposited with ASU, 14360). Blair (1954) caught ten at Bugbee Ranch.

Sigmodon hispidus Say & Ord, 1825 (Rodentia: Cricetidae)
Hispid Cotton Rat

Surprisingly scarce in 2002–2003: only one capture (0.3/100 trap-nights), in the upland mesquite grassland at Sanford-Yake on 22 October 2002. *Sigmodon hispidus* was very common in LMNRA in the 1970s (Killebrew 1979) with densities of up to 137.1–281.4/ha, (e.g., in AFQ, Bugbee and Spring canyons; 7 specimens). Yancey et al. (1998) collected 36 specimens in the early 1990s. According to Davis and Schmidly (1994) Texas populations of *S. hispidus* experience dramatic fluctuation, rising and falling about every ten years with highest densities reported in wetter years. Perhaps the LMNRA population crashed during the prolonged drought in the late 1990s–early 2000s, and also during Blair's (1954) study (only 4 collected). A pregnant female caught on 22 October 2002 produced a litter of 6 in captivity.

Neotoma leucodon Merriam, 1894 (Rodentia: Cricetidae)
White-throated Woodrat

Common in rocky slopes and canyons throughout LMNRA. Five were caught in the 2002–2003 study (1.5/100 trap-nights), and nests of this species were found in additional locations (Table 4); one specimen deposited with ASU (14358). Killebrew (1979) collected 8 and reported densities of 4–14/ha on rocky slopes; Yancey et al. (1998) collected 13.

Neotoma micropus Baird, 1855 (Rodentia: Cricetidae)
Southern Plains Woodrat

Common in sandy areas and uplands with *Yucca* and *Opuntia*, as well as in the borrow area. Six were caught during this study (7/100 trap-nights), e.g., one deposited with ASU, 14359; >5 *N. micropus* and their nests were noted in additional locations (Table 4). Killebrew (1979) found this species in cottonwood groves, where nests were constructed under fallen trees, and also in buildings; he collected 2 specimens and reported densities of 2–7/ha. Yancey et al. (1979) collected three, and Blair (1954) sixteen at Bugbee Ranch.

Ondatra zibethicus (Linnaeus, 1766) (Rodentia: Cricetidae)
Common Muskrat

Killebrew (1979) found *O. zibethicus* common in the areas where *Castor canadensis* was also present: Bonita Creek, Chicken Creek and Sanford Marsh (5 specimens). In addition, three *O. zibethicus* were caught at Sanford Marsh in 1984 by L. Heitz and T. Snow (WTAMU collection). Blair (1954) also collected five from a “dense population” at Bugbee Ranch. However, *O. zibethicus* was not recorded by Yancey et al. (1998) or during my

study, although I did not focus on aquatic habitats.

Mus musculus Linnaeus, 1766 (Rodentia: Muridae)
House Mouse

Killebrew (1979) collected 4 in Bugbee, McBride Canyon, and at Plum Creek, and Yancey et al. (1998) at Sanford-Yake and in Bugbee Canyon. Blair (1954) caught two at Bugbee Ranch in cottonwood stands. I found none in the 2002–2003 study.

Erethizon dorsatum (Linnaeus, 1758) (Rodentia: Erethizontidae)
North American Porcupine

Rare. In LMNRA *E. dorsatum* is confined to treed portions of the valley and the Canadian River's tributaries. Killebrew (1979) observed “abundant signs” of gnawing in cottonwood and hackberry groves, and Yancey et al. (1998) reported a roadkilled porcupine from Sanford Dam. Only one live *E. dorsatum* was observed during the current study, in a lone tree at Dolomite Point on 10 June 2002 (Figure 5), and two roadkilled at Sanford Dam on 18 September 2002 and by Bugbee Creek on 25 June 2003 respectively. Feeding signs and tracks were observed in additional locations (Table 4).

Canis latrans Say, 1823 (Carnivora: Canidae)
Coyote

Common and widespread (Table 4), up to 3–4 heard or seen at each site. Killebrew (1979) and Yancey et al. (1998) also found *C. latrans* common in the study area. One specimen is in WTAMU.

Urocyon cinereoargenteus (Schreber, 1775)
(Carnivora: Canidae)
Gray Fox

The only record of *Urocyon cinereoargenteus* from LMNRA is from Spring Canyon (Killebrew 1979). Davis and Schmidly (1994) reported this species in Potter County, but not in Hutchinson County. Not recorded by Yancey et al. (1998) or during my study. Tracks of a small fox were regularly seen in a sandy draw in AFQ in March–May 2002, but all attempts to photograph the animal with a trail camera were unsuccessful. In June 2003 an unidentified fox was seen along Cedar Canyon Road in Sanford-Yake area (Hutchinson Co.) by LMNRA personnel and visitors, but subsequent searches failed to find foxes or their tracks. No roadkilled foxes were seen or reported in the general study area.

Bassariscus astutus (Lichtenstein, 1830) (Carnivora: Procyonidae)
Ringtail

Observed once in Saddle Horse Canyon in the 1970s (Killebrew 1979), but not recorded since (Yancey et al.



Figure 5. Mammals found in Lake Meredith National Recreation Area, Texas: **A:** *Erethizon dorsatum*, **B:** *Procyon lotor* at a bait station, **C:** *Procyon lotor*, skull, **D:** *Taxidea taxus*, tracks. Photographs by Michael Patrikeev.

1998, this study). *B. astutus* may still occur in the study area albeit in small numbers. Blair (1954) did not report it from Bugbee Ranch.

Procyon lotor (Linnaeus, 1758) (Carnivora: Procyonidae)
Raccoon

Uncommon, but widespread, mostly along the Canadian River and its tributaries and around Lake Meredith (Table 4), e.g., near picnic areas. Photographed by a trail camera during this study (Figure 5).

Taxidea taxus (Schreber, 1777) (Carnivora: Mustelidae)
American Badger

Uncommon or rare. Signs of this species were observed by Killebrew (1979), but not by Yancey et al. (1998). In 2002–2003, tracks of *T. taxus* were regularly seen at the Mullinaw Crossing and Chicken Creek (Figure 5), but none was observed or photographed during extensive night searches and trail camera sessions in LMNRA. *T. taxus* may be more common in the adjacent private lands: one was seen crossing FM 1913 north of Big Blue Creek (Moore Co.) on 14 April 2003, and roadkilled badgers were seen along State Highway 136 south of Fritch, at the intersection of SH 136 and FM 1559 west of Borger (both in Hutchinson Co.), and US 287 north of the Canadian River Bridge (Potter County). In Texas, *T. taxus* preys primarily

on *Xerospermophilus spilosoma*, *Ictidomys tridecemlineatus* and *Cynomys ludovicianus* (Davis and Schmidly 1994), and the low prey densities might explain the paucity of badgers in 2002–2003. *Xerospermophilus spilosoma* and *Ictidomys tridecemlineatus* declined in the study area since the 1970s, and *Cynomys ludovicianus* was absent from the LMNRA proper during this study.

Mephitis mephitis (Schreber, 1776) (Carnivora: Mephitidae)
Striped Skunk

Absent or rare. In the late 1970s *M. mephitis* was observed and collected at LMNRA (Killebrew 1979), e.g., in McBride Canyon. Killebrew (1979) commented that *M. mephitis* “was noted in virtually every recreation area at the lake and was particularly abundant around picnic areas where they were observed foraging in trash cans”. Blair (1954) also collected six at Bugbee Ranch. However, no *M. mephitis* was detected by Yancey et al. (1998) or in my study. Roadkilled striped skunks were common along SH 136 between Masterson and Amarillo, but not in or near the study area.

Lynx rufus (Schreber, 1777) (Carnivora: Felidae)
Bobcat

Rare. Killebrew (1979) observed tracks and signs in areas remote from picnic and camping sites, including

rocky slopes and sandy areas. No signs were recorded by Yancey et al. (1998), but in 2003 I found tracks at Chicken Creek at the south end of LMNRA.

Odocoileus hemionus (Rafinesque, 1817) (Artiodactyla: Cervidae)

Mule Deer

Uncommon (Table 4). Estimated density of *O. hemionus* in the late 1970s in AFQ was 0.06–0.12/km², and of both *O. hemionus* and *O. virginianus* 0.4 to 2.3/km² (Killebrew 1979). Mostly found on rocky slopes with juniper or mesquite. Small herds were observed in winter through mid-spring, e.g., a herd of 8 at Sanford Dam on 21 December 2001. A doe and fawn at the Blue West on 2 June 2002.

Odocoileus virginianus (Zimmermann, 1780) (Artiodactyla: Cervidae)

White-tailed Deer

Relatively common and widespread through riparian habitats of the Canadian River Valley and associated creeks (Table 4). According to Jones et al. (1988) native population of *O. virginianus* in LMNRA was supplemented with stocked animals from elsewhere during the 1940s–1950s. Killebrew (1979) estimated densities of 0.06–0.12/km² in AFQ for *O. virginianus*, and of 0.4–2.3/km² for both *O. hemionus* and *O. virginianus* in LMNRA. Density of ca. 0.5/km recorded during spotlight surveys in 2002–2003. A doe with a fawn observed in Plum Creek Canyon on 19 July 2003.

Antilocapra americana (Ord, 1815) (Artiodactyla: Antilocapridae)

Pronghorn

Probably no longer present in LMNRA and AFQ. Killebrew (1979) reported herds of 10–23 in upland prairies (possibly) within LMNRA, noticing very few young. Yancey et al. (1998) failed to find any in 1991–1992, probably because both protected areas were fenced by then, and *A. americana* is often unwilling to cross barbed wire fences (Davis and Schmidly 1994). In 2001–2003, groups of 12–30 were observed on private lands in the general vicinity of LMNRA, most often along FM 1913 east of Four Way (Moore County), in Alibates Ranch off SH 136 (Potter County) and east of Plum Creek Road (Moore County). Replacement of top and bottom strands of barbed wire with smooth wire on the perimeter fences was underway in the parks in the early 2000s (J. Rancier pers. comm.) to allow *A. americana* to cross in and out of the parks.

DISCUSSION

Trailmaster™ camera surveys in LMNRA/AFQ were ineffective due to a variety of environmental factors including heat and wind. The TM-550 sensors are

triggered by a combination of heat and movement, and on the plains of Texas the ground heats up quickly and retains heat for some time. The combination of ground heat and wind-blown debris, rain, or flies, attracted to meat bait, easily triggered TM-550 and the camera, and quickly used up the film, mostly shooting blanks. Additionally, seeds and other vegetable stuffs at the bait station attracted small rodents which would trigger the camera, and use up the film before any larger animals could have discovered the bait. In addition, TM-550 sensors have a very wide range and could be triggered by movement at 90° on either side of the sensor, resulting in additional blanks. Programming sensors for night use only, increasing intervals between picture taking events, removal of vegetable bait, and narrowing TM-550 field of view with masking tape did not improve efficiency of these surveys. On hot days meat at the bait stations putrefied quickly attracting flies, probably making the bait less attractive to carnivorous mammals.

Bat netting was largely unsuccessful due to persisting winds, although bats in general were uncommon in the study area. Bats silhouette well against the evening sky, yet none were seen during frequent twilight drives or walks in 2002–2003. The Texas Tech study of 1991–1992 (Yancey et al. 1998) did not record any bats. Yet, Killebrew (1979) considered *Eptesicus fuscus* common, and collected three other species. It is conceivable that environmental conditions in the study area have changed since the late 1970s, but other means of bat detection (acoustic detectors and harp traps) should be employed before drawing conclusions regarding paucity of Chiroptera in LMNRA and AFQ.

On the whole, the 2002–2003 study found 65.9% of all mammals previously recorded in LMNRA and AFQ (compared to 45.5% reported by Yancey et al. 1998, and 77.3% by Killebrew 1979). The present study provides first published records of Least Shrew (*Cryptotis parva*), Desert Shrew (*Notiosorex crawfordi*), Nine-banded Armadillo (*Dasypus novemcinctus*), and Fox Squirrel (*Sciurus niger*) for LMNRA. Specimens of the first two species were collected, and remains of the armadillo were photographed. The two shrews and the squirrel, however, are known from other localities within the three counties, but the armadillo is probably a recent arrival (although Killebrew (1979) cited anecdotal reports for both the armadillo and the squirrel).

Killebrew (1979) recorded 36 species from LMNRA and AFQ, and Yancey et al. (1998) 21 species, including four species missed by Killebrew. Ten species (including three species of bats) were not observed in LMNRA since the Killebrew study in the 1970s, although four of these have been recorded in the vicinity of the recreation area in 2002–2003. In total, the three studies detected 43 species of mammals in LMNRA, and 10 additional species in the adjacent parts of Hutchinson, Potter, and

Moore counties (Killebrew 1979; Yancey et al. 1998; this study). Blair (1954) reported 30 species from Bugbee Ranch. Killebrew (1979) collected at least 105 rodents (10 species) other than gophers, the muskrat and the prairie dog, 14 gophers (2 species), and 3 insectivores (all moles) (Table 1). Overall he reported 6,280 trap-nights that would translate into a relatively low success rate for small and medium-sized rodents (only 1.67/100 trap-nights); however, many animals caught during his study were toe-clipped and released (total catch not reported). Killebrew (1979) also was unclear on whether his 6,280 trap-nights included spear and harpoon-traps for burrowing species, pit-falls, Conibear, suitcase, and large Tomahawk traps; the actual capture rates in his study were likely higher than presented in his unpublished report. Numbers from Killebrew (1979) cited in Table 1 refers to estimated densities, and to specimens entered into the West Texas A&M University mammal catalogue (courtesy of R. Matlack, WTAMU). Some of those specimens had since been lost or discarded. Yancey et al. (1998) collected 218 specimens (12 species) of rodents, other than gophers, 3 gophers (1 species), and 1 insectivore (mole), but the total trapping effort was not reported (Table 1). Blair's (1954) study of Bugbee Ranch produced 201 rodents (15 species), other than gophers and muskrats, 21 gophers (1 species), and 19 insectivores (3 species). Blair did not report on trapping effort either

Simpson Diversity Index was highest for the Killebrew (1979) study, and lowest for Yancey et al. (1998). However, when SI was calculated only for the trapped small mammals the Yancey et al. study ranked higher than my study and Blair (1954); the highest ranking was Killebrew (1979) (Table 5).

Jaccard's similarity coefficient (Table 6, Figure 6) demonstrated most parallels between Killebrew (1979) and the current study; and least similarity between Killebrew and Yancey et al. (1998). However, these differences in species diversity are likely artifacts of sampling efforts and/or natural population fluctuations rather than changes in distribution and population status.

Four species (*Ictidomys tridecemlineatus*, *Cynomys ludovicianus*, *Mephitis mephitis*, and *Antilocapra*

americana) have declined in the protected areas or perhaps became locally extirpated. *Taxidea taxus* might have declined in LMNRA in response to diminished prey (*Ictidomys*, *Xerospermophilus* and *Cynomys*). Populations of six rodent species (*Perognathus flavus*, *Chaetodipus hispidus*, *Reithrodontomys megalotis*, *R. montanus*, *Peromyscus maniculatus*, and *Sigmodon hispidus*) likely undergo cyclic changes, which may explain the paucity of records in some years.

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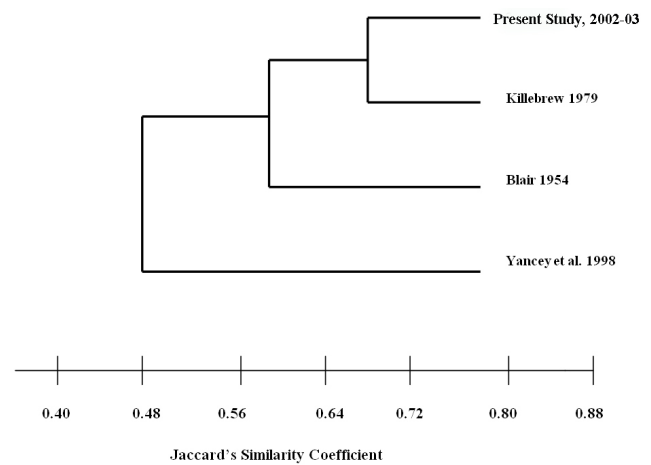


Figure 6. Jaccard similarity coefficient for the three mammal inventories of LMNRA, as well as Blair's (1954) study.

Table 5. Simpson Index (SI) expressed as a negative logarithm for all mammalian species, and small mammals (rodents and insectivores) trapped in the four studies discussed in this paper.

Surveys	2002–2003	Yancey et al. 1998	Killebrew 1979	Blair 1954
All species	2.122	1.551	2.302	1.581
Trapped rodents and insectivores	1.435	1.514	1.877	1.310

Table 6. Jaccard similarity coefficient (J) for the four mammal studies conducted in LMNRA and the vicinity.

Surveys	2002–2003	Yancey et al. 1998	Killebrew 1979	Blair 1954
2002–2003	x	0.52941	0.68292	0.5641
Yancey et al. 1998	0.52941	x	0.48648	0.53125
Killebrew 1979	0.68292	0.48648	x	0.6
Blair 1954	0.5641	0.53125	0.6	x

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Appendix 1. Voucher specimens from Lake Meredith National Recreation Area and Alibates Flint Quarries National Monument, Texas, USA.

Didelphis virginiana (TTU 47798), *Cryptotis parva* (ASU 14356), *Notiosorex crawfordi* (ASU 14357), *Scalopus aquaticus* (TTU 61708; WTAMU 573, 574, 822), *Lasiurus borealis* (WTAMU 603, 604), *Antrozous pallidus* (WTAMU 601, 602), *Corynorhinus townsendii* (TTU 47799, WTAMU 600, 616), *Sylvilagus audubonii* (TTU 61516, 61832; WTAMU 621, 629, 633), *Sylvilagus floridanus* (TTU 61709 and 61833), *Xerospermophilus spilosoma* (WTAMU 583, 605, 1062), *Cynomys ludovicianus* (WTAMU 628), *Geomys bursarius* (563–66, 1063), *Cratogeomys castanops* (TTU 61234, 61235; WTAMU 567–70, 572, 575, 576, 669, 1003), *Perognathus flavus* (TTU 59954–56, 60176, 60177, 61237, 61238, 61522, 61638, 61639, 61640, 61641, 61714–17, and 61840–43), *Chaetodipus hispidus* (TTU 59861–64, 59953, 60178, 60179, 60331, 61518–20, 61645, 61720, 61721, 61834, 61835–37, 62332, 62333; WTAMU 617, 835), *Dipodomys ordii* (TTU 59866, 60180, 61239–42, 61517, 61657–60, 61724, 61847–49; WTAMU 271, 309, 335, 394, 467, 606, 607, 610, 611, 613–15, 623–26, 631, 632, 641, 642, 644–53, 655, 659–61, 670, 706, 709, 762, 1066, 1078), *Reithrodontomys megalotis* (ASU 14362, 14363; TTU 60358, 61548, 61694), *Reithrodontomys montanus* (TTU 60359, 60360, 61271, 61272, 61549), *Peromyscus leucopus* (ASU 14361, TTU 59873–82, 59958–63, 60182–89, 60335–57, 61259–65, 61529–39, 61673–85, 61741–50, 61869–78, 62336; WTAMU 311, 336, 457, 465, 561, 562, 668, 1052–61, 1067–70), *Peromyscus maniculatus* (ASU 14364–14371; TTU 61757, 61758, 61887, 61888; WTAMU 225, 236, 310, 432, 435, 456, 460, 663, 1050, 1051, 1079, 1085, 1093), *Onychomys leucogaster* (ASU 14360; TTU 61524, 61850; WTAMU 627, 1071), *Sigmodon hispidus* (TTU 59868–72, 59964–67, 60190, 60361–66, 61550–57, 61695–97, 61773–77, 61913–15, 62338; WTAMU 585, 587, 594, 595, 1016, 1064, 1065), *Neotoma leucodon* (ASU 14358; TTU 59867, 59957, 60181, 60332, 60333, 61243, 61649, 61763–68; WTAMU 577, 579, 581, 582, 588, 591, 596, 662), *Neotoma micropus* (ASU 14359, TTU 60334, 61655, 61770; WTAMU 593, 597), *Ondatra zibethicus* (WTAMU 618–20, 778, 779, 1465, 1470, 1523, 1731), *Mus musculus* (TTU 60367; WTAMU 334, 1089–91), *Canis latrans* (WTAMU 1576), *Mephitis mephitis* (WTAMU 639).

Appendix 2. Potentially occurring species. In addition to the 43 species recorded by this and previous studies in LMNRA and AFQ, other 12 species are known from Hutchinson, Moore and Potter Counties, and neighboring counties, and may occur in the study area.

Cave Myotis (*Myotis velifer*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), and Big Freetail Bat (*Nyctinomops macrotis*) are known from elsewhere in Potter and

Hutchinson Counties (Jones et al., 1988, Davis and Schmidly 1994), and California Myotis (*M. californicus*), Western Small-footed Myotis (*M. ciliolabrum*), and Western Pipistrelle (*Parastrellus hesperus*) from Randall County south of Potter County (Schmidly 2004); Eastern Pipistrelle (*Perimyotis subflavus*) may also occur (Schmidly 2004).

Plains Pocket Mouse (*Perognathus flavescens*) was collected by Blair (1954) in the vicinity of Stinnett, northwest of LMNRA, and may occur in the study area as well. Norway Rat (*Rattus norvegicus*) occurs in Potter County (Yancey et al. 1998).

Vulpes velox is known from Hutchinson, Moore and Potter counties (Davis and Schmidly 1994); it was suspected for LMNRA (Killebrew 1979) but apparently never observed. Tracks of a small fox were regularly seen during this study in a sandy draw in AFQ in March-

May 2002. All attempts to photograph the animal with a remote camera were unsuccessful. Predation by coyotes (Kamler et al. 2003) may be responsible for absence/paucity of *Vulpes velox* in LMNRA/AFQ.

Eastern Spotted Skunk (*Spilogale putorius*) is known from one record in Moore County (Jones et al. 1988), and Mountain Lion (*Felis concolor*) formerly occurred in the area, e.g., an old record from Moore County (Jones et al. 1988, Davis and Schmidly 1994), although Killebrew (1979) regarded anecdotal reports of Mountain Lions from LMNRA as sightings of unspotted bobcats. Additionally, he reported *Mustela frenata* specimens from Potter County, but did not provide additional information. Schmidly (2004) showed no records of *M. frenata* from the northern Texas Panhandle.