

MAMMALS OF THE CUATRO CIÉNEGAS BASIN, COAHUILA, MEXICO

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ABSTRACT—The current (1996–1997 survey) mammalian fauna of the Cuatro Ciénegas Basin, Coahuila, Mexico, is compared with records of the past century as well as records from undated (pre-1953) owl-pellet records and undated (pre-1700) archaeological remains. The basin supports one of the largest freshwater areas in the deserts of northern Mexico and is located along the Sierra del Carmen–Sierra Madre Oriental Filter-Barrier, between the arid Chihuahuan and tropical Tamaulipan biotic provinces. The freshwater environment has remained remarkably stable through Pleistocene climatic oscillations, but more recently has been subjected to human-induced impact. Comparison of archaeological, historical, and current mammalian fauna depicts the well-known extirpation of larger carnivores and ungulates by humans; the shift to a drier, more Chihuahuan environment; and loss of species during the past century, including the apparent and unexplained disappearance of 4 species of rodents from the basin.

RESUMEN—La fauna de mamíferos actual del Bolsón de Cuatro Ciénegas, Coahuila, México (basado en un inventario de 1996–1997) es comparada con registros del siglo pasado, con descripciones anteriores basadas en registros sin fecha (antes de 1953) de egagrópilas de lechuza, y con restos arqueológicos sin fecha (antes de 1700). El bolsón sostiene una de las áreas de agua dulce más grandes de los desiertos norteños de México, y está situado a lo largo de la Barrera-Filtro de la Sierra del Carmen – Sierra Madre Oriental, entre las provincias bióticas Chihuahuense (árido) y Tamaulipeca (tropical). El ambiente de agua dulce se ha mantenido notablemente estable a través de las oscilaciones climáticas pleistocénicas, pero más recientemente ha sido objeto de impacto inducido por humanos. La comparación de la mastofauna arqueológica, histórica, y actual representa la extirpación bien conocida de grandes carnívoros y de ungulados por seres humanos; el cambio a un ambiente más Chihuahuense, más seco; y la pérdida de especies durante el siglo pasado, incluyendo la desaparición aparente e inexplicable de cuatro especies de roedores del bolsón.

The Cuatro Ciénegas Basin (Bolsón de Cuatro Ciénegas) of central Coahuila, Mexico, has long been recognized for its exceptional biodiversity, including the greatest number of endemic species of any place in North America (Stein et al., 2000). This 1,500-km² “biological island” (Contreras-Balderas, 1990) rests astride the northern extension of the Sierra Madre Oriental, ranging from about 740 m on the grassy basin floor to above 3,000 m in the surrounding mountains (Fig. 1). The basin is located along the Sierra del Carmen – Sierra Madre Oriental Filter-Barrier (Baker, 1956), which separates the arid Mesa del Norte (also Chihuahuan-Zacatecas, Chihuahuan, or Mapimian biotic province) from

the tropical Gulf Coast Plain (Tamaulipan biotic province; Dice, 1943; Goldman and Moore, 1945; Findley and Caire, 1974; Morafka, 1974). The basin lies at the eastern edge of the Coahuilan subregion of the Chihuahuan regional desert (Hafner and Riddle, 2005); the subregion is bounded by the Sierra Madre Oriental, Sierra Parras, Río Nazas, Sierra Madre Occidental, Río Conchos, and Río Grande.

Abundant freshwater of the basin originates in springs that emerge in hundreds of interconnected, travertine-lined pozas (spring-fed pools) and lagunas (spring-fed lakes), from which diverse endemic fish, aquatic snail, and crustacean faunas have been described (e.g., Minckley,

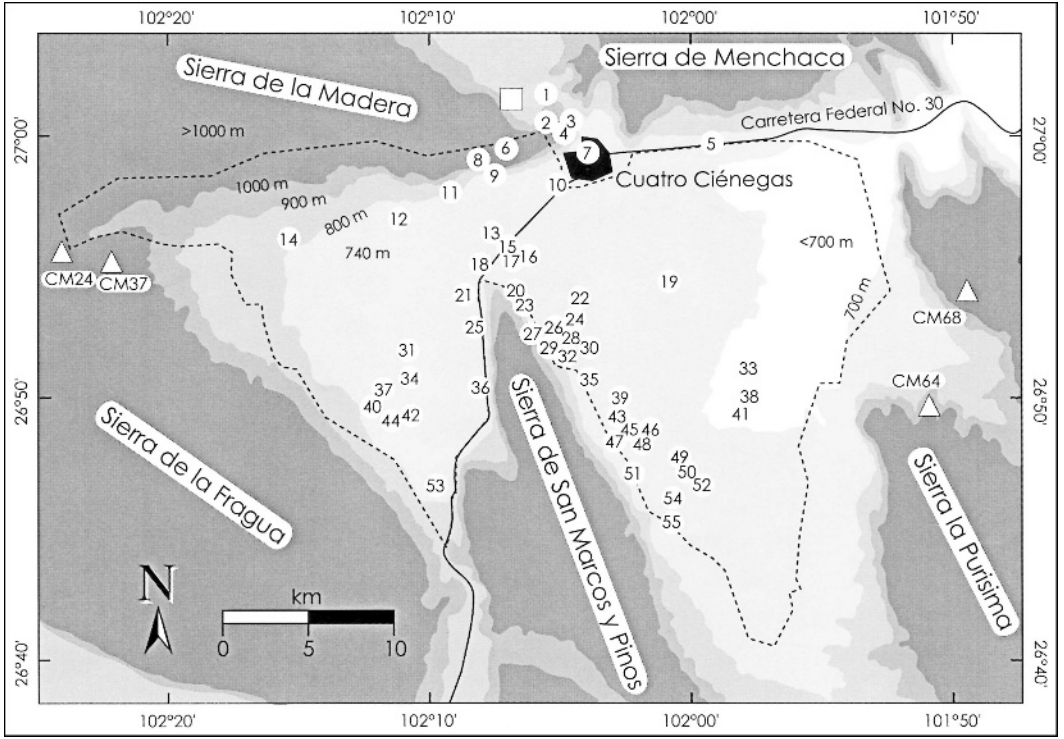


FIG. 1—Shaded contour map of the Cuatro Ciénegas Basin, Coahuila, Mexico: numbered circles indicate sites where mammals were captured or observed during the 1996–1997 survey, or represented by museum specimens not previously reported in the literature; triangles and associated CM numbers indicate archaeological sites from which mammals were described (Gilmore, 1947); square indicates site from which mammals were described from owl pellets (Baker, 1953); dashed line indicates the boundary of the Área de Protección de Flora y Fauna de Cuatro Ciénegas.

1969, 1974; Cole, 1984; Hershler, 1985). The basin is drained to the east via the Río Salado de los Nadadores. The diverse flora of the basin, which includes a variety of endemic, gypsophilous species, has been described by Pinkava (1974, 1984). In recognition of the biotic diversity of the basin, the Mexican federal government in 1994 delineated the floor of the basin as a 3,632.6 km² protected area of flora and fauna (Secretaría de Desarrollo Social, 1994). Human-induced threats to the biota of the basin include diversion of freshwater via canals for agriculture, direct agricultural conversion, overgrazing, mining, and tourist development centered in the pueblo of Cuatro Ciénegas de Carranza, which was founded in 1880 (as Nuestra Señora de los Dolores y Cuatro Ciénegas).

The high level of endemism found within plants, fishes, aquatic snails, crustaceans, and

scorpions (Sissom and Hendrixson, 2005) of the Cuatro Ciénegas Basin is due both to presence of such a vast wetland area within the dry Chihuahuan Desert (<200 mm of annual rainfall) and the long-term stability of the basin’s environment. Unlike terminal basins elsewhere in arid western North America that harbored pluvial lakes that oscillated greatly during Pleistocene glacial-interglacial cycles, the aquatic environment of the basin (and presumably the terrestrial environment nourished by these waters) has been remarkably stable during the late Quaternary, without development of a pluvial lake (Meyer, 1973).

Mammals of the Cuatro Ciénegas Basin—In marked contrast to the detailed descriptions of the flora, aquatic fauna, and reptiles and amphibians (McCoy, 1984) of the Cuatro Ciénegas Basin, the current mammalian fauna of the region is poorly known. The first list of 36

TABLE 1—Taxonomic listing of species recorded or believed to occur in the Cuatro Ciénegas Basin, Coahuila, Mexico (X = specimen record; m = occurrence shown on distribution map without verified record; v = visual record or pers. comm. of same; ? = probably extant, based on peripheral records): A) undated archaeological sites (Gilmore, 1947) are numbered as in Fig. 1; B) single site for undated owl pellets (Baker, 1953; indicated in Fig. 1); C) records from Baker (1956); D) records from Hall (1981); E) current records (museum specimens and visual records [in parentheses]; localities numbered as in Fig. 1); museums (acronyms are defined in text): 1 = UANL-MVS; 2 = UANL-M; 3 = UCM; 4 = TNHC; 5 = USNM; 6 = LSUMZ; 7 = UAMI; 8 = NMMNH.

Species	A	B	C	D	E	Museum(s)
<i>Didelphis virginiana</i>			v	m		
<i>Notiosorex crawfordi</i>		X	m	m	?	
<i>Mormoops megalophylla</i>				m	24	1
<i>Choeronycteris mexicana</i>			m	m	1, 27, 28, 47, 48, 54, 55	1, 2
<i>Leptonycteris nivalis</i>				m	2	3
<i>Antrozous pallidus</i>		X	X	X	27, 28, (29), 51, 55	1, 2
<i>Corynorhinus townsendii</i>			m	m	4, 8, 13, 25, 27	1, 2, 4, 5
<i>Eptesicus fuscus</i>			X	X	8, 13, 20	1, 2, 4
<i>Euderma maculatum</i>				m	?	
<i>Idionycteris phyllotis</i>				m	?	
<i>Lasiurus cinereus</i>				m	?	
<i>L. xanthinus</i>			m	m	2	3
<i>Myotis auriculatus</i>				m	?	
<i>M. californicus</i>			m	m	13, 55	1, 2
<i>M. thysanodes</i>				X	8, 9	1, 2
<i>M. velifer</i>			m	m	13	4
<i>M. yumanensis</i>				m	?	
<i>Perimyotis hesperus</i>			X	X	7, 13, 26, 49	1, 4
<i>Eumops perotis</i>	68		X	m	?	
<i>Nyctinomops femorosaccus</i>				m	2	7
<i>N. macrotis</i>				m	15	1
<i>Tadarida brasiliensis</i>			m	m	2, 8, 13, 15, 52	1, 2, 3, 4
<i>Canis latrans</i>	24, 68		m	m	7, 10, 16, (19), (25)	1, 4
<i>C. lupus</i>	24, 68					
<i>Urocyon cinereoargenteus</i>	24, 68		m	m	5, (19), 28, (34)	1, 2
<i>Vulpes velox</i>	24, 68		m	m	?	
<i>Ursus americanus</i>	68		v	m		
<i>U. arctos</i>	68					
<i>Lynx rufus</i>	24, 68		m	m	(50)	
<i>Puma concolor</i>	68		v	m	?	
<i>Conepatus mesoleucus</i>	68		m	m	?	
<i>Mephitis macroura</i>			m	m	?	
<i>M. mephitis</i>	68		m	m		
<i>Spilogale putorius</i>	24, 68		m	m	?	
<i>Mustela frenata</i>				m	?	
<i>Taxidea taxus</i>	24, 68		m	m	(19)	
<i>Bassariscus astutus</i>	24, 68		m	m	25, (27)	2
<i>Nasua narica</i>	68, v			m		
<i>Procyon lotor</i>	68		m	m	?	
<i>Pecari tajacu</i>			m	m		
<i>Cervus elaphus</i>	68					
<i>Odocoileus hemionus</i>	24, 37, 64, 68		m	m		
<i>O. virginianus</i>	24, 37, 68		X	X	(26), (46), (51)	
<i>Antilocapra americana</i>	37, 68			m		
<i>Bison bison</i>	24, 68					
<i>Ammospermophilus interpres</i>	24		m	m	7, 23, 55	1, 4
<i>Spermophilus mexicanus</i>	24, 68		m	m	6, 7, 23, 39, 45	1, 2, 4
<i>S. spilosoma</i>	24, 37		X	m		

TABLE 1—Continued.

Species	A	B	C	D	E	Museum(s)
<i>S. variegatus</i>	24, 37, 64, 68		m	m	(55)	
<i>Cratogeomys castanops</i>	24, 68			X	3, 7, 26, 27, 38	1, 4, 6, 8
<i>Thomomys bottae</i>	68	X	m	m		
<i>Chaetodipus eremicus</i>	24, 68	X	X	X	7, 14, 18, 22, 25, 26, 33, 34, 36, 37, 44, 46, 47, 48, 52	1, 2, 4, 8
<i>C. hispidus</i>		X	m	m	38, 41	1
<i>C. nelsoni</i>	24	X	m	m	6, 7, 16, 18, 25, 26, 29, 45, 46, 47, 55	1, 2, 4
<i>Dipodomys merriami</i>		X	X	X	7, 12, 14, 16, 17, 18, 19, 21, 24, 25, 26, 29, 32, 34, 40, 42, 44, 45, 46, 48, 53	1, 2, 8
<i>D. nelsoni</i>	24, 37			m	11, 14, 25, 37, 40, 44	1, 2
<i>D. ordii</i>				m	25	2
<i>Perognathus flavus</i>		X	m	m	33	1, 8
<i>Neotoma leucodon</i>	24, 37, 68	X	X	X	15, 47, 54	1, 2
<i>N. micropus</i>	24, 68	X	m	m	7, 22, 25, 44, 49	1, 4
<i>Onychomys arenicola</i>		X	m	m		
<i>Peromyscus difficilis</i>				m		
<i>P. eremicus</i>		X	m	m	6, 14, 16, 19, 22, 25, 26, 34, 39, 42, 44, 46, 47	1, 2
<i>P. leucopus</i>			X	X		
<i>P. maniculatus</i>		X	m	m		
<i>P. pectoralis</i>			m	m		
<i>Reithrodontomys fulvescens</i>		X	m	m	6, 26	1
<i>R. megalotis</i>				m	18	2
<i>Sigmodon hispidus</i>	24	X	X	X		
<i>Erethizon dorsatum</i>	68			m		
<i>Lepus californicus</i>	24, 37, 68		m	m	25, 26, 31, (34), (39), 45, 49	1, 2
<i>Sylvilagus audubonii</i>	24, 37, 68		m	m	25, 30, 51	1
<i>S. floridanus</i>				m	35, 43, 48, 51, 54	1

mammals from the region (Gilmore, 1947; Table 1) was based on undated archaeological deposits from 5 sites surrounding the basin. These deposits included species that were estimated to have been regionally extirpated nearly 300 y ago (elk, *Cervus elephas*—Gilmore, 1947:161), as well as species believed to have disappeared from the area within the 1800s or 1900s (bison, *Bison bison*; wolves, *Canis lupus*; brown bears, *Ursus arctos*; and pronghorn, *Antilocapra americana*). Based on presence of these species, deposits appear to be ≥ 300 y old.

Baker (1953; Table 1) reported 14 species of mammals from the northern rim of the basin based on bones recovered from disintegrating owl pellets from a cave 3 m NW of Cuatro Ciénegas (Fig. 1), adding 9 species not previously reported by Gilmore (1947). (Baker

[1953] reported only the southern plains woodrat, *Neotoma micropus*; but Baker [1956] cited Baker [1953] as reporting both *N. micropus* and the eastern white-throated woodrat, *N. albigula* [now *leucodon*—Edwards et al., 2001].) Age of these deposits is unknown; due to the arid environment, the pellets might have been only years or perhaps hundreds of years old. In describing the distribution of mammals of Coahuila, Baker (1956; Table 1) indicated 49 species as occurring in the basin: 14 species were reported based on collected specimens (11 spp.) or visual reports (3 spp.); 7 were based on owl pellets (Baker, 1953) alone; 3 were based on both owl pellets and archaeological material (Gilmore, 1947); 16 were based on archaeological material alone; and 9 were assumed to occur in the region based on peripheral records. Hall

(1981; Table 1) indicated the occurrence of 69 species of mammals from the basin, including 2 new recent records (fringed myotis, *Myotis thysanodes*, and yellow-faced pocket gopher, *Cratogeomys castanops*) and an additional 18 species indicated on distribution maps as probably occurring in the area. Four of these latter species had been reported by Gilmore (1947) from archaeological remains, but were considered by Baker (1956) to be locally extirpated (white-nosed coati, *Nasua narica*; *A. americana*; and North American porcupine, *Erethizon dorsatum*) or were excluded by Baker (1956) without comment (Nelson's kangaroo rat, *Dipodomys nelsoni*, reported as *D. spectabilis* by Gilmore, 1947). Neither Baker (1956) nor Hall (1981) included the extirpated species *C. elephas*, *B. bison*, *C. lupus*, or *U. arctos* (reported by Gilmore, 1947) as surviving in the basin, and both apparently agreed with Gilmore (1947) that archaeological records of bighorn sheep (*Ovis canadensis*) originated outside of the basin. According to Medellín et al. (2005), no verified populations of *O. canadensis* survive in central Coahuila, and this species also appears to have been regionally extirpated. Thus, as of 1981, the list of 69 mammals purported to occur within the Cuatro Ciénegas Basin (Table 1) included 19 species documented only from archaeological remains of unknown antiquity, 10 species documented from owl pellets of more recent but unknown antiquity (including 3 also represented in the archaeological record), 23 species considered as likely to occur in the basin based on surrounding records, and only 17 species actually documented as occurring in the valley during the 1900s (including the visual record of *N. narica* reported by Gilmore [1947] that was discounted without comment by Baker [1956] and Hall [1981]).

Environmental Stability and Faunal Shifts—The general environment of the Cuatro Ciénegas Basin has remained remarkably stable throughout the climatic oscillations of the Pleistocene glaciations (Meyer, 1973). The local environment more recently has been subjected to profound impact, particularly canal construction related to agricultural development (between the late 1800s and 1960s—Dinger et al., 2005), direct agricultural conversion, introduction of exotic plants and animals, mining, and overgrazing. Agricultural activities increased 300% and livestock activities by 70% between 1960 and

1999, and extraction of gypsum (from evaporites on the floor of the basin) tripled between 1989 and 1999 (SEMARNAP, 1999). As of 1999, canals drained between 1,730 and 2,620 l/sec of water from the basin. Conversion of natural habitat increased from 102 units of production in 1930 to 1,139 units in 1994, which represents >1,000% increase in water use.

The long-term environmental stability of the Cuatro Ciénegas Basin, its location at the boundary of 2 very different biotic provinces, and relatively recent environmental perturbations provide a setting in which to examine mammalian faunal shifts possibly associated with climatic and human-induced environmental change. Small mammals are particularly valuable "biogeographic indicator species" of past environmental conditions (Harris, 1985; Sullivan, 1988; Hafner, 1993, 1994). The availability of archaeological (Gilmore, 1947), more recent (Baker, 1953), and early 1900s (Baker, 1956; Hall, 1981) mammal records for the basin provide the foundation for a comparison with the current mammal fauna of the basin. During 12 mo in 1996 and 1997, the Universidad Autónoma de Nuevo León (UANL) undertook a survey of the Cuatro Ciénegas Basin to develop a baseline inventory of the mammalian fauna.

METHODS—Collections were made from throughout the basin, predominately within the protected area, each month from November 1996 to November 1997. Specimens were collected using Victor rat traps, MacAbee gopher traps, mist nets, and 0.22 or 0.20-caliber rifles. Voucher specimens (skin + skeleton, skeleton-only, or skull-only) were deposited in the Colección del Laboratorio de Manejo de Vida Silvestre at UANL (UANL-MVS). Fieldwork also included interviews with local residents about recent and past sightings of mammals in the region. Recent collections in North America were queried simultaneously for records not previously reported.

RESULTS—We collected a total of 287 specimens representing 28 species during field survey, and confirmed an additional 4 species with visual sightings. Records for 29 species, including 7 not collected during 1996–1997, were documented by previously unreported specimens in the following collections: Colección Mastozoológica, UANL (UANL-M); Texas Natural History Collection, University of Texas, Austin (TNHC); University of Colorado Museum (UCM); Colección de Mamíferos, Universidad Autónoma Metropolitana, Unidad Iztapalapa (UAMI);

Museum of Natural Science, Louisiana State University (LSUMZ); New Mexico Museum of Natural History (NMMNH); and the United States National Museum (USNM). A list of exact localities is available from the senior author.

We have confirmed that 39 species currently occur within the Cuatro Ciénegas Basin (Table 1); only 9 of these species were documented previously from trapping or visual records. Thirty trapping or visual records new for the 1900s include 11 previously recorded only from archaeological material; 4 previously reported only from owl pellets; 2 reported from both of the latter; and 13 previously indicated as probably occurring in the region (on distribution maps without verified records). Wholly new records for the basin include 10 bats, 2 rodents (western harvest mouse, *Reithrodontomys megalotis* and Ord's kangaroo rat, *Dipodomys ordii*), and one lagomorph (eastern cottontail, *Sylvilagus floridanus*). Of the 39 total species, 30 species are widespread in occurrence, being found west and east of the Sierra del Carmen – Sierra Madre Oriental Filter-Barrier (Baker, 1956). Nine species previously reported as occurring unequivocally in the basin during the 1900s were not detected during this survey: Virginia opossum (*Didelphis virginiana*), western bonneted bat (*Eumops perotis*), American black bear (*Ursus americanus*), cougar (*Puma concolor*), white-nosed coati, spotted ground squirrel (*Spermophilus spilosoma*), white-footed deer mouse (*Peromyscus leucopus*), hispid cotton rat (*Sigmodon hispidus*), and North American porcupine.

DISCUSSION—Probable Additions to the Mammalian Inventory—Although this survey resulted in the most complete inventory of mammals yet compiled for the Cuatro Ciénegas Basin, it is likely that particularly rare or secretive species were not detected during survey work. We predict (based on peripheral records) that additional survey efforts will increase the list of extant mammals by 14 species: 1 insectivore, 7 carnivores, and 6 bats (Table 1). Records for the desert shrew (*Notiosorex crawfordi*) are notoriously spotty throughout its distribution, and the single record from owl pellets (Baker 1953) remains the only record for Coahuila. Carnivores, being nocturnal and secretive, might easily have been missed, particularly if they seldom venture onto the basin floor; indeed, only 1 of the 14 species considered by Baker (1956) to be extant was

sighted in previous surveys; we have documented an additional 5 species. Of the remaining 8 species lacking recent records, we consider only the striped skunk (*Mephitis mephitis*) as unlikely to persist in the basin; the archaeological record for the basin is well south of the periphery of its documented recent distribution. Local residents report the occurrence in areas surrounding the basin of swift fox (*Vulpes velox*) and cougar, but also of American black bear and mule deer (*Odocoileus hemionus*), both of which we consider to be locally extirpated. Of 16 species of bats predicted to occur in the basin by Baker (1956) or Hall (1981), 10 were documented during this survey, and it is likely that additional netting will detect some or all of the remaining 6 species.

Environmental Stability—Comparison of the current inventory with archaeological records (Gilmore, 1947) reflects the long-term environmental stability of the local ecosystem and records the well-known extirpation of larger game animals by humans. (The archaeological record of the jaguar, *Panthera onca*, is dubious; Gilmore (1947:156) stated that although the species “occasionally occur[s] today...in the region,” the remains “may be puma.”) Of the 36 species unequivocally recorded from the basin from archaeological sites, 23 probably are extant; 17 were detected in our survey, and an additional 6 species (1 bat and 5 carnivores) likely were not detected in our survey due to scarcity or secretive habit. Humans evidently extirpated 2 carnivore and 3 ungulate species before the 1900s (see above). Of the remaining 8 species, only 2 were not recorded during the 1900s: striped skunk and mule deer evidently disappeared before that century due either to range contraction or local extirpation.

Local Extirpations and Faunal Shifts—The haphazard nature of previous sampling of mammals from the Cuatro Ciénegas Basin (archaeological, owl pellets, or trapping) precludes any consideration of new records as representing actual immigrations into the basin. However, absences from our comprehensive survey of common and easily detected species recorded during the 1900s likely reflect actual disappearance from the basin. Our survey failed to detect 13 species that were previously recorded from the basin during the 1900s (including 4 species known only from owl pellets). We consider it likely that 3 of these species were simply missed in our survey due to scarcity or secretive habit: N.

crawfordi, *E. perotis*, and *P. concolor* (known from owl pellets, one nearby record, and visual records, respectively). Two species (American black bear and North American porcupine) were probably locally extirpated by hunting. Baker (1956:298) reported American black bears as "fairly common" in the mountains surrounding the basin, but stated that the "bear population is being slowly reduced because the animal is shot at every opportunity." Medellín et al. (2005) reported no verified populations of American black bears remaining in the region. The single record for a North American porcupine from the basin (USNM 282139) is from archaeological deposits at a site near montane pine forests (CM 68—Gilmore, 1947). Baker (1956) and Anderson (1972) reported that North American porcupines occur infrequently in the mountainous areas of Coahuila and Chihuahua (respectively). Local residents observed a North American porcupine in mountains near Cuatro Ciénegas "2 to 3 y ago" and report that North American porcupines were observed and hunted in the basin "40 to 50 y ago" (A. J. Contreras-Balderas, pers. comm.). List et al. (1999) interpreted the remains at the CM 68 site as evidence of human predation of the North American porcupine which, coupled with climatic change, has resulted in the range contraction of North American porcupines in central Mexico. They report that ranchers and cowboys kill porcupines on sight in the one area of northern Chihuahua in which porcupines are still regularly observed (the Janos-Nuevo Casas Grande region). North American porcupines may yet persist in the higher, forested regions surrounding the Cuatro Ciénegas Basin, but evidently have been extirpated from the basin floor.

Of the 39 species of verified current occurrence in the basin, 30 are widespread in distribution, while 5 occur only in the Chihuahuan biotic province and 4 only in the Tamaulipan province. The distribution of an additional 7 Chihuahuan and 9 Tamaulipan species approach the Cuatro Ciénegas Basin from the west and east, respectively (Hall, 1981). Remains in owl pellets, collection records, or sightings document the former distribution in the basin of 3 of these Chihuahuan species and 4 of the Tamaulipan species. If *E. perotis* (a Chihuahuan species) is still extant in the basin (as is likely), the basin has lost 2 Chihuahuan species (from 8 to 6 of 12 possible species) during the past century, compared to

a loss of 4 Tamaulipan species (from 8 to 4 of 13 possible species) and 2 widespread species.

The apparent disappearance of 4 Tamaulipan species (*D. virginiana*, *N. narica*, *P. leucopus*, and *S. hispidus*) from the basin may indicate a slight drying trend in the basin floor due to agricultural conversion, climatic change, or a combination thereof. The opossum is usually quite common and obvious where it occurs; Baker (1956:166) reported the last known sighting of the opossum (along the Río Salado) by a local resident. White-nosed coatis occur in small numbers along forested streams of eastern Coahuila, and are commonly observed (Baker, 1956); Gilmore (1947:155) reported a possible observation of a white-nosed coati along the eastern edge of the basin in 1940–1941. Both species of rodent (*P. leucopus* and *S. hispidus*) are easily detected where they occur, and would likely have been found in our survey if present. The disappearance of *S. hispidus* is particularly noteworthy, as it was recorded in archaeological and owl pellet remains as well as from previous trapping records.

It is more difficult to account for the disappearance from the basin of 2 widespread species (Botta's pocket gopher [*Thomomys bottae*] and spotted ground squirrel) or 2 Chihuahuan species (Mearn's grasshopper mouse [*Onychomys arenicola*] and North American deer mouse [*Peromyscus maniculatus*]). Both *S. spilosoma* and *T. bottae* were recorded in archaeological deposits; *T. bottae*, *O. arenicola*, and *P. maniculatus* were recorded in owl pellets; and only *S. spilosoma* was recorded from previous trapping records. These species are easily detected and captured, and it is unlikely that they were missed during our survey. Perhaps, the gopher and 2 mice occurred only peripherally in the basin, in the vicinity of the owl roost northwest of Cuatro Ciénegas. According to Baker (1956:205), the spotted ground squirrel accommodates easily to grazing and agricultural conversion, becoming a "troublesome pest." Although we know of no eradication effort, it is possible that these squirrels succumbed to poisoning or trapping campaigns during agricultural conversion of the basin floor.

Additional collecting immediately northwest (6 m NW Cuatro Ciénegas; 1999) and about 20 km south (1 m SE Hundido; 1997) of the basin failed to detect any of the 6 species of rodents discussed above (D. J. Hafner, pers. observ.). It is likely that these species, as well as

opossums and white-nosed coatis, no longer occur in the basin, whether due to climatic change, human-induced environmental impact, or a combination thereof. A gradual drying of the basin might account for the loss of the 4 Tamaulipan species, but not necessarily for the loss of the 2 widespread rodents or, particularly, for the loss of the 2 arid-adapted Chihuahuan species.

“Accumulated” Range Maps—Hafner and Shuster (1996) criticized the interpretation of range maps such as those employed by Hall (1981) as “snapshots in time.” They pointed out that whereas documentation of temporally conservative distributions may support this static view, these “accumulated” range maps often represent data that have been collected over a period of more than a century, and that supposed marginal records from disparate times may blur, rather than define, distributional limits. In this case, distribution maps for the Cuatro Ciénegas Basin include records spanning ≥ 300 , and perhaps thousands of years. Range shifts of considerable magnitude over a matter of decades have been documented for a variety of species: e.g., least weasel, *Mustela nivalis* (450 km—Frey, 1992); least shrew, *Cryptotis parva* (225 km—Hafner and Shuster, 1996); perimyotis bat, *Perimyotis subflavus* (≥ 175 km—Fitzgerald et al., 1989; Bogan and Cryan, 2000; Geluso et al., 2005; White et al., 2006). Certainly at the local level, accumulated range maps must be read with caution. That being said, the implicit predictions by Hall (1981) of occurrence of 42 species of mammals in the Cuatro Ciénegas Basin based only on peripheral records have been quite accurate. This survey has documented the existence in the basin of 24 (57%) of these species; 10 of 16 bats, 6 of 14 carnivores, 6 of 8 rodents, and all 3 species of lagomorphs. It is likely that further, more taxon-directed survey efforts will increase this level of predictive accuracy.

Survey efforts during 1996–1997 now have provided a confident baseline inventory of ≥ 39 native mammals occurring in the Cuatro Ciénegas Basin. It is likely that further survey efforts, including methods specifically directed at carnivores, bats, and the desert shrew, will add up to 14 species to that inventory. Exact delineation of the current eastern and western distributional limits of recently lost species (particularly the rodents) in the area of the Cuatro Ciénegas

Basin might facilitate an understanding of the cause of their disappearance, and identify specific and causally related environmental changes that have occurred in the basin.

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