Survey of the hooded skunk in the Trans-Pecos Ecoregion

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Chapter 1: Executive Summary

The hooded skunk (*Mephitis macroura*) is recognized as a species of greatest conservation need in Texas and is among the rarest carnivores in the state. It is one of five skunk species occurring in Texas and its documentation has proven difficult, in part due to similarities in pelage coloration and pattern with the ubiquitous striped skunk (*Mephitis mephitis*). We studied this species to meet three objectives: 1) determine hooded skunk historical and recent occurrence records in the state, 2) conduct a field-based study of the lower elevations of the Big Bend region of Texas to inform local presence, and 3) model the distribution of the species with an emphasis on Chihuahuan Desert populations. This report details the results of our studies and how those research objectives were met.

We first identified and reviewed all Texas hooded skunk occurrence records originating from both the scientific literature and preserved specimens in museum collections. We reviewed images from several camera trap databases and photographs uploaded to iNaturalist for additional occurrence records. Our review confirmed that only a single preserved specimen from Texas has been added to research collections since 1974. That year is especially noteworthy as it marks the completion of a skunk ecological survey in the Trans-Pecos by Robert Patton on which much of our regional knowledge is derived. The one specimen since then was salvaged in 1999 from Jeff Davis County near Davis Mountains State Park. Examination of preserved specimens revealed six records that were either misidentified as hooded skunks or had incorrect data that precluded their occurrence in Texas. In all, of 25 preserved specimens, 19 were either reviewed and confirmed (17) or conditionally confirmed (2). Examination of over 700 images of skunks originating from camera trap surveys of Trans Pecos skunks available on the Texas Natural Diversity Database revealed striped, hog-nosed, and desert spotted skunk presence but

not hooded skunks. Likewise, we examined images purported to be hooded skunks from Alpine and El Paso on iNaturalist and concluded that both were striped skunks rather than hooded. The findings necessitate the revision of distribution of hooded skunks in Texas resulting in the proposed removal of forty-four percent of earlier proposed ranges, a decrease of approximately 26,422 km².

Our second objective was to survey sites in the Big Bend region of Brewster County to determine presence of hooded skunks outside of known areas of occurrence. Between January 2024 and February 2025, we placed cameras based on habitat suitability ranking at Big Bend National Park, Black Gap Wildlife Management Area, and El Carmen Land and Conservation Co., LLC, CEMEX INC., Texas. At both Black Gap and El Carmen, cameras were placed in part at guzzlers, water catchment devices designed to provide water to wildlife, and at random locations. Fifty-four camera traps were operated over 5697 survey nights. By site, 24 cameras were deployed at Black Gap, 17 at Big Bend, and 13 at El Carmen. We accumulated over 100,000 images of animals of which most were birds or ungulates (white-tailed deer-*Odocoileus virginianus*, mule deer-*O. hemionus*, and collared peccary-*Dicotyles tajacu*). We detected 12 carnivore species (in order of highest number of camera locations): coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), American black bear (*Ursus americanus*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), ringtail (*Bassariscus astutus*), mountain lion (*Puma concolor*), American hog-nosed skunk (*Conepatus leuconotus*), desert spotted skunk (*Spilogale leucoparia*), northern raccoon (*Procyon lotor*), and hooded skunk. Across all camera traps, hooded skunk detections originated from two paired camera traps deployed within Black Gap. Subsequent review of images and pelage pattern suggest that all observations were of the same individual hooded skunk.

We additionally reviewed images from a concurrent camera trap survey conducted within the Chisos Mountains by personnel at Big Bend National Park from 2021 through 2024. Within the 12-camera dataset, we identified all four skunk species that occur in the region. Striped skunks (n = 216, 32%) and hog-nosed skunks (n = 210, 31%) were detected most frequently, while desert spotted skunks (n = 162, 24%) were the third most detected. Hooded skunk detections comprised 13% of visits (n = 93) and were at 8 of the 12 camera locations and in all months of the year. They occurred in all 4 years of the study; however, there was a notable decrease in annual detections from 2021 (n = 44) to 2024 (n = 12). Based on these data, there is likely a viable population of hooded skunks in the Chisos Mountains of Big Bend National Park; however, the reported detections there and at Black Gap Wildlife Management Area represent the only confirmed records in Texas since 1999.

Our third objective was to model the distribution of hooded skunks broadly across their range, from Costa Rica north to the southwestern United States, and more specifically across the Chihuahuan Desert, including portions of Texas. We compiled *Mephitis macroura* occurrence records from three primary sources. First, we queried the Global Biodiversity Information Facility (GBIF), retaining only non-observational, non-paleontological records. This search returned 918 *M. macroura* records classified as "Preserved Specimen" with georeferenced coordinates. Second, we curated all research-grade hooded skunk observations from iNaturalist spanning 2002 through 30 April 2025. Third, we incorporated Texas occurrence records from the previously described camera trap surveys. To model *M. macroura's* distribution, we used 19 bioclimatic variables averaged across 1970–2000 at a resolution of 2.5 arcminutes.

We retained 896 *M. macroura* occurrence records to build the species distribution model. After removing spatially duplicate records and applying 10-km spatial thinning, 450 records

were used in the final model. These records originated from all seven countries where the species is known to occur—the United States, Mexico, Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica—and spanned 1971–2025. The model predicted lower occurrence across the Mexican Plateau and into the U.S. – Mexico borderlands, but relatively higher occurrence along both the Sierra Madre Oriental and Sierra Madre Occidental. Within the borderlands, the highest predictive occurrence was concentrated in the northern Sierra Madre Occidental of Sonora, Mexico, and in southeastern Arizona. In Texas, the highest predictive occurrence extended across the broader Davis Mountain region, although most of the Trans-Pecos region was characterized by either low or moderate predictive values. Within Brewster County, the Chisos Mountains, Northern Rosillos, and the northern extent of the Sierra del Carmens exhibited moderate predictive probability. Despite this, much of the area surveyed by camera traps was predicted to have low probability.

In summary, this research met the contracted deliverables and our results revealed the following new information: 1) the historical distribution of hooded skunks in Texas was as much as a third smaller than portrayed in range maps for the species, 2) our camera trap survey of the southern part of Brewster County confirmed a diverse carnivore community but only detected a single hooded skunk at two adjacent cameras in Black Gap Wildlife Management Area, 3) in contrast, the Chisos Mountains of Big Bend National Park had 93 detections over a 4-year period indicating a viable population in that area of the state, 4) the modeling of species distribution accurately predicted occurrence of hooded skunks in the northern limits of the Sierra del Carmen, an area that included our detection in Black Gap Wildlife Management Area and 5) the modeling of species distribution also suggests that the Davis Mountains may represent a potential site for future investigations of continued hooded skunk presence in Texas.

Chapter 2: Historical and contemporary occurrence of hooded skunks (*Mephitis macroura*) in Texas

INTRODUCTION

Texas is home to a diverse carnivore assemblage with no place more species rich than the Trans-Pecos ecoregion (Schmidly and Bradley 2016). This ecoregion has 15 carnivore species of which seven are species of greatest conservation need (TPWD 2025). The hooded skunk, *Mephitis macroura*, stands out as a species in need of immediate attention regarding conservation status within Texas (Jefferson et al. 2017, Yancey et al. 2023). Occurrence records suggest it was historically distributed in at least six counties across the Trans-Pecos ecoregion (Schmidly and Bradley 2016); however, the last known specimen was collected in 1999 (Yancey et al. 2017) with the only confirmed occurrence records from the 21st century originating from camera trap surveys within Big Bend National Park (Stevens 2017, Jefferson et al. 2022). *Mephitis macroura* is considered rare in Texas (Yancey et al. 2017), in part due to Texas being located at the extreme northeastern portion of the distribution of the species (Hwang and Lariviere 2001).

Mephitis macroura was first described by H. Lichtenstein in 1832 from specimens collected in the mountains near Mexico City (Hass and Dragoo 2023). It was nearly a century before species presence was confirmed in Texas (Blair 1940, Schmidly and Bradley 2016). In the interim, the species was reported as present in the American southwest (Mearns 1897) and given a subspecific designation (*M. m. milleri*) based upon morphological differences from those specimens collected in Mexico (Mearns 1897, Howell 1901).

The early and mid-20th century was a period of scientific survey across the Trans-Pecos region of Texas. What started with Vernon Bailey's seminal biological survey (Bailey 1905) continued through the century resulting in multiple biological surveys of the region. Initially, the

relevant efforts were broad mammalian inventories conducted either across or at specific locations within the Trans-Pecos (Bailey 1905, Blair 1940, Davis and Robertson 1944, Blair and Miller 1949); however, the mid-20th century saw a shift to localized inventory of newly acquired and conserved properties throughout the region (Borrell and Bryant 1942, Tamsitt 1954, Genoways et al. 1975, Yancey 1997, Yancey et al. 2006). Later shifts resulted in the survey of specific species to address knowledge gaps (Patton 1974) or conservation concerns (Hewitt 2022). Additionally, localized attempts to assess changes in species composition across the 20th century were conducted at specific locations (*e.g.*, Yancey 1997, DeBaca 2008, Scott 2022). The sole, comprehensive study of the Trans-Pecos region's skunk community by Robert Patton (1974) provided a population-level assessment of *M. macroura* while a more recent study produced the only preserved specimen originating from Texas since Patton's study (DeBaca 2008, Yancey et al. 2017).

In the fifty years since Patton's examination, new technology and methodologies such as camera traps and citizen scientist applications have emerged, matured, and are now routinely used for biological survey and wildlife monitoring (Steenweg et al. 2016, Kays et al. 2020, Perkins et al. 2022). While these technologies provided the first known occurrence records of *M. macroura* in the Chisos Mountains of Big Bend National Park (Stevens 2017, Jefferson et al. 2022), these are the only known records from Texas over the past 25 years (Schmidly and Bradley 2016, Yancey et al. 2023). Lack of *M. macroura* occurrence records in Texas has led authors to question its continued presence, suggest a declining population, and call for examination of the species distribution and conservation status within the state (Schmidly and Bradley 2016, Jefferson et al. 2022, Yancey et al. 2023). While *M. macroura* is categorized as secure across its geographic distribution (Cuarón et al. 2016), the species has received

insufficient efforts across much of its geographic range and specifically within Central America to make a truly informed assessment (Hernandez-Sanchez et al. 2022). While it is possible that the species is still distributed within its known historical range in Texas, and lack of recent occurrence records reflect lack of targeted survey effort, it is equally plausible that the paucity of records is emblematic of a declining population. We addressed the issue by conducting a comprehensive examination of *M. macroura* records in Texas including identification and review of all known preserved specimens, review and revision of its known geographic distribution in the state, and quantification of localities of known occurrence and potential absence.

MATERIALS AND METHODS

Preserved Specimens

We created a *Mephitis macroura* occurrence dataset that included preserved specimens originating from Texas. First, we queried and retained all Texas *M. macroura* records from the Global Biodiversity Information Facility (GBIF) via the program rgbif (Chamberlain 2024, GBIF 2025). Individual Texas natural history collections were further queried to identify preserved specimens not identified in the GBIF query (Appendix 2.1). Finally, publications that listed *M. macroura* occurrence, county records, and specimens examined (e.g. Schmidly 1977) were reviewed to identify preserved specimens not identified with the above techniques. One of us visited these natural history collections or collaborated with collection managers to examine the preserved specimens. High resolution images were taken of each specimen and the relevant portions of the preparator's catalogue and the collector's field notes.

Assessment of previous species identification was completed using described pelage patterns (Patton 1974, Schmidly and Bradley 2016, Hass and Dragoo 2023). As there is a long history of misidentification of *M. macroura* across the American southwest (Hass and Dragoo 2024), any preserved specimen that incompletely adhered to these patterns, was further assessed

for species identification. One of us (JCP) sent the specimen images independently to the others and noted skunk researchers Adam Ferguson and Jerry Dragoo for an independent assessment. All preserved specimens were then either categorized as *M. macroura*, *Mephitis mephitis* (striped skunk), or unconfirmed and categorized as *Mephitis sp*. Any specimen that was preserved as skull only was categorized as *Mephitis sp.* unless it was previously reported by Patton (1974).

Non-vouchered Photographic Images

We conducted a camera trap survey across the Big Bend region of Brewster County, Texas (This report – Chapter 3). From January 2024 through September 2025, we surveyed Big Bend National Park, Black Gap Wildlife Management Area (Black Gap), and El Carmen Land and Conservation Co., LLC (El Carmen). We collaborated with National Park Service (NPS) personnel to review photographic images of skunks from a concurrently conducted camera trap survey of the Chisos Mountains within Big Bend National Park. Skunk images from a Texas Parks and Wildlife Department (TPWD) funded camera trap survey of kit fox (*Vulpes macrotis*) across the Trans-Pecos (Hewitt et al. 2022) were provided by TPWD personnel in the Texas Natural Diversity Database Program. Finally, camera trap images from a mammal survey of the Davis Mountains (Scott 2022) were also reviewed. All images were categorized as one of the four skunk species that occur within the region (*Conepatus leuconotus*, *Spilogale leucoparia*, *M. macroura*, or *M. mephitis*), *Mephitis sp.* for images not sufficient to differentiate between *M. macroura* and *M. mephitis*, or *Mephitidae* for images not sufficient for differentiation to genus. To identify between the two *Mephitis*, we built upon previously reported diagnostic patterns (Patton 1974, Schmidly and Bradley 2016, and Hass and Dragoo 2023).

Literature Review and Meta-data Assessment

We conducted a literature search for published accounts within the Trans-Pecos ecoregion that yielded prepared specimens, non-photographic evidence, or other reports of

occurrence of the four skunk species (Table 2.1). Efforts were made to objectively constrain the inclusion of previously published works to those that documented quantifiable skunk presence originating from the author's original efforts. Our objectives were to first include *M. macroura* occurrence records not otherwise identified; and second, to identify surveys and survey locations with quantifiable skunk occurrence records. This second objective was intended to help infer locations of potential absence for *M. macroura* under the assumption that if a survey employed sufficient effort and methodologies capable of detecting all four skunk species (if present), then surveyed locations with confirmed skunk occurrence but not *M. macroura* may represent true absence rather than unconfirmed absence.

All published reports were compiled with year(s) of survey, methodology, and presence-absence outcomes for each of the four skunk species. Methodology was categorized generally as traditional inventory by capture, shooting, or salvaging of individuals which resulted in preserved specimens, camera trap survey which generated non-vouchered photographic images, and crowd source from iNaturalist which included citizen scientist submitted images of live skunks, skunks in live traps, and deceased skunks. These results were compiled at both the spatial extent originally reported by the author and then at the county level if information provided by the authors was sufficient for breakout (Table 2.1). We then added results from the previously identified camera trap surveys and iNaturalist (iNaturalist 2025, iNaturalist 2025b). Across the entire literature review and resultant dataset, human observations were excluded leaving only preserved specimens and non-vouchered photographic records in the dataset.

Any publication that reported a mix of specimen collection and/or specimens existing in natural history collections such as parasitological examination of striped skunks (Hughes et al. 2017) or all skunks (Gulas-Wroblewski et al. 2023) were excluded as we could not link skunk

occurrence records to specific survey effort and location. Any work that presented previously reported preserved specimens (Schmidly 1977, Schmidly and Bradley 2016, Jefferson et al. 2022) was omitted. Published works that reported single species presence were reviewed for scope and effort but not used in the meta-data assessment.

RESULTS

Use of all available methods identified *Mephitis macroura* occurrence records originating from Texas. We confirm that 19 preserved *M. macroura* specimens are housed across four natural history collections (Appendix 2.1). We reviewed 4,679 camera trap images of skunks from the Trans-Pecos region captured via camera traps. Although camera trap surveys originated from nine Trans-Pecos counties, *M. macroura* were detected at only eight camera traps within the Chisos Mountains of Big Bend National Park and two camera stations at Black Gap Wildlife Management Area. In addition, we evaluated more than 500 skunk images (classified as either "research grade" or "needs identification") submitted to iNaturalist (iNaturalist 2025b). While one record from Alpine (25 August 2024) and one from El Paso (31 May 2025) were designated as research-grade *M. macroura*, we concluded the individuals depicted were both *M. mephitis*. Finally, we identified 22 published accounts reporting skunk occurrence and eight published accounts of *M. macroura* occurrence within the Trans-Pecos region (Appendix 2.2).

Preserved Specimens

All queries for preserved specimens yielded 25 *M. macroura* records identified as originating from Texas with six records determined to be erroneous or unverified (Appendix 2.1). Two preserved specimens were unanimously identified as *M. mephitis*, two were reviewed and categorized as *Mephitis sp*., and two were *M. macroura* but erroneously attributed to Texas (Appendix 2.3). We confirmed the species identity of 19 preserved *M. macroura* specimens originating from four counties—Brewster, Jeff Davis, Presidio, and Reeves (Appendix 2.1). Two

M. mephitis specimens originated from Pecos County, and the unconfirmed *Mephitis sp*. records were from Pecos and Ward counties.

As *M. macroura* is a less commonly examined species (Hernandez-Sanchez et al. 2022), identification of errors and unsupported species identifications within the Texas preserved dataset were unsurprising even those perpetuated for nearly 100 years. A series of three individuals were collected southeast of Fort Stockton in Pecos County during the winter of 1925-26 and represented the sole known occurrence records from this county (Patton 1974; Schmidly and Bradley 2016, Yancey II et al. 2023). All three were collected by J. Stokely Ligon, an early 20th-century naturalist employed by both the United States Biological Survey and the New Mexico Game and Fish Commission. Upon review of photographs of all three specimens, it was the unanimous, independent judgment of all reviewers that two of the specimens (YPM 1977, 1978; Appendix 2.1) were *Mephitis mephitis* and additional genetic analysis was not warranted.

The third specimen (MSB 13141; Appendix 2.1) proved more problematic. Although it displayed a somewhat pronounced hood, it exhibited two white dorsal stripes extending posteriorly from the neck—a pelage pattern documented only in *M. mephitis* and not in *M. macroura* (Schmidly and Bradley 2016). While this individual was previously reviewed and confirmed as *M. macroura* (Schmidly 1977), our internal review unanimously recommended reclassifying it as *Mephitis sp*. This individual is either *M. mephitis* or exhibits a phenotype not currently described in natural history collections. The absence of such variation in existing collections reflects the Merriamian shortfall (Stevens 2023), a concept describing how taxonomic uncertainty arises from limited phenotypic diversity within natural history collections.

We categorized a Ward County preserved specimen (TTU53; Appendix 2.1) as *Mephitis sp.* While the collection event details are not known for this individual, it was used to extend the

range of the species by 75 miles (Packard 1964). Packard did not collect this individual, and we were unable to ascertain whether he ever examined this specimen prior to preparation. As this specimen is a skull only and there exists no quantifiable methodology to distinguish the *Mephitis* species apart based upon skull characteristics, we recommend the change in species identification as previously noted.

Non-vouchered Photographic Images

Twelve camera traps were operated by NPS personnel across the Chisos Mountain range from 2021 through 2024 (T. Athens, National Park Service, Big Bend National Park, Wildlife Biologist, pers. comm.). Camera traps captured 2,400 skunk images with cameras set to record a burst of three consecutive images per trigger event. After classifying temporal independence as one unique visitation per species per camera per 24-hour period, 714 unique detection events were logged across these 12 cameras. *Mephitis mephitis* (n = 216, 30%) and *C. leuconotus* (n = 210, 29%) were detected most frequently, while *S. leucoparia* were the third most detected (n = 162, 23%). *Mephitis macroura* detections comprised 13% of visits (n = *93*). Cumulatively, there were 33 unique visitations categorized as either *Mephitis sp.* (1%) or *Mephitidae* (3.5%). No species was detected at all 12 camera traps; however, one station recorded only a single *M. macroura* visit, and we suspect an issue with either data transfer or survey effort at that location. *Mephitis mephitis* and *S. leucoparia* were detected at eleven cameras traps, *C. leuconotus* at ten, and *M. macroura* at eight. *Mephitis macroura* visits were recorded in all four years and in every month; however, there was a notable decrease in annual visits from 2021 (n = 44) to 2024 (n = 12). As of report submission, we have not received temporal deployment and camera operational status information from NPS personnel. It is possible that this decrease reflects reduced survey effort rather than an ecological trend.

The TPWD–funded kit fox survey resulted in 732 baited camera traps deployed across nine counties from 2018 through 2020 (Hewitt et al. 2022). Camera traps were placed in low-elevation grasslands with slopes less than 5%, with an average deployment duration of 14 days per camera (Hewitt et al. 2022). A total of 741 skunk images were reviewed using a 24-hour threshold for temporal independence, resulting in 295 unique visitation events. Skunks were detected on 33 of the 48 properties surveyed (69%), including all six properties in Brewster County and none at the single property surveyed in El Paso County. Skunks were detected at 85 of the 732 individual camera stations (12%), ranging from 0% (0/8) in El Paso County to 42% (10/24) in Terrell County (Hewitt et al. 2022). Twenty-two properties were surveyed in counties with known historical *M. macroura* presence (*i.e.*, Brewster, Jeff Davis, Presidio, and Reeves counties), with skunks detected at 20 properties (91%) and at 55 of the 325 camera stations (17%). Within this subset, 219 visitation events were of *M. mephitis* (74%), 23 were of *C. leuconotus* (8%), and four were of *S. leucoparia* (1%). Forty-nine visitation events (17%) were categorized more generally as either *Mephitidae* (n = 11) or *Mephitis* spp. (n = 38).

We operated 54 camera traps across southern Brewster County from 2024 – 2025 and recorded 889 total images of skunks. We detected *C. leuconotus*, *M. mephitis*, and *S. leucoparia* at Black Gap, Big Bend, and El Carmen. *Mephitis macroura* was detected at two camera trap stations within Black Gap deployed within 300 m of each other. At least one skunk species was detected at 17 unique stations (31%) with three stations recording two species (6%) and one station recording both three and four species each (2%). *Mephitis mephitis* was detected at 10 unique camera traps (19%), *C. leuconotus* at seven (13%), *S. leucoparia* at six (11%), and *M. macroura* at two (4%). Seventy-seven *M. macroura* images were recorded at two cameras deployed 262 meters apart, with seven images originating from a randomly placed camera (9%)

and 70 (91%) originating from one placed adjacent to a guzzler. Review of these images indicate that this was the same individual skunk that exhibited a grey-backed and faint lateral line pelage pattern. With a 12-hour defined period of independence, this individual was detected at the water guzzler on 11 nights, the randomly placed camera one night, and at both on two nights. The camera at the guzzler was operational for 68 consecutive nights yielding a detection rate of nineteen percent (13/68) while the random camera was operational for 193 consecutive nights resulting in a detection rate of 2 percent (3/193).

Literature Review

We identified 22 published accounts that reported occurrence of skunks from surveyed locations throughout the Trans-Pecos (Appendix 2.2). Cumulatively, eight accounts published *M. macroura* occurrence records; however, one account (Packard 1964) was previously noted as including an unverified preserved specimen. Two accounts provided occurrence records without either preserved specimens or non-vouchered photographic images (Patton 1974, Oertli et al. 2009); although, in Patton (1974) these records were in addition to preserved specimen records (See *Balmorhea* below). Cumulatively, seven published accounts provided quantifiable evidence *M. macroura* occurrence throughout the region (Appendix 2.2). Of the remaining 14 accounts, eight provided verifiable occurrence records of at least two of the other skunk species. Six accounts were categorized with either insufficient survey effort or methodologies to fully assess the local skunk community (Appendix 2.2). With the inclusion of images from the NPS camera trap survey, our camera trap survey, the TPWD kit fox survey (Hewitt et al. 2022), and occurrence records from iNaturalist, 18 unique datasets were included in the meta-data assessment.

Trans-Pecos Meta-data Assessment

Published accounts were available for 12 of the 19 confirmed preserved specimens (Blair 1940, Blair and Miller 1949, Tamsitt 1954, Patton 1974, Debaca 2008, and Yancey et al. 2017); however, note that the latter two publications detail the same specimen. We identified and compiled presence-absence occurrence results for each of the four skunk species across 14 previously published survey accounts and four new survey datasets (Appendix 2.2). Cumulatively, we identified 18 unique survey datasets across all nine Trans-Pecos counties with 38 unique county-level survey replications that span 1889 through 2025.

We identified four data sources that spanned most of the Trans-Pecos ecoregion (Bailey 1905, Patton 1974, Hewitt et al. 2022, and iNaturalist 2025). Of these, only Patton (1974) reported occurrences of *M. macroura*, while all four datasets included records of *C. leuconotus*, *S. leucoparia*, and *M. mephitis*. We encountered difficulties disentangling county-level occurrence data for both Bailey (1905) and Patton (1974). Therefore, for the purposes of assessment, Bailey's records were resolved at the county level for Brewster and Jeff Davis counties, while Patton's data are presented for Brewster, Jeff Davis, Reeves, Presidio, and Terrell counties. Additionally, we had difficulty disentangling survey results from the Guadalupe Mountain region, as this locality spans three counties, including Eddy County, New Mexico, with four published survey accounts (Davis 1940, Davis and Robertson 1944, Genoways et al. 1975, Lonsinger 2010). The first three report skunk occurrence records exclusively from Culberson County, while the latter did not specify a county. Given that Lonsinger's (2010) work primarily occurred within the Guadalupe Mountains, all occurrence records were attributed to Culberson County. Across these four accounts and all additional collection events from Hudspeth, Culberson, and Eddy counties, *M. macroura* has yet to be documented (Schmidly and Bradley 2016).

The 18 surveys spanned over 15 decades (1889 to 2025) and yielded both preserved specimens and non-vouchered photographic evidence for all four skunk species (Table 2.1). *Conepatus leuconotus* was documented in every survey while *M. mephitis* and *S. leucoparia* were both recorded in 17 surveys (94%). *Mephitis macroura* was the least frequently detected, present in only 8 of 18 surveys (44%). Citizen science data from iNaturalist (2025b) contributed presence records for all species except *M. macroura*. Traditional inventory surveys were conducted 12 times, resulting in preserved specimens for *C. leuconotus* across 12 surveys, *M. mephitis* on 11 surveys, *S. leucoparia* on 11 surveys, and *M. macroura* across 5 surveys. Five camera trap surveys detected the other three species consistently across all surveys; however, Yancey et al. (2019) reported a salvaged *S. leucoparia* in an update of the mammal fauna of the Chinati Mountains where other skunk occurrences were exclusively from camera traps. *Mephitis macroura* was detected in three camera trap surveys conducted within southern Brewster County and with cameras deployed within the Chisos Mountains of Big Bend National Park and the northern extent of the Sierra Del Carmen Mountains in Black Gap WMA (Stevens 2017, This report - Chapter 3).

Table 2.1. Results of skunk presence recorded within 18 datasets from original research conducted in the Trans-Pecos ecoregion of Texas from 1889 through 2025. *Conepatus leuconotus* (COLE), *Mephitis macroura* (MEMA), *Mephitis mephitis* (MEME), and *Spilogale leucoparia* (SPLE).

Author (s)	Year	Type	County	Location	COLE	MEMA	MEME	SPLE
Bailey, V.B.	1905	Inventory	Trans-Pecos	Trans-Pecos	1	0	1	1
Blair, W.F.	1940	Inventory	Jeff Davis	Davis Mountains	1	1	1	1
Borell and Bryant	1942	Inventory	Brewster	Big Bend NP	1	0	1	1
Davis and Robertson	1944	Inventory	Culberson	Guadalupe Montains NP	1	0	1	1
Blair and Miller	1949	Inventory	Presidio	Sierra Vieja	1	1	1	1
Hermann, J.A.	1950	Inventory	Terrell	Stockton Plateau	1	0	1	1
Tamsitt, J.R.	1954	Inventory	Brewster	Black Gap WMA	1	1	0	1
Patton, R.F.	1974	Inventory	Reeves	Trans-Pecos	1	1	1	1
Genoways et al.	1974	Inventory	Culberson	Guadalupe Mountains NP	1	0	1	1
Yancey, F.D.	1997	Inventory	Presidio	Big Bend Ranch SP	1	0	1	0
DeBaca, R.	2008	Inventory	Jeff Davis	Davis Mountains	1	1	1	1
Lonsinger, R.L.	2010	Inventory	Culberson	Guadalupe Mountains NP	1	0	1	1
Stevens, S.	2017	Camera Trap	Brewster	Chisos Mountain	1	1	1	1
Yancey, F.D.	2019	Camera Trap	Presidio	Chinati Mountains SNA	1	0	1	1
Hewitt et al.	2022	Camera Trap	Brewster	Trans-Pecos	1	0	1	1
This report	2025	Camera Trap	Brewster	Southern Brewster	1	1	1	1
This report - NPS	2025	Camera Trap	Brewster	Big Bend NP	1	1	1	1
iNaturalist	2025	Citizen Sicence	Trans-Pecos	Trans-Pecos	1	0	1	1

We further partitioned the occurrence dataset to the county level, resulting in 38 county-level replicates across the 18 unique surveys. Results from the TPWD kit fox survey were not included for El Paso County, as no skunks were detected and only eight cameras were deployed at a single survey site (Hewitt et al. 2022, Table 1). Citizen scientist reports from iNaturalist originated from all nine counties. On average, 4.2 surveys were conducted per county, ranging from one survey conducted in El Paso County to eight surveys in Brewster County. Survey meta-data for Hudspeth and Pecos counties were available only from the TPWD kit fox and iNaturalist datasets.

Across the four species, *M. mephitis* occurrence was reported in nine Trans-Pecos counties, *C. leuconotus* and *S. leucoparia* in eight counties each, and *M. macroura* in four

counties (Schmidly and Bradley 2016; Jefferson et al. 2022; This report – Chapter 3). Our county-level meta-data assessment provides new non-vouchered photographic evidence of *C. leuconotus* and *S. leucoparia* presence in Hudspeth County from iNaturalist (2025b), while failing to identify known presence of *S. leucoparia* in El Paso County (Schmidly and Bradley 2016; Jefferson et al. 2022).

Mephitis mephitis occurrence was identified in 17 surveys over 36 total county-level replicates (95%), while *C. leuconotus* occurrence was identified across 34 county replicates (89%). *S. leucoparia* occurrence was documented across 25 county replicates (66%). *Mephitis macroura* occurrence was confirmed in eight surveys from four counties across nine replicates (24%). Of the 38 total county replicates, 24 (63%) were conducted in counties with confirmed historical *M. macroura* presence, and 14 (37%) conducted in the five other Trans-Pecos counties. Within this partition, *M. macroura* occurrence records originated from nine of the 24 replicates (38%) from Brewster, Jeff Davis, Presidio, and Reeves counties.

Davis Mountains Region

We identified seven mammal survey datasets and seven *M. macroura* preserved specimens from Jeff Davis County (Appendices 2.1 and 2.2). Review of the United States Biological Survey account from the Davis Mountains indicated multiple surveys of the region, notably in 1890 and 1902, during which *C. leuconotus*, *M. mephitis,* and *S. leucoparia* were collected (Bailey 1905, Blair 1940, Schmidly et al. 2022). The first *M. macroura* specimen was collected north of Mount Livermore, within the present-day Davis Mountains Preserve, in 1937 (Blair 1940). Subsequent *M. macroura* collection events occurred in 1941, 1969 (n = 2), 1970, 1972, and 1999 (Patton 1974, DeBaca 2008, Yancey et al. 2017; Appendix 2.2). Latter collection events occurred in or near the current boundaries of Davis Mountain State Park or the town of Fort Davis, with locality data indicating that four of the six were adjacent to Limpia Creek. Of

the seven surveys, six were deemed sufficiently robust for inclusion in our meta-data assessment (Appendix 2.2). Scott (2022) conducted the most recent survey and primarily assessed changes in small mammal density and abundance within the Davis Mountain Preserve. Although both live trapping and camera trapping were employed, and one *M. mephitis* detected via camera trap (recorded as *Mephitis sp*. in Table 10), the survey effort was categorized as insufficient to reliably detect *M. macroura* if present.

DeBaca (2008) and Debaca and Jones (2004) provided the most comprehensive review of the region's mammalian fauna, including a biogeographical assessment of the northeastern Chihuahuan Desert montane mammal community. Although DeBaca's work centered on bat and rodent species, all four skunk species were documented within Davis Mountains State Park, with none recorded in the Davis Mountains Preserve (DeBaca 2008; Table 3.1).

The six published survey datasets from Jeff Davis County and the Davis Mountains region provided additional insight into four of the seven preserved specimens including the only genetically confirmed *M. macroura* from Texas (DeBaca 2008, Yancey et al. 2017). Although survey efforts span from 1890 to 2025, we suggest that the reviewed efforts conducted since DeBaca (2008)—representing the entirety of the 21st century, to date—have been insufficient to reliably detect *M. macroura* presence. Aside from Scott (2022), the only recent presence data were provided via iNaturalist and by Hewitt et al. (2022), with the latter deploying camera traps exclusively in low-elevation grasslands rather than in montane habitats.

Big Bend Region

The area within this section is defined broadly to contain southern Brewster and southeastern Presidio Counties and more specifically, Big Bend National Park, Big Bend Ranch State Park, Black Gap Wildlife Management Area, and El Carmen Land and Conservation Co., LLC. Much like the Davis Mountains, the Big Bend Region has a lengthy history of biological

survey dating to the early 20th century (Bailey 1905, Schmidly et al. 2022). Within the region, we identified nine surveys ranging from at least 1901 (Bailey 1905, Schmidly et al. 2022) through 2025 (iNaturalist 2025, This report; Appendix 2.2). Cumulatively, we identified two preserved *M. macroura* specimens (Appendix 2.1) and non-vouchered photographic images originating from 12 unique camera traps (Stevens 2017, Jefferson et al. 2022).

While parts of the present-day Big Bend National Park and Terlingua were surveyed by Bailey (1905), current day Black Gap, El Carmen, and Big Bend Ranch State Park were not (Schmidly et al. 2022). After legislation was passed to establish Big Bend National Park, mammalian inventory of the area was conducted over 110 days afield in 1936 and 1937 in at least 12 unique survey locations (Borell and Bryant 1942). These efforts failed to detect *M. macroura*, although 11 total carnivores were detected, including three skunk species resulting in 12 preserved specimens (Borell and Bryant 1942). *Mephitis macroura* was first recorded from Brewster County in 1944 near McKinney Springs within the current extent of the Big Bend (TCWC3599, Appendix 2.1). The specimen was prepared by W.B. Davis, but collection event details are unknown. However, Davis later reported a *M. macroura* captured in "a stand of heavy willows along the sandy banks of Tornillo Creek" in Brewster County (Davis 1974). As Tornillo Creek lies within the national park, is fed by McKinney Springs, and this specimen represents the only known collection event from the park, we conclude these are the details for this specimen.

In 1948, the predecessor to the Texas Parks and Wildlife Department purchased 54,000 acres of degraded rangeland northeast of the national park for creation of the Black Gap Wildlife Management Area. In 1951, the mammalian fauna of Black Gap was inventoried over two separate excursions of 11 cumulative days (Tamsitt 1954). A single *M. macroura* (TTU92559,

Appendix 2.1) and *S. leucoparia* were captured and preserved while two *C. leuconotus* skulls were salvaged (Tamsitt 1954). *Mephitis mephitis* presence was not identified during the survey. Tamsitt also surveyed the La Mota Mountain region of Presidio County, currently within Big Bend Ranch State Park, but failed to record presence of any skunk species (Tamsitt 1954). Patton collected *C. leuconotus* and *M. mephitis* in both Brewster and Presidio counties, *S. leucoparia* in Presidio County; however, *M. macroura* were not described from either county (Patton 1974).

The late 20th and early 21st century brought a renewed interest in the region's mammalian fauna. Extensive surveys were conducted within the newly acquired Hart Ranch area of Big Bend National Park (Yancy et al. 2006) and across Big Bend Ranch State Park straddling both Brewster and Presidio Counties (Yancey 1997). None of these traditional surveys resulted in a *M. macroura* preserved specimen. The region was further surveyed by camera traps (Stevens 2017, Yancey et al. 2019, Hewitt et al. 2022, and this study - Chapter 3). While unique properties surveyed by Hewitt (et al. 2022) are not known (due to landowner privacy agreements with TPWD), Big Bend Ranch State Park and Black Gap were surveyed. Across the four unique camera trap surveys conducted within this region, three detected all four species with *M. macroura* occurrences originating from the Chisos Mountains of Big Bend (Stevens 2017, This report – Chapter 3) and the Sierra del Carmen Mountains of Black Gap (This report – Chapter 3). Hewitt (et al. 2022) failed to detect *S. leucoparia* and *M. macroura* within the Big Bend region.

Balmorhea

The town of Balmorhea is located 20 kilometers northeast of the Davis Mountains in Reeves County. Balmorhea was the location of a long-term skunk monitoring survey that involved examination of preserved specimens, collection and preparation of new specimens, and observation of marked individuals (Patton 1974). While newly preserved specimens originated

from throughout the Trans-Pecos, observations of *M. macroura*—including foraging and denning behavior—were recorded exclusively within a 48 km² study area centered on Balmorhea. Patton captured individuals that were subsequently released, as well as at least 15 individuals that were prepared and examined from Balmorhea (Patton 1974, Table 12). We identified eight preserved specimens attributed to Patton (Appendix 2.1), six originating from Balmorhea and two from Jeff Davis County. The digestive tract of 10 individuals was examined, indicating that of the 24 total preserved specimens assessed, Patton either salvaged or collected at least 10 individuals (Patton 1974). Thus, as many as nine individuals from Patton's work in Balmorhea (1974, Table 12) currently lack a known preserved specimen (or specimen number) and were not identified through either the GBIF query (GBIF 2025) or our visit to TCWC. It remains unclear whether these individuals were released after capture and marking to facilitate behavioral observations, or whether prepared specimens have since been lost.

After the research by Patton (1974) only a single reference to the presence of *M. macroura* has been made near Balmorhea. A sighting of a hooded skunk was reported by R. DeBaca (DeBaca and Jones 2004) near a canal in Balmorhea State Park in habitat dominated by mesquite and catclaw acacia (*Senegalia greggii*). No date was given for that observation; however, field work by DeBaca was conducted between February 2000 and June 2002.

DISCUSSION

Our efforts represent the most comprehensive assessment of *Mephitis macroura* in Texas ever conducted and the first in more than 50 years (Patton 1974). Results suggest that the species was likely never widely distributed within the state and may have only inhabited the Chisos, Davis, and Sierra Del Carmen Mountains, their foothills, and associated drainages. Our recommendation to remove the Pecos and Ward County *Mephitis sp.* occurrence records from

the known distribution of the species in Texas, resulted in a stark decrease in the known geographic distribution in the state as these preserved specimens represented the sole occurrence records from these counties (Patton 1974, Schmidly 1977, Hall 1981, Schmidly and Bradley 2016). Exclusion of these records reduced the total number of known preserved specimens from Texas by 24% and the number of counties with confirmed historical occurrence by 33% (from six to four). Moreover, their removal necessitated a re-estimation of the potential geographic distribution in Texas. While previous authors have proposed slightly different state distributions (Schmidly 1977, Hall 1981, Schmidly and Bradley 2016), our revised distribution—based strictly on confirmed preserved specimens—removes more than forty percent of earlier proposed ranges and eliminates approximately 26,422 km² from the state distribution. Based on our findings, there is little justification for retaining eastern Brewster, western Terrell, central and eastern Pecos, Crane, Ward, Winkler, Loving, and Ward Counties as areas of potential *M. macroura* occurrence (Schmidly and Bradley 2016).

Thirty-seven percent of preserved specimens (n = 7) originated from the Davis Mountains region of Jeff Davis County. When expanded to include adjacent portions of Brewster, Presidio, and Reeves Counties, this proportion increases to 83% (n = 16), including two specimens from near Alpine and one from the Sierra Viejas region of Presidio County (Blair and Miller 1949). Toyah Creek originates in the Davis Mountains and flows northeast through Reeves County into Balmorhea. While land cover types near Balmorhea differ from that of the Davis Mountains, the area supports abundant free-standing water derived from natural springs and Lake Balmorhea. Rocks forming Lake Balmorhea dam were identified as diurnal resting sites for *M. macroura* (Patton 1974). Whether presence in Balmorhea was attributed to the anthropomorphic creation of diurnal resting locations, the availability of free-standing water, the presence of agricultural

fields, soil conducive for foraging, or some combination thereof remains unclear. However, across all known Texas occurrence localities, three consistent trends emerge: association with higher elevation and corresponding land-cover types, and when absent, use of anthropogenic diurnal resting structures and proximity to water sources (Tamsitt 1954, Blair and Miller 1949, Patton 1974). However, Patton (1974) noted that *M. macroura* were less likely to use buildings compared to the other species while the other two authors captured two individuals within or adjacent to buildings. Comparatively, *M. macroura* in Arizona (Hass 2003) frequently used buildings, sheds, and culverts as diurnal resting locations and were more likely than *M. mephitis* to use resting locations on rocky hillsides

Initially, our objective was to evaluate *M. macroura* occupancy within southern Brewster County. While we recognized the apparent historical rarity of the species within the Trans-Pecos, we hypothesized that the lack of occurrence records could be attributed either to insufficient survey effort or to previous works failing to identify *Mephitis* to species level. While the latter proved true, we found cumulative survey effort across most of the Trans-Pecos to likely be sufficient to detect *M. macroura* if present. However, within the datasets we assessed, survey effort during the 21st century in the Davis Mountains region and Balmorhea was insufficient for reliable detection, and we propose that *M. macroura* likely persists in both areas. Moreover, the accumulation of skunk occurrence records from 18 survey datasets does not necessarily equate to survey effort or methodology sufficient for *M. macroura* detection. While we are unaware of previous works explicitly addressing optimal survey techniques for *M. macroura*, a substantial body of literature addresses survey efficacy for carnivore communities, particularly for sympatric skunk species. *Conepatus leuconotus* is notoriously difficult to capture efficiently in traps as they rarely respond to bait (Bailey 1905), while a long history of work has detailed the challenges of

detecting *Spilogale* species (Merriam 1897, Genoways et al. 1975, Dukes et al. 2022, Perkins et al. 2022).

In contrast to the idea that specialized methodology is required to detect *M. macroura*, there is compelling evidence that the species can reliably be detected across a wide range of survey types with varying objectives and techniques. Multiple camera-trap surveys across central and northern Mexico, either individually or in aggregate, reported *M. macroura* as among the most detected mammal species (Farias-Gonzalez and Hernandez-Mendoza 2021, Brione-Salas et al. 2023). Additionally, *M. macroura* was documented as the second most common skunk species in southeastern Arizona (Hass 2003). While *C. leuconotus* was the least common skunk species reported by Patton (1974), he did report a larger geographic distribution compared to *M. macroura* and as previously noted, the frequency of encountering *C. leuconotus* could be a relic of inadequate live-capture methodology.

Our extensive iNaturalist query (iNaturalist 2025, This report – Chapter 4) yielded more than 1,500 *M. macroura* occurrence records including camera-trap surveys that each produced over 100 occurrence records and "BioBlitz" events at universities across Mexico and Honduras. While *M. macroura* is undoubtedly more abundant in these regions, the sheer number of records and the ease with which untrained students documented the species through the iNaturalist mobile application suggest that its presence is relatively straightforward to confirm. Moreover, the results suggest that in most regions it is an easily identifiable species (as *M. mephitis* does not occur within these regions) and occurrence records originate from easily accessible locations, both of which are known biases within the iNaturalist platform (Geurts et al. 2023). While much of the Trans-Pecos is difficult to access, portions of the Chisos Mountains, the Davis Mountains, and roadways within the broader Davis Mountains region are readily accessible. Comparable

settings in southeastern Arizona produced historical preserved specimens (Mearns 1897), a monitored population (Hass 2003), and recent iNaturalist records, including images of road-killed individuals and live animals in campgrounds or near water sources. In contrast, equivalent locales in Texas, such as campgrounds within Big Bend National Park or Davis Mountains State Park, consistently yield records of the other three skunk species in the iNaturalist dataset but no records of *M. macroura*.

The biological survey of Texas was conducted intermittently from 1889 through 1906 and comprised 2185 cumulative days afield by 12 total individuals (Schmidly et al. 2022, Table 1). Vernon Bailey, the chief naturalist for the survey, spent 424 total days afield prior to 1904 (Schmidly et al. 2022, Table 1). During the entire period, surveys were conducted at 21 sites in the Trans-Pecos ecoregion and 3 sites across the western Edwards Plateau (Schmidly et al. 2022, Figure 6). Notably, the survey failed to detect *M. macroura* in Texas during this period (Bailey 1905). In the aggregate, the 20th and 21st century surveys have replicated these efforts many times over with *M. macroura* occurrence records originating primarily from the larger Chisos and Davis Mountain regions. Even though *M. macroura* has never been located throughout much of the Trans-Pecos we are uncomfortable presenting the idea that the species is not present in mountainous regions with relatively little survey effort or locations that provide water and anthropogenic cover like Balmorhea. While this is certainly a possibility, it is also as likely that the species is rare or increasingly rare throughout the region, unidentified subpopulations exist, and future perhaps species-specific surveys are needed to further inform the true geographic distribution. Based upon our findings, *M. macroura* should now be considered one of the rarest carnivore species in Texas.

APPENDIX 2.1.

Mephitis macroura Preserved Specimens from Texas

Specimen Review Result	Collection	Catalogue Number	Observer	Year	State	County	General Location
Reviewed and confirmed	UMMZ	79398	Blair, W.	1937	Texas	Jeff Davis	Davis Mountains
	TCWC	2240	Stevens, J. T.	1941	Texas	Jeff Davis	Davis Mountains
	TCWC	3599	Davis, W. B.	1944	Texas	Brewster	Big Bend NP
	TTU	92779	Miller, C. E.	1948	Texas	Presidio	Sierra Vieja
	TTU	92559	Kennerly, T. E.	1951	Texas	Brewster	Black Gap WMA
	TCWC	11400	Pine, R. H.	1963	Texas	Brewster	Doubtful Canyon
	SRSU	534	Meineke, D. A.	1964	Texas	Brewster	Alpine
	TCWC	28290	Patton, R. F.	1969	Texas	Jeff Davis	Davis Mountains
	TCWC	28288	Patton, R. F.	1969	Texas	Reeves	Balmorhea
	TTU	9298	Reichman, O. J.	1969	Texas	Jeff Davis	Davis Mountains
	TCWC	28291	Patton, R. F.	1970	Texas	Reeves	Balmorhea
	TCWC	28365	Patton, R. F.	1970	Texas	Jeff Davis	Fort Davis
	TCWC	28289	Patton, R. F.	1972	Texas	Reeves	Balmorhea
	TCWC	28294	Patton, R. F.	1972	Texas	Reeves	Balmorhea
	TCWC	28292	Patton, R. F.	1972	Texas	Reeves	Balmorhea
	TTU	17410	Williams, S. L.	1972	Texas	Jeff Davis	Fort Davis
	TTU	126091	Jones, C.	1999	Texas	Jeff Davis	Davis Mountains
Conditionally confirmed	SRSU	763	Schmidly 1977	1965	Texas	Brewster	Alpine
	TCWC	28293	Patton, R. F.	UNKN	Texas	UNKN	Likely Balmorhea
Specimen records removed	MSB	13141	Ligon, J. S.	1925	Texas	Pecos	SE of Fort Davis
	YPM	1977	Ligon, J. S.	1926	Texas	Pecos	SE of Fort Davis
	YPM	1978	Ligon, J. S.	1926	Texas	Pecos	SE of Fort Davis
	MCZ	33909	Griswold, J. A.	1935	Arizona	Kerr	Tucson
	UMZM	15907	Dalquest, W.W.	1946	Veracruz	Veracruz	Peidras Negras
	TTU	53	Pilcher, B.	1960	Texas	Ward	Royalty

Abbreviations: Biodiversity Research and Teaching Collections at Texas A&M University (*TCWC*), the Natural Science Research Laboratory at Texas Tech University (*TTU*), the James F. Scudday Vertebrate Collection at Sul Ross State University (*SRSU*), and the Museum of Zoology at the University of Michigan (*UMMZ*), Museum of Southwestern Biology at University of New Mexico (*MSB),* Yale Peabody Museum of Natural History (*YPM*), Museum of Comparative Zoology at Harvard University (*MCZ*), Philip L. Wright Zoology Museum at University of Montana (*UMZM*). Unknown (*UNKN*).

APPENDIX 2.2.

Annotated bibliography of Trans-Pecos skunk related publications used to identify *Mephitis macroura* occurrence records and construct occurrence dataset from survey results. Publications with shared datasets are denoted with (*). Publications noted as ([1]) were deemed to have insufficient survey effort or methodologies for inclusion in the meta-data assessment dataset.

Bailey, V. 1905. Biological survey of Texas. North American Fauna no. 25:1-222.

Blair, W. F. 1940. A contribution to the ecology and faunal relationships of the mammals of the Davis Mountain region, southwestern Texas. Miscellaneous Publications, Museum of Zoology, University of Michigan 46:1-39.

Blair, W. F. and C. E. Miller Jr. 1949. The mammals of the Sierra Vieja Region, Southwestern Texas, with remarks on the biogeographic position of the region. Texas Journal of Science 1:67-91.

Borell, A. E. and M. E. Bryant. 1942. Mammals of the Big Bend area of Texas. California University Publications in Zoology 48:1-62.

[1]Bradley, R. D., D. S. Carroll, M. L. Clary, C. D. Edwards, I. Tiemann-Boege, M. J. Hamilton. R. A. Van Den Bussche, and C. Jones. Comments on some small mammals from the Big Bend and Trans-Pecos Regions of Texas 1999. Occasional Papers, Museum of Texas Tech University 193:1-7.

*Davis W.B. 1940. Mammals of the Guadalupe Mountains of western Texas. Occasional Papers Museum of Zoology, Louisiana State University 7:69-84.

*Davis, W.B. and J. L. Robertson, Jr. 1944. The mammals of Culberson County, Texas. Journal of Mammalogy 25:254-273.

*Note shared dataset between Davis (1940) and Davis and Robertson (1944). Survey results applied from Davis and Robertson (1944)

[*]DeBaca, R. S. 2008. Distribution of mammals in the Davis Mountains, Texas and surrounding areas. PhD Dissertation, Texas Tech University.

[*]Debaca, R. S. and C. Jones. 2004. Report on the mammals of the Davis Mountains: an emphasis on the species documented at Texas Nature Conservancy properties. Unpublished report to Texas Nature Conservancy.

[*]Note shared reference of *Mephitis macroura* prepared specimen TTU 126091 between DeBaca (2008), Debaca and Jones (2004), and Yancey et al. 2017.

[1]Denyes, H. A. 1956. Natural terrestrial communities of Brewster County, Texas with special reference to the distribution of mammals. American Midland Naturalist 55:289-320.

Genoways, H. H., R. J. Baker, and J. E. Cornely. 1975. Mammals of Guadalupe Mountains National Park, Texas. Mammalogy Papers: University of Nebraska State Museum 114:271-332.

Herman, J. A. 1950. The mammals of the Stockton Plateau of northeastern Terrell County, Texas. Texas Journal of Science 3:368-393.

Hewitt, M. O., D. L. Karelus, L. A. Harveson, R. L. Martin, and P. M. Harveson. 2022. Modeling habitat use and potential distribution of kit fox in the Trans-Pecos, Texas. Journal of Wildlife Management. DOI: 10.1002/jwmg.22303.

[1]Jones, C. and M. W. Lockwood. 2008. Additions to the mammalian fauna of Big Bend Ranch State Park, Texas. Occasional Papers, Museum of Texas Tech University 282:1-3.

Lonsinger, R. L. 2010. Fine scale genetic structure driven by habitat-dependent selection in a mesocarnivore. M.S. thesis. New Mexico State University, Las Cruces, New Mexico.

[1]Oertli, E. H., P. J. Wilson, P. R. Hunt, T. J. Sidwa, and R. E. Rohde. 2009. Epidemiology of rabies in skunks in Texas. 234:616-620.

Patton, R. F. 1974. Ecological and behavioral relationships of the skunks of Trans-Pecos Texas. Ph.D. dissertation. Texas A&M University, College Station, Texas.

[1]Scott, R. M. 2022. A resurvey of the terrestrial mammals of the Davis Mountains Preserve, Texas. M. S. Thesis, Angelo State University 1-106.

Stevens, S. 2017. Distribution and habitat selection of carnivores in Big Bend National Park, Texas. M.S. Thesis, Sul Ross State University.

Tamsitt, J. R. 1954. The mammals of two areas in the Big Bend Region of Trans-Pecos Texas. Texas Journal of Science 4:33-61.

Yancey, F. D., II. 1997. The mammals of Big Bend Ranch State Park, Texas. Special Publications, Museum of Texas Tech University 39:1–210.

[1]Yancey, F. D. II, R. W. Manning, and C. Jones. 2006. Mammals of the Harte Ranch area of Big Bend National Park, Brewster County, Texas. Occasional Papers, Museum of Texas Tech University 253:1-15.

[*]Yancey, F. D., II, R. W. Manning, J. R. Goetze, L. L. Lindsey, R. D. Bradley and C. Jones. 2017. The hooded skunk (*Mephitis macroura*) from the Davis Mountains of west Texas: natural history, morphology, molecular characteristics, and conservation status. Texas Journal of Science 69:87-95.

[*]Note shared dataset referencing *Mephitis macroura* prepared specimen TTU 126091 between Yancey et al. 2017, Debaca and Jones (2004), and DeBaca (2008).

Yancey, F. D., R. W. Manning, S. Kasper, M. W. Lockwood, J. R. Goetze, and N. E. Havlik. 2019. Update on the mammals of Chinati Mountains State Natural Area, Texas. Special Publications, Museum of Texas Tech University 71:697-712.

APPENDIX 2.3.

Notation of Removed "Texas" *Mephitis macroura* Preserved Specimens

Two specimens from the early 20th century were identified with transcription errors resulting in the specimen state locality of Texas, but with verbatim local designations that does not match any known locality in Texas. The first (MCZ 33909) indicates a verbatim locality of "Arizona, 16 mi E of Tucson" but a state of Texas and county of Kerr. An examination of J.A. Griswold's collection log from March 1935 indicates he never left Arizona during March 1935, collected and prepped additional specimens on 15 March 1935, and listed these specimens with a state locality of Arizona. An error report for this specimen was submitted to the MCZ. A second specimen (UMZM 15907) was identified in the Philip L. Wright Zoological Museum (UMZM) at the University of Montana. This individual was collected by W.W. Dalquest in 1946 within the state of Texas at a verbatim locality of "Rio Blanco, 20 km WNW Piedras Negras Yeracruz (sic)". While employed by E.R. Hall at University of Kansas, Dalquest conducted a multiyear (1946 -1947) mammal survey of Veracruz, Mexico (Horner and Stangle 2001) which resulted in the description of a new hooded skunk subspecies (Hall and Dalquest 1950). Five total specimens from Veracruz were examined and three were collected at locality "Mexico, Veracruz, Rio Blanco, 20 km WNW Piedras Negras". We hypothesize that one of the 5 specimens was either traded or permanently loaned to the UMZM from KU (the other 4 are currently at KU) and Texas was inadvertently listed as the locality. We initiated correspondence with both KU and UMZM to rectify this issue.

Chapter 3: Survey of the carnivore assemblage in southern Brewster County, Texas

INTRODUCTION

Texas is one of the most biodiverse states in the United States in part due to its 11 unique ecoregions (Griffith et al. 2007). The state is geographically positioned to host a mixture of species from the eastern deciduous forests, the southern Great Plains, the southern Rocky Mountains, and the northeastern Chihuahuan Desert (Schmidly et al. 2022). Mammals, and carnivores (Order Carnivora) in particular, are emblematic of this biodiversity, as 21 extant species from six families naturally occur within the state (Schmidly and Bradley 2016). While California supports a greater total richness of mammals than Texas (Hall 1981), Texas maintains the highest diversity of terrestrial carnivores among U.S. states. The Trans-Pecos ecoregion of western Texas is composed of desert basins and isolated mountain ranges (sky islands) within the northeastern extent of the Chihuahuan Desert (Griffith et al. 2007). Carnivore diversity peaks in this region, with 15 of the state's 21 species (Schmidly and Bradley 2016). This assemblage reflects a combination of common, widely distributed species such as *Canis latrans* (coyote), *Urocyon cinereoargenteus* (gray fox), *Lynx rufus* (bobcat), and *Mephitis mephitis* (striped skunk), along with species that are broadly distributed across North America but restricted to limited ranges in Texas, including *Ursus americanus* (American black bear) and *Puma concolor* (mountain lion; Schmidly and Bradley 2016). Among this assemblage, the hooded skunk (*Mephitis macroura*) is noted as increasingly rare and poorly understood (Hernandez-Sanchez et al. 2022, Jefferson et al. 2022; Yancey et al. 2023).

In the 21st century, digital camera traps emerged as one of the most widely used tools for monitoring wildlife populations, particularly carnivores (Kays et al. 2020; Dukes et al. 2022). Their utility lies in the ability to detect a broad suite of species that vary in size and behavior; however, efficiency is not uniform across species. Estimates of species diversity and detection

rates are influenced not only by study scope and survey effort, but also by species commonness, with rare species requiring up to seven times the sampling effort compared to common species (Kays et al. 2020). Detection is also influenced by animal size, temporal variation in species' activity and annual phenology (Kays et al. 2022; Kays et al. 2020; Kolowski et al. 2020).

To mitigate survey inefficiencies for rare species, several strategies have been proposed, including combining multiple independent survey techniques (Gompper et al. 2006), deploying lures or attractants (Ferreras et al. 2018; Mills et al. 2019; Avrin et al. 2021), or substantially increasing survey effort (Kays et al. 2020). However, these strategies are often constrained by survey scale, logistical feasibility, or landowner and agency restrictions. In arid environments, an alternative strategy is to focus survey effort at water sources, both natural and anthropogenic. Yet, surveys restricted to water sources may incompletely capture the local carnivore community, either due to interspecific interactions that alter use of water sites or infrequent use of the resources by some species (Atwood et al. 2011).

Our objective was to conduct a camera trap survey of the carnivore assemblage within a portion of the Texas Trans-Pecos ecoregion. We aimed to evaluate how the local assemblage partitions resources while also focusing on the detection and ecology of *M. macroura*. Camera trap deployment locations were selected using environmental variables associated with *M. macroura* occurrence records (This report – Chapter 2). Although attractants were not permitted, surveys were conducted both at random locations and at perennial water sources. Survey design considerations and limitations were particularly important for *M. macroura* as we sought to distinguish true presence from potential effects of interspecific interactions.

MATERIALS AND METHODS

Study Area

From January 2024 through September 2025, we conducted a camera trap survey across three adjacent properties in the Trans-Pecos ecoregion of Brewster County, Texas (Figure 3.1). Big Bend National Park (Big Bend) encompasses more than 324,000 ha of conserved Chihuahuan Desert, with vegetation ranging from desert basin communities to riparian zones along the Rio Grande River to pine–oak forests in the Chisos Mountains. Elevation spans from 565 m at Rio Grande Village to 2,387 m at Emory Peak. East and northeast of Big Bend lies Black Gap Wildlife Management Area, a 41,600-ha tract bisected by Ranch Road 2627, bound by 25 miles of the Rio Grande River and that includes the northernmost extent of the Sierra del Carmen Mountains. Black Gap is actively managed for wildlife conservation through practices such as revegetation and provision of supplemental water while also providing the opportunity to legally take many of the carnivore species detailed within. These objectives, along with recreational opportunities, contrast with the preservation-focused management of Big Bend. The El Carmen Land & Conservation Co. LLC., CEMEX INC. Texas (hereafter El Carmen) manages a 10,900-ha private conservation property in southern Brewster County, situated between Big Bend, Black Gap, and the Rio Grande River. Prior to purchase in 2003, this site was heavily degraded by overgrazing domestic and feral livestock (B. McKinney, El Carmen Land & Conservation Company LLC, Wildlife Coordinator, pers. comm.) but has since undergone extensive habitat restoration and is now managed for wildlife conservation, including food supplementation and installation of water catchments. Unlike Big Bend and Black Gap, El Carmen is closed to the public, though access is permitted on a case-by-case basis.

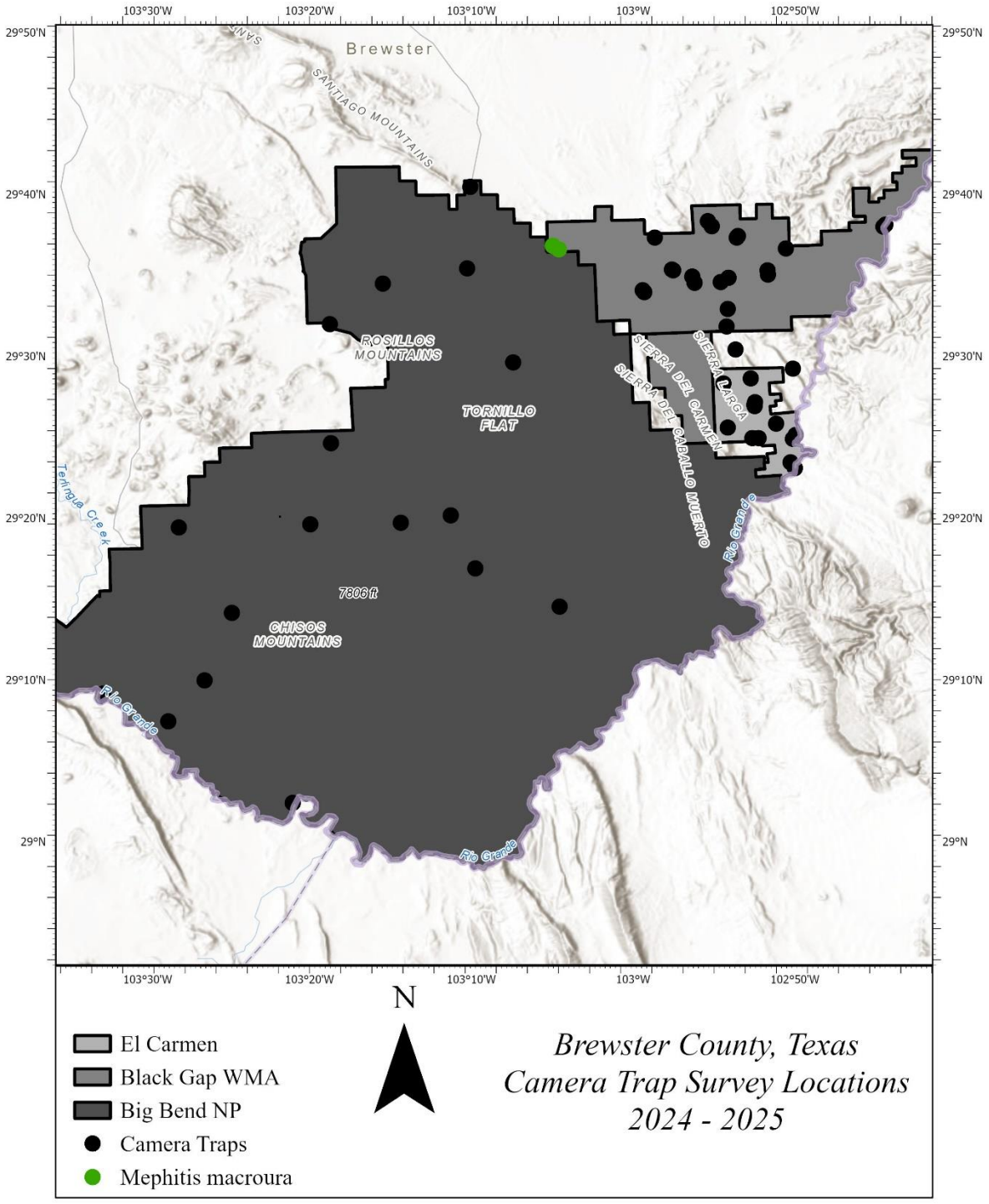


Figure 3.1 Locations of camera traps deployed across the Big Bend region of Brewster County, Texas from 2024 – 2025. The study area is generalized and includes private inholdings.

Habitat Suitability Ranking

Prior to camera deployment, we conducted a habitat suitability ranking to implement a stratified random sampling design. *A priori*, we sought to use historical occurrence records from Texas and northern Mexico. However, many of these records originated from locations with vegetative communities not present within southern Brewster County, or within our study area, and only found within the Chisos Mountains. To mitigate this issue, we removed historical occurrence records from outside of our study area (Stevens 2017, Jefferson et al. 2022, This report-Chapter 2). This left us with an overrepresentation of records from within the Chisos Mountains. Cumulatively, nine of the 11 occurrence records originated from either within or adjacent to the Chisos Mountains within Big Bend (This report - Chapter 2).

We used information from the 10 m resolution Texas Parks and Wildlife Department Ecological Mapping System (Elliot et al. 2014) to assess and rank potential *M. macroura* habitat associated with these 11 occurrence records. This ranking classification was used solely to inform randomly stratified camera-trap survey locations. To identify the vegetative communities associated with *M. macroura*, we first applied a 1-kilometer buffer around each location and then conducted a summary analysis of the proportion of vegetation types within each buffer. To check for consistency across the Chisos Mountains, this procedure was repeated on a subset of nine lower-elevation locations and again on all 11 locations, but with vegetation types found only in the Chisos Mountains removed. In each instance, the ranking of the top three vegetation types remained the same: succulent desert scrub, mixed desert shrubland, and hill and foothill grassland vegetation types ranked the highest and together accounted for 52% of the land-cover at 10 m resolution in the global assessment. *A priori*, we planned to rank every vegetation type that contributed more than 5% to the global assessment; however, the four vegetation types (Pinyon–Juniper Woodland, Lower Montane Riparian Shrubland, Gray Oak Savanna and

Woodland, and Deciduous Chaparral; 27% total) either occurred solely within the Chisos Mountain range or were in locations intentionally omitted from survey due to accessibility.

Across the global assessment, we identified 30 total vegetation types, of which 15 accounted for less than 1% individually and 6.7% cumulatively. Creosotebush scrub was more than 30% of the cumulative vegetation types across the study area and dominated the lower-elevation desert basins however, it contributed only 2.7% to the global occurrence buffers. While this vegetation type was not included in initial survey plans, spatial and logistical constraints necessitated additional survey locations that fell outside of the high-ranking vegetation types. We increased potential survey locations by including creosotebush scrub. Using the vegetation type percentages associated with known *M. macroura* occurrence records within the region, we assigned a nominal value of 1, representing the highest probability of presence to succulent desert scrub and mixed desert shrubland, a value of 2 representing moderate probability to hill and foothill grassland, and value of 3, representing the lowest probability of species presence to creosotebush scrub. We then used the majority rule to reclassify these nominal rankings at 100 m resolution and weighted these ranked classes such that 35% of cameras deployment locations would fall in succulent desert scrub and mixed desert shrubland vegetation each, 20% in hill and foothill grasslands, and 10% in desert creosotebush scrub.

To build upon the vegetation ranking we applied the slope classification within the TPWD dataset. This is a categorical classification based upon a continuous measurement where a category of 0 equates to no slope, 1 equates to a slight increase, 4 a moderate increase, and 10 represents a vertical increase of 10 m across 10 horizontal meters. For personnel safety, all cells classified as 10 were removed from consideration. Cells classified as 4 were retained with the caveat that each potential location was first ground-truthed and the safety of actual deployment

considered. To the linear riparian drainages within the study site, we applied a 100 m buffer and then reclassified the entire survey site at 100 m resolution as either riparian (1) or not (2).

To further truncate potential camera deployment locations, we applied a 1.61-kilometer buffer around all roads, including paved roads (excluding Chisos Basin Road within Big Bend), maintained off-road, and un-maintained off-road routes within the study area, and retained only these buffered locations for future consideration. We then applied the same procedure to all drainages, creeks, streams, and the Rio Grande River within the study area. Thus, potential deployment locations were considered only if they fell within 1.61 kilometers of both a road and a drainage. We were faced with additional constraints on camera deployments across the three sites. At Black Gap and El Carmen, constraints were solely due to the smaller geographic size of these sites, whereas the total number of camera stations within Big Bend was restricted and all potential deployment locations within were first vetted to ensure that no archaeological relics or endangered plant species occurred nearby. Due to an ongoing camera trap survey in the Chisos Mountain range conducted by Big Bend personnel, we did not operate any cameras there. Spatial independence was further defined as a randomly selected location within the previously identified buffers that was at least 5-kilometers apart within Big Bend and at least 3 kilometers apart within Black Gap and El Carmen. Finally, potential deployment locations were randomly selected based upon these parameters.

Water Associated Camera Trap Survey

At Black Gap and El Carmen, we deployed camera traps adjacent to anthropogenic water sources. Earthen water catchment tanks and guzzlers were positioned throughout both sites; however, only guzzlers were surveyed, as many of the tanks were dry throughout 2024. We identified all guzzlers within 1 kilometer of a random camera trap, at least 3 kilometers from all other random camera traps, and at least 3 kilometers from all other water associated camera

traps. Cameras were then deployed at guzzlers paired with random camera traps and operated simultaneously. Two random camera traps fell within 1 kilometer of the Rio Grande River, and we randomly selected an azimuth from these camera traps to the river and deployed the paired water cameras within 10 m adjacent to the river.

Data Collection and Compilation

Camera traps were deployed for a minimum of 13 weeks with units checked at either monthly or bi-monthly intervals. Any camera incapable of recording wildlife detections during the deployment was classified as inoperable, and the total number of inoperable days was documented. Causes of inoperability included wildlife interference, camera or SD card malfunction, and human disturbance. To ensure that each location was sufficiently surveyed to detect uncommon species, we established a survey threshold of 6 operational weeks (equivalent to 42 trap nights) to define a satisfactory sampling effort. Cameras that reached this threshold within the first 13 weeks were retrieved, while cameras failing to meet the threshold were left an additional month.

All camera trap images were uploaded to the Brewster County Carnivore Survey project on Wildlife Insights (Perkins et al. 2025), where they were first processed by the platform's automated species identification tool (Ahumada et al. 2020). Images were then reviewed for species accuracy, catalogued, and a species occurrence matrix was downloaded. Next, we aggregated total species detected per camera trap across the three sites and two survey types (random and water associated) and present results in Table 3.2.

Big Bend National Park Collaborative Survey

Bend National Park personnel have maintained a long-term camera trap survey within the Chisos Mountains that began in 2014 (Stevens 2017) and has been continuously operated since

2021. To avoid duplication of survey effort and minimize the number of deployed devices within this area, personnel provided all images identified as skunks from 2021 through 2024. Twelve cameras were deployed across the Chisos Mountains in a grid array, with all cameras separated by at least 3 kilometers. Personnel did not provide a camera operational history or images of species other than skunks, preventing us from determining exact deployment schedules and operational periods.

RESULTS

From January 2024 through September 2025, we operated 59 camera traps across the three survey sites, with at least 15 camera traps deployed at any one time. Five cameras experienced complete failure and were subsequently excluded. The remaining 54 cameras were deployed for 6749 survey nights, of which 5697 (84%) were operational nights and 487 (16%) were inoperable (Table 3.1). By site, 24 cameras were deployed at Black Gap, 17 at Big Bend, and 13 at El Carmen. Thirty-four cameras (63%) were placed at random locations and twenty (37%) were associated with water sources (Table 3.1).

Table 3.1. Summary statistics of effort for a camera trap survey of the carnivore assemblage across three sites in Brewster County, Texas. Total cameras deployed is noted as (*n*). "Average" is the average number of nights individual cameras were operational per survey site.

Site	Camera Type	*n*	Deployed Nights	Operational Nights	Operational %	Average
BIBE	Random	17	1860	1818	97.7	107
Black Gap						
	Random	11	1945	1614	83.0	147
	Water	13	1647	1149	69.8	88
	Total	24	3592	2763	76.9	115
El Carmen						
	Random	6	712	616	86.5	103
	Water	7	585	500	85.5	71
	Total	13	1297	1116	86.0	86
Total						
	Random	34	4517	4048	89.6	119
	Water	20	2232	1649	73.9	82
	Total	54	6749	5697	84.4	106

Over 20 months of survey we generated more than 100,000 images of wildlife in southern Brewster County. Images were primarily of non-target taxonomic groups with avian species contributing more than half of the total images. *Odocoileus hemionus, O. virginianus,* and *Pecari tajacu* cumulatively contributed more than 20,000 images. We detected 12 carnivore species, originating from six taxonomic families, including all four skunk species (Table 3.2). Two uncommon carnivores known to inhabit the region (*Vulpes macrotis*—kit fox and *Neogale frenata*—long-tailed weasel) were not detected (Schmidly and Bradley 2016, Stevens 2017, Hewitt et al. 2022). *Canis latrans* was detected most frequently with visitations recorded at 69% (n = 37) of all camera traps with the lowest rates record at El Carmen random cameras (18%) and the highest at El Carmen water cameras (86%). *Urocyon cinereoargenteus* were detected at 54% of all camera traps (*n* = 29) and more frequently at random camera traps (59%) compared to water

camera traps (45%). El Carmen random camera traps accounted for the lowest amount of species diversity (n = 6/12) while Black Gap water-associated camera traps detected all 12 species. Eleven species were detected at the Big Bend random camera traps.

Water Associated Camera Trap Survey

Eight of the twelve carnivore species were detected more frequently at water associated cameras compared to random camera traps (Table 3.2). The difference in detection frequency for *T. taxus* was minute (2.4% more frequently at random cameras) but more pronounced for *U. cinereoargenteus* (14%) and *S. leucoparia* (100%). The other eight species were 26% more likely to be detected at a water-associated camera trap compared to a random camera trap (Range: 12% to 41%). Two species, *M. macroura* and *P. lotor,* were each 41% more likely to be detected at a water-associated camera trap versus a random camera trap; however, these were the least commonly detected species (at 4% and 7% of all cameras respectively) and findings may be a relic of low sample size. Of these two, only *M. macroura* appeared on both cameras within a paired dyad. In both instances, there was exactly one *M. mephitis* detection at each of the two random cameras while there was nearly one *M. mephitis* visitation per night at the water sources.

Table 3.2. Count of carnivore detections per camera, location, and survey type from a camera trap survey conducted across southern Brewster County, Texas from 2024 through 2025. Numbers in parentheses indicate the total number of camera traps per site and survey type.

Species	Black Gap (11)	Black Gap Water (13)	Big Bend (17)	EL Carmen (6)	EL Carmen Water (7)	Total (54)	Total (54) %	Random (34) %	Water (20) %
Bassariscus astutus	2	3	2	2	1	10	18.5	17.6	20.0
Canis latrans	6	11	13	1	6	37	68.5	58.8	85.0
Conepatus leuconotus	1	2	3	0	1	7	13.0	11.8	15.0
Lynx rufus	5	5	7	0	3	20	37.0	35.3	40.0
Mephitis macroura	1	1	0	0	0	2	3.7	2.9	5.0
Mephitis mephitis	4	3	1	0	2	10	18.5	14.7	25.0
Procyon lotor	1	1	1	0	1	4	7.4	5.9	10.0
Puma concolor	5	3	1	0	1	10	18.5	17.6	20.0
Spilogale leucoparia	3	0	2	1	0	6	11.1	17.6	0.0
Taxidea taxus	1	5	7	3	1	17	31.5	32.4	30.0
Urocyon cinereoargenteus	7	5	8	5	4	29	53.7	58.8	45.0
Ursus americanus	10	7	3	2	3	25	46.3	44.1	50.0
Total Species per Survey	12	11	11	6	10				

Across the three sites, *C. leuconotus* , *M. macroura,* and *M. mephitis* were detected at both random and water associated cameras, while *S. leucoparia* were detected at random cameras only. However, of the six camera traps where *S. leucoparia* were detected, only one was paired with a water associated camera. *Conepatus leuconotus* was detected at fewer camera traps (13%) compared to *M. mephitis* (18%), but this may be attributed to higher *M. mephitis* rates at water associated cameras (25%). Across the 10 camera locations where *M. mephitis* was detected, six originated near a water source and five were near anthropogenic structures such as those present at Black Gap and El Carmen headquarters. *Spilogale leucoparia* was detected at six unique camera traps, five of which occurred at locations of higher elevation and sloped drainages ($n = 4$) or a low elevation drainage ($n = 1$). All drainages were either heavily vegetated or contained large rocks and boulders that could serve as cover for the more diminutive species (Schmidly and Bradley 2016). Additionally, we recorded short-term, seemingly mutualistic behavior between *S. leucoparia* and *U. cinereoargenteus* at two of the camera stations including a camera station not

deployed on a drainage with heavy cover. Similar behavior has been observed between *Spilogale angustifrons* and *U. cinereoargenteus* in Mexico (Farcias-Gonzalez and Vega-Flores 2019, Mejenes-Lopez et al. 2021). These behaviors are thought to decrease predation risk and increase spatial use by both species but have not previously been reported for *S. leucoparia* and *U. cinereoargenteus* (Farcias-Gonzalez and Vega-Flores 2019, Mejenes-Lopez et al. 2021).

Big Bend National Park Collaborative Survey

Twelve camera traps were operated by National Park Service personnel across the Chisos Mountain range from 2021 through 2024 (T. Athens, National Park Service, Big Bend National Park, Wildlife Biologist, pers. comm.). Camera traps captured 2,400 total images with cameras set to record a burst of three consecutive images per trigger event. After defining temporal independence as one unique visitation per species per camera per 24-hour period, 714 unique detection events were logged across these 12 cameras. Cumulatively, there were 33 unique visitations categorized as either *Mephitis* spp. (1%) or *Mephitidae* (3.5%), yielding 668 visitations of the four species. *Mephitis mephitis* (n = 216, 32%) and *C. leuconotus* (n = 210, 31%) were detected most frequently, while *S. leucoparia* (n = 162, 24%) were the third most detected. Hooded skunk detections comprised 13% of visits (*M. macroura*, n = 93). No species were detected at all 12 camera traps; however, one station recorded only a single *M. macroura* visit, and we suspect an issue with either data transfer or survey effort at that location. *M. mephitis* and *S. leucoparia* were detected at eleven camera traps, *C. leuconotus* at ten, and *M. macroura* at eight. *M. macroura* visits were recorded in all four years and in every month; however, there was a notable decrease in annual visits from 2021 (n = 44) to 2024 (n = 12). After removal of the questionable camera trap station, an average of 3.5 species per station were detected across the remaining 11 stations (range: 2–4). The four camera stations situated across the northern face of the Chisos Mountains provided the lowest average (3 species per camera)

due to *M. macroura* detections at only one station. It is unknown whether this is an artifact of small sample size, small population size, or if the species' ecology precludes use of space on northward-facing slopes.

The Big Bend collaborative dataset primarily contained images of skunks; however, several three-image series included two species simultaneously. We documented interspecific interactions between skunks and both *C. latrans* and *U. cinereoargenteus*. In one sequence, a *C. latrans* appeared carrying a deceased *Mephitis sp*. in its mouth. Due to the position of the carcass, the skunk could not be identified to species, and it remains unclear whether the observation represented predation or scavenging. Multiple sequences depicted *U. cinereoargenteus* and *C. leuconotus*. Unlike the short-term behavioral associations previously documented with *S. leucoparia*, these skunk–fox interactions appeared incidental: the images showed a family unit of *U. cinereoargenteus* subadults and a single *C. leuconotus*, with the only behavioral interaction being defensive posturing by the skunk. Similar patterns of spatial–temporal association, but not behavioral interaction, between these species have also been reported in Mexico (Perez-Irineo et al. 2019). Finally, we recorded a sequence showing a short-term behavioral association between *U. cinereoargenteus* and *S. leucoparia*.

DISCUSSION

Initially, the efforts and objectives reported herein were designed as a species-specific camera trap survey to assess *Mephitis macroura* occupancy and multi-species occupancy with *M. macroura* as the focal unit. By fall 2024, however, it became evident that *M. macroura* was not sufficiently present throughout the study area to support such analyses or to provide insight beyond previously known occurrence information from the Chisos Mountains (Stevens 2017, Jefferson et al. 2022). Consequently, the overarching scope of this work shifted toward a Texas-centric review of historical and contemporary occurrences (This report – Chapter 2) and a

species distribution assessment across the entire geographic range (This report – Chapter 4). These changes necessitated a reduction in camera trap survey effort compared to what was originally planned. Although we are obligated to report the results of our survey, we present only general summary statistics without formal statistical analyses. The information provided here is intended to contextualize Chapters 2 and 4, to describe methodological details underlying our publicly available camera trap dataset (Perkins et al. 2024, 2025), and to offer a general overview of the carnivore assemblage in southern Brewster County.

Across the survey, we noticed emergent trends within the carnivore assemblage. While *C. latrans* and *U. cinereoargenteus* were the most widely and frequently detected species, the two were infrequently detected at the same camara traps. Moreover, there appeared to be a temporal avoidance of *C. latrans* by *U. cinereoargenteus* at locations where both were detected. This spatial and temporal avoidance has been reported from anthropogenic water sources surveyed within the Trans-Pecos (Atwood et al. 2011), and from mountainous environments in a similarly arid environment (Sultaire et al. 2023) but may not be uniform across all locations as survey of riparian forests in southeastern Arizona indicated little avoidance or altered activity patterns between *U. cinereoargenteus* and *C. latrans* (Herzog, and Bateman 2021). Interspecific interactions between the two species are generally categorized as a form of intraguild competition and predation with *C. latrans* serving as the dominant predator. These emergent trends and images of a coyote carrying a deceased *U. cinereoargenteus* recorded at Black Gap support the idea that these interactions are in place within southern Brewster County. In the future, we will assess the dataset to find support for this hypothesis.

Mephitis mephitis is the most widely distributed skunk in Texas (Schmidly and Bradley 2016; Jefferson et al. 2022). While this ubiquitous species is known to be abundant across a wide

variety of landscapes and anthropogenic land uses, it may not be the most abundant skunk species locally (Jefferson et al. 2022; Allen et al. 2023). Through our survey and the Big Bend collaborative survey, we found little evidence that *M. mephitis* was less abundant compared to the other skunk species in southern Brewster County. It was the most frequently detected species and was detected at the most camera stations within both our survey and the collaborative survey across the Chisos Mountains. Historical surveys within the region seemingly support this result. Both Bailey (1905) and Borrell and Bryant (1942) noted it as the most frequently examined skunk during their respective surveys of the region. It was reported to occur from the Rio Grande River bottom to the higher elevations of the Chisos Mountains, not abundant in any one area, but more common in the Chisos Mountains (Borrell and Bryant 1942). *M. mephitis* was not detected during a survey of Black Gap WMA, while the other three species were however, the survey effort lasted only 11 days (Tamsitt 1954). More recently, it was the only skunk detected during a survey of the Hart Ranch area of Big Bend National Park (Yancey et al. 2006) and the most common skunk detected at Black Gap (this report – Chapter 2; Hewitt et al. 2022). While Stevens' (2017) original survey of the Chisos Mountains detected *C. leuconotus* more frequently and at more camera trap stations, *M. mephitis* and *M. macroura* were reported as a single group.

Through our initial *M. macroura* habitat ranking, we identified two locations within the study area—the North Rosillos Mountain and the northernmost extent of the Sierra del Carmen Mountain range (i.e, Dead Horse Mountain)--that contained vegetation types similar, albeit less spatially extensive, to those of the Chisos Mountains. The higher elevations of both locations were intentionally excluded from survey due to inaccessibility and private property inholdings, but the foothills of each were included. Both camera traps that recorded *M. macroura* were deployed within Black Gap WMA along a drainage emanating from the northeastern most

portion of Dead Horse Mountain. Cumulatively, across all three sites, we deployed five camera traps within or adjacent to this mountain range resulting in four operational camera traps with data. Unfortunately, the sole water associated camera trap was the one on Black Gap that detected *M. macroura*. Uncertainty remains as to whether a *M. macroura* population exists within the Dead Horse Mountains; however, these observations now represent the second confirmed species presence records associated with the range (This report – Chapter 2). In 1944, a preserved specimen was taken at McKinney Springs within current day Big Bend National Park. This location is at the western base of the Dead Horse Mountains, contains multiple drainages that converge to feed into Tornillo Creek, and has a perennial water source.

Vegetation adjacent to the Rio Grande River was largely dissimilar to that of the Chisos Mountains; however, based on historical records and the species' ecology, we initially hypothesized that *M. macroura* could occur in these riparian areas (Hwang and Larivière 2001; This report – Chapter 2). While *M. macroura* was not detected at these locations, survey effort was limited, with only eight camera traps deployed within 1 km of the river. Moreover, although *C. leuconotus* and *M. mephitis* were detected along the river, these detections originated from just two camera stations. Outside of the Chisos Mountains, skunks appear to be uncommon throughout the study area, with *M. mephitis* seemingly restricted to sites providing water and anthropogenic structures or small-scale land cover alterations. An emerging trend is that low-elevation, sparsely vegetated habitats cannot support skunks without supplemental resources of anthropogenic origin. While we hypothesize that *M. macroura* may persist at low abundance within the study area, the most likely locations are the aforementioned mountain ranges or sites with perennial water. We recommend that future assessments of *M. macroura* in the region shift

survey effort away from these low-elevation habitats toward areas that provide both cover and year-round water.

Our results largely align with known survey inefficiencies for local communities (Kays et al. 2020). Uncommon or rare species were detected less frequently, and additional survey effort paired with statistical analysis will be required to determine how abundant these species are and how they orient themselves across the landscape. Of the two uncommon species not detected, *V. macrotis* was not recorded by either recent, local camera trap effort (Stevens 2017; Hewitt et al. 2022) and *N. frenata* was detected only within the basin region of the Chisos Mountains (Stevens 2017) and was not reported by Hewitt et al. (2022). In contrast, common species such as *C. latrans* and *U. cinereoargenteus* required relatively little survey effort to detect at individual sites and future analyses should focus on quantifying resource partitioning between these two species. In addition, skunk ecology in the region may be better understood by assessing spatial distribution and resource partitioning among the four species collectively, using both our dataset and the collaborative Big Bend dataset, rather than restricting focus to *M. macroura* alone.

Chapter 4: Global Distribution of the Hooded Skunk (*Mephitis macroura*) with Predictive Occurrence within the Trans-Pecos Region of Texas

INTRODUCTION

The 21st century saw the rise of modeling species distributions from presence only occurrence records (Franklin 2009, Elith et al. 2011, Peterson et al. 2011) in large part due to the ease and utility of the maximum entropy (MaxEnt) algorithm (Phillips et al. 2006). MaxEnt is a technique that uses presence only occurrence data to create correlative models that predict the distribution of a focal species and have been used in conservation planning, predicting the spread of invasive species, modeling effects of climate change, and predictions of species richness and diversity (Elith et al. 2011, Peterson et al. 2011). While species distribution models (SDMs) include a niche assessment, they are not evaluations of a species' environmental niche although they have been presented as such (Peterson and Soberon 2012). Simplistically, SDMs are used to predict where a species may occur while environmental niche models (ENMs) are used to explain why the species occurs there (Araujo and Guisan 2006, Peterson et al. 2011, Peterson and Soberon 2012).

The American Southwest supports a diverse carnivore community, with the hooded skunk (*Mephitis macroura*) identified as a species potentially requiring conservation attention (Schmidly & Bradley 2016, Hass and Dragoo 2023). Its range extends from Arizona, New Mexico, and Texas southward to northwestern Costa Rica (Hall 1981, Hwang and Lariviere 2001). While patchily distributed in the northeastern Chihuahuan Desert (Schmidly and Bradley 2016; Hass and Dragoo 2023), the species is among the most common carnivores in the western Chihuahuan Desert (Haas 2003, Coronel-Arellano et al. 2018). Currently four subspecies of the hooded skunk are recognized (Hall 1981; Hwang and Lariviere 2001), however, these designations were proposed in the early to mid-twentieth century, based on limited specimens

from few populations in the U.S.–Mexico borderlands and Central America. The first major revision of hooded skunk systematics (Howell 1901) reclassified the previously distinct northern hooded skunk (*Mephitis milleri*, Mearns 1897) with the type locality from Pima County, Arizona, as the subspecies *M. m. milleri*. Howell examined 165 specimens from 18 Mexican states and Arizona to propose this subspecific distinction, separating *M. m. milleri* from *M. m. macroura* (Lichtenstein 1832, type locality northwest of Mexico City). Goodwin later elevated *M. m. richardsoni* to subspecific status based on 7 specimens from 2 localities in Nicaragua (Goodwin 1957). Richardson's hooded skunk ranges from southern Oaxaca, Mexico, to northwestern Costa Rica (Goodwin 1957, Hall 1981, Hwang and Lariviere 2001).With minor modification, Goodwin's revision established the latitudinal pattern still recognized today: *M. m. milleri* occurs across the Mexican Plateau, including the Chihuahuan Desert and U.S.–Mexican borderlands; *M. m. macroura* occupies central Mexico including south of the Trans-Mexican Volcanic Belt; and *M. m. richardsoni* is distributed south of the Isthmus of Tehuantepec through Central America (Hall 1981, Hwang and Lariviere 2001). A fourth subspecies (*M. m. eximinus*) is currently recognized based upon the examination of 5 specimens from Veracruz, Mexico (Hall and Dalquest 1950). Subspecific designation was hypothesized primarily due to perceived isolation from *M. m. macroura* on the Mexican Plateau and secondarily due to differences in size, tail length, and skull length. There is little evidence that the two most recent hooded skunk designations were based on quantifiable analyses, or that any of the subspecific designations have since been reassessed.

Historically, hooded skunk occurrence records originated from 6 counties in the Trans-Pecos Ecoregion (Schmidly and Bradley 2016); however, recent assessment suggests that the species may be restricted to the Chisos and Davis Mountain ranges, foothills, and drainages (This

report-Chapter2.). Over the previous half century, only a single preserved specimen originated from Texas (Yancey et al. 2017) although a recent camera trap survey confirmed presence within the Chisos Mountain Range (Stevens, 2017, Jefferson et al. 2022). Similarly, in New Mexico, hooded skunk occurrence records primarily originate from 6 counties in the southwestern portion of the state with a single record east of the Rio Grande River (Hass and Dragoo 2023). With the frequency of camera trap surveys within the northeastern Chihuahuan Desert and the global emergence of citizen scientist-based specimen reporting applications (e.g. iNaturalist), the lack of recent hooded skunk occurrence records in Texas and southeastern New Mexico is concerning.

Mephitis macroura inhabits multiple land cover types including grasslands, forests, pastures, and deserts (Hass and Dragoo 2017, Hass and Dragoo 2023) across the northern Chihuahuan Desert and exhibits evidence of anthropogenic commensalism (Patton 1974, Hass 2003). An environmental niche assessment indicated significant similarity between hooded and striped skunk (*Mephitis mephitis*) niches across the region (Hass and Dragoo 2017). The same assessment suggested that the hooded skunk's geographic distribution was likely restricted by climate (e.g., isothermality and temperature) and secondarily by land cover type with grasslands and open shrublands being the highest percent land covers used (Hass and Dragoo 2017). An estimated 0.5% of the United States Chihuahuan Desert ecoregion incurred landcover change from 1973 – 2000 (Ruhlman et al. 2012); however, overgrazing and droughts in the early 20th century transformed much of the semidesert grassland land cover into desert shrublands. With this anthropogenic land cover change it is possible that *M. macroura* is now restricted to sky islands across the borderland region and in Texas. The growing concern over *M. macroura* in Texas will necessitate continued survey efforts to locate species presence, individual

populations, and any differentiation among these populations. The research reported herein provides valuable information as to the predicted occurrence of hooded skunks in Texas.

MATERIALS AND METHODS

Study Area

The geographic distribution of *M. macroura* extends southward from the United States Chihuahuan Desert ecoregion to northwestern Costa Rica (Hwang and Lariviere 2001). The species is not found on the Yucatan Peninsula, and the Usumacinta River may be a barrier to eastward dispersal in Mexico and Guatemala. From Guatemala south, the species is primarily distributed in western and central parts of Central America and may be restricted from the rainforest biomes in eastern Guatemala, Honduras, Nicaragua, and Costa Rica. We set the study extent based upon previously proposed distribution limits (Hall, 1981) with notable alterations. Hall's previously proposed range incompletely extended westward to the Pacific Ocean in three areas of Mexico. As we identified *M. macroura* occurrence records in these locales, we set the westward extent, south of Arizona, as the eastern extent of the Bay of California and the Pacific Ocean. Similarly, we identified presence locations in the Mexican states of Tamaulipas and Veracruz that necessitated a slight extension of the range in this locale. Finally, as noted in Chapter 2, we removed locations in the Texas Trans-Pecos ecoregion without historical occurrence records (Figure 4.1).

Species Distribution Modeling

Species distribution modeling was conducted in program R using the Wallace package (Kass et al. 2018, 2023) and followed the workflow guidelines of Kass et al. (2024), which recommend additional packages to enhance analytical utility. Wallace is built on the *shiny* web application framework, providing a graphical user interface (GUI) for species distribution modeling (Kass et al. 2023). Many of the supplementary packages outlined by Kass et al. (2024)

are already incorporated as GUI options within Wallace, while others can be added as user-specified inputs. For this study, we implemented maximum entropy modeling (Phillips et al. 2006) within the Wallace *shiny* application.

Occurrence Data Processing

We compiled *Mephitis macroura* occurrence records from three primary sources. First, we queried the Global Biodiversity Information Facility (GBIF) via the R package rgbif (Chamberlain et al. 2024), retaining only non-observational, non-paleontological records. This search returned 918 *M. macroura* records classified as "Preserved Specimen" with georeferenced coordinates (GBIF 2025). Second, we curated all research-grade hooded skunk observations from iNaturalist spanning 2002 through 30 April 2025 (iNaturalist 2025). Third, we incorporated occurrence records from recent camera-trap surveys in Big Bend National Park (Stevens 2017, Jefferson et al. 2022, This report – Chapter 3).

Following data aggregation, we evaluated and corrected locality errors using the R package CoordinateCleaner (Zizka et al. 2019). This package flags potentially problematic records, including those located at administrative centroids, spatial outliers, or records with suspicious formatting (Zizka et al. 2019, Kass et al. 2024). The final hooded skunk dataset was partitioned temporally to create a "modern" subset by excluding records with questionable georeferencing and aligning the dataset with the temporal extent of the WorldClim climate database (Fick and Hijmans 2017).

Occurrence records originating from natural history collections and collaborative science efforts are typically derived from unstructured, opportunistic events rather than from studies with robust sampling designs, and therefore often incur spatial sampling bias (Erickson and Smith 2021, Kass et al, 2024). Geographic bias resulting from uneven sampling effort is widespread in non-systematically collected datasets (Zizka et al. 2021). To address this, we first visualized

potential bias using the sampbias package in program R (Zizka et al. 2021) and then reduced bias by spatially thinning occurrence records with a distance-based method available in Wallace (spThin; Aiello-Lammens et al. 2015). Because published estimates of *M. macroura* home range are lacking, we used *Mephitis mephitis* (striped skunk) as a proxy and applied a thinning distance of 10 km to *M. macroura* records. Finally, we partitioned occurrence data for model evaluation and tuning using spatial partitioning with *k*-fold cross-validation, with 4 total folds. In this sequence, the occurrence data are divided into the 4 folds, the model is built using all folds except one, evaluated against the withheld fold, and the process is iterated (Phillips et al. 2006).

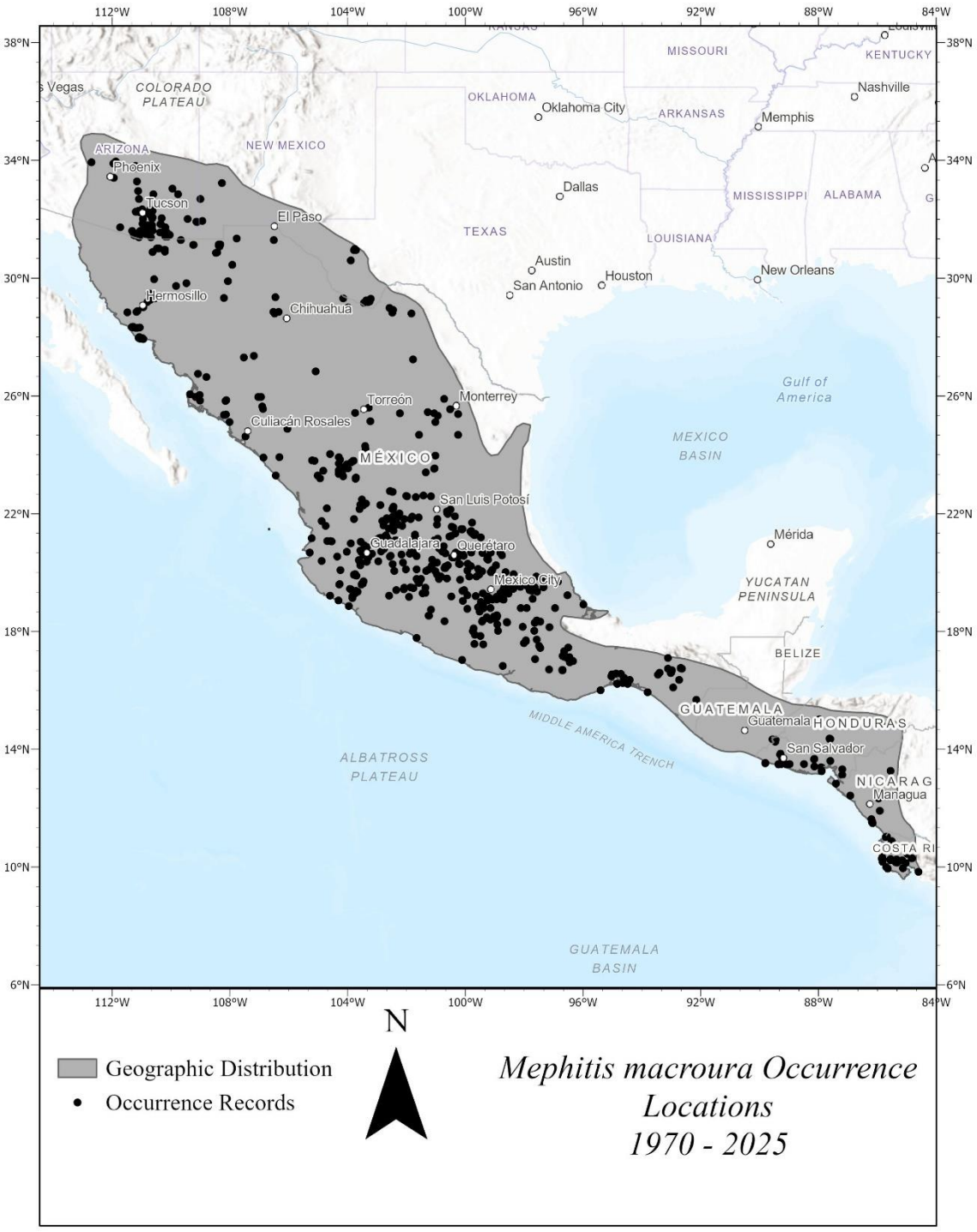


Figure 4.1. *Mephitis macroura* occurrence records from 1970 through 2025.

Environmental Data Processing and Model Creation

To model *M. macroura's* distribution, we used 19 bioclimatic variables averaged across 1970–2000 (WorldClim version 2.1; Fick and Hijmans 2017) at a resolution of 2.5 arcminutes. Prior to modeling, we assessed correlations among the top-ranked variables in the environmental dataset. While expert knowledge can be used to remove correlated variables, an alternative approach is variable selection, in which the most explanatory variables are retained (Vignali et al. 2020). We performed variable selection and retention in the SDMtune package in program R (Vignali et al. 2020). This process starts with a trained model and iteratively tunes it by identifying correlated variable pairs using Spearman's rank correlation coefficient (> 0.7) and quantifying the contribution of each variable. For each pair, the less contributive variable was identified, removed, the model retrained, and the process repeated until no pairs remained with a rank correlation > 0.7 (Vignali et al. 2020). All remaining variables were then retained to create models in Wallace.

We used four feature classes (linear, linear-quadratic, hinge, and linear-quadratic-hinge) with regularization set between 0.5 and 4 with a step value of 1 resulting in 16 total candidate models. Model parameters were chosen to provide generalization and avoid overfitting the model to the training dataset (Phillips et al. 2006, Peterson et al. 2011). Among these models, we restricted candidate models to those with a delta AICc value of less than 2.0 (Akaike's Information Criteria, Akaike 1974), an area under the curve (AUC) score of at least 0.70 for the test dataset, Continuous Boyce Index (CBI, Boyce et al. 2002) values of at least 0.8, and an average omission rate of the testing dataset at 10% that is approximately 0.1. Any model that met these standards was reviewed for ecological accuracy prior to selection of the final model.

RESULTS

From the three data sources, we retained 896 *M. macroura* occurrence records to build the species distribution model. After removing spatially duplicate records and applying the 10-km spatial thinning, 450 records were used in the final model. These records originated from all six countries where the species is known to occur—United States, Mexico, Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica—and spanned 1971–2025. Occurrence records showed two main clusters, one in southeastern Arizona and another along the Trans-Mexican Volcanic Belt in central Mexico (Figure 4.1).

Our removal of correlated environmental variables in SDMtune (Vignali et al. 2020) resulted in six variables used to create the species distribution model. Among 16 candidate models, the linear–quadratic–hinge model with a 1.5 regularization multiplier ranked highest (Table 4.1; Appendix 4.1). This model had the best delta AICc score and the highest weighted AICc score (0.552; Table 4.1). Although two additional models had delta AICc scores under 2, both had lower weighted AICc scores than the top model, and one required 47 total coefficients—22 more than the selected model.

We additionally used three other metrics to select the final model: AUC, CBI, and omission rate. The top model scored 0.72 AUC on the training dataset and 0.70 on the testing dataset. With the acknowledgment that there is a plethora of issues associated with AUC interpretation (Peterson et al. 2011), these values indicate that the model moderately outperformed a random model, and because the difference between training and testing scores was small, the model was not overparameterized. The top model averaged 0.868 CBI across the validation dataset with a standard deviation of 0.06 across all replicates. These results indicate that average predictions, as well as replicates across each fold, were consistently high in areas of presence and that the model was not overparameterized to the training dataset.

Table 4.1. Model evaluation statistics for area under curve (AUC), Continuous Boyce Index (CBI), omission rate at 10% threshold, Akaike's information criterion (AIC), and number of coefficients per model (*n)*. Test refers to the testing dataset, train refers to the validation dataset, and standard deviation is denoted as (SD).

Feature Class	AUC Test	AUC Train	CBI Train	CBI Test	CBI Test (SD)	Omission Rate (.1)	Omission Rate SD	AICc	Delta AICc	Weighted AIC	*n*
LQH	0.718	0.7	0.969	0.868	0.063	0.103	0.052	10157.2	0	0.55184	25
H	0.718	0.698	0.976	0.87	0.062	0.109	0.059	10159	1.791	0.22537	25
H	0.732	0.703	0.967	0.86	0.077	0.131	0.057	10159	1.82	0.22215	47
LQH	0.712	0.694	0.974	0.862	0.054	0.11	0.061	10171	13.846	0.00054	20
LQH	0.732	0.703	0.963	0.859	0.072	0.129	0.047	10174.5	17.388	~0	53
H	0.71	0.691	0.972	0.85	0.055	0.108	0.057	10180.5	23.308	~0	22
LQH	0.704	0.68	0.976	0.851	0.054	0.112	0.075	10187.7	30.575	~0	17
H	0.703	0.682	0.958	0.816	0.083	0.105	0.059	10191.7	34.519	~0	16
LQ	0.675	0.666	0.917	0.862	0.063	0.116	0.071	10211.6	54.41	~0	10
LQ	0.662	0.654	0.957	0.91	0.058	0.103	0.058	10229.4	72.269	~0	9
LQ	0.659	0.65	0.962	0.901	0.051	0.11	0.061	10235.5	78.352	~0	9
L	0.652	0.646	0.955	0.921	0.027	0.106	0.052	10236.6	79.472	~0	6
L	0.651	0.645	0.954	0.902	0.041	0.106	0.056	10239	81.829	~0	6
L	0.65	0.643	0.945	0.894	0.039	0.106	0.056	10243.2	86.037	~0	6
LQ	0.655	0.645	0.949	0.894	0.063	0.112	0.064	10244.3	87.106	~0	9
L	0.648	0.641	0.945	0.901	0.052	0.102	0.049	10246.5	89.291	~0	5

The average test omission rate at a 10% threshold was calculated across all replicates of the top model. By design, a generalized model should have an omission rate of approximately 0.1 at the 10% threshold; otherwise, the model risks overfitting (Peterson et al. 2011). The average omission rate for our top model was 0.103 with a standard deviation of 0.052 across all replicates (Table 4.1). Collectively, these metrics indicate that the top model was sufficiently generalized, with moderate predictive power without evidence of overfitting.

Of the six WorldClim bioclimatic variables retained in the species distribution model, two represented temperature (annual mean temperature – Bio1; mean diurnal range – Bio2) and four represented precipitation (annual precipitation – Bio12; precipitation of the driest month – Bio14; precipitation seasonality – Bio15; precipitation of the coldest quarter – Bio19). The response to both temperature variables indicated low probability of occurrence at values below 5 °C and peak probability between 10 and 15 °C (Perkins et al. 2025). Broadly, *M. macroura* showed higher predicted occurrence across both temperate and warmer, arid climates, though it

may be excluded from locations with high diurnal temperature variation such as extreme desert environments. Response to annual precipitation peaked near 100 cm, while precipitation of the driest month peaked near 0 cm. Taken together, these responses suggest that *M. macroura* occurrence probability is highest in areas with moderate annual rainfall but strong seasonality, including very dry months, such as upland regions and dry tropical forests, but not in humid subtropical rainforests.

To estimate occurrence probability, the raw Maxent prediction was transformed using a complementary log-log function under a Poisson point process (Phillips et al. 2017), producing raster values ranging from 0 to 1, with higher values indicating greater probability of occurrence. The resultant raster was then expressed across the study area (Figure 4.2). Overall, predictive occurrence was lower across the eastern portion of the range compared to the west, except for the northwesternmost extent along the Bay of California. Although occurrence records were identified in this region, it represents a range extension from Hall (1981). The model predicted lower occurrence across the Mexican Plateau and into the U.S. borderlands, but relatively higher occurrence along both the Sierra Madre Oriental and Sierra Madre Occidental. Within the borderlands, the highest predictive occurrence was concentrated in the northern Sierra Madre Occidental of Sonora, Mexico, and in southeastern Arizona.

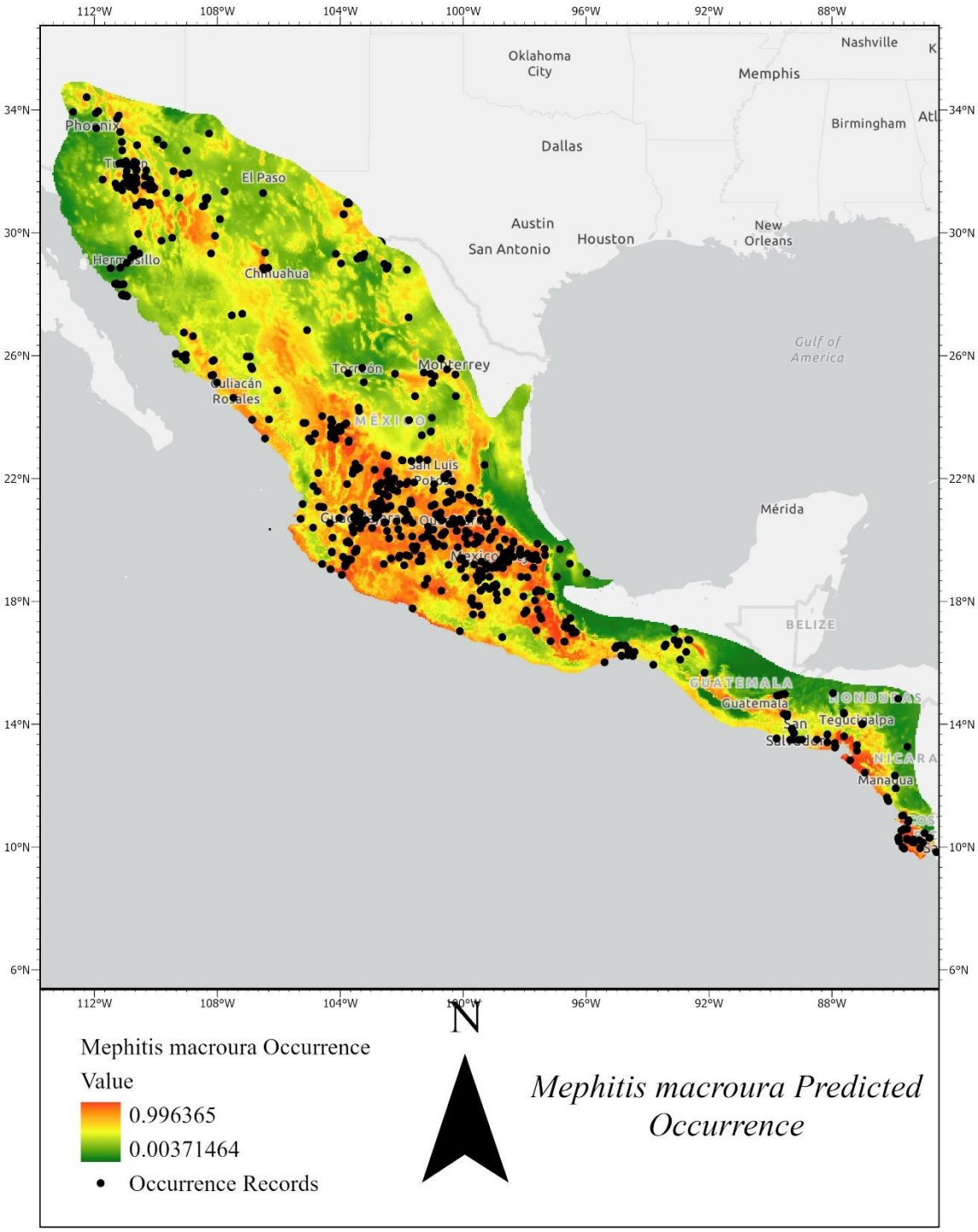


Figure 4.2. Complementary log-log transformed *Mephitis macroura* predictive occurrence probability.

DISCUSSION

We focused our species distribution model on the entire geographic range rather than restricting analyses to Texas or to the *Mephitis macroura milleri* subspecies. This approach was intentional, as regional or subspecies models may overlook important variation that emerges only at broader scales (Peterson et al. 2011). Geographically, *M. macroura* appears limited in eastward expansion across much of its range, likely due to the extent of humid subtropical rainforests. The species also seems restricted northward by decreasing annual temperatures and moderate precipitation during the coldest quarter. While Hass and Dragoo (2017) suggested that the Colorado River served as a barrier to dispersal in Arizona, their habitat suitability maps (Figure 24.1) indicate a decline in suitability that corresponds with latitude.

Across Texas, our model accurately predicted areas of relatively higher occurrence probability where known records exist (Fig. 4.3). While this was to be expected as these occurrence records were used to build the model, only six Texas records, representing 1.3% of the total occurrence dataset, were included. This low observed omission also encompassed historical occurrence locations (e.g., predating 1970) not used to build the model (this-report - Chapter 2). Occurrence records from Balmorhea were located in areas of lower predicted probability (range: 0.36 – 0.38), but these values were not truly low when considered relative to the global output (range: 0.003–0.99). Previous hypotheses suggest that the Balmorhea population may be supported by anthropogenic landscape alteration and resource provisioning (Patton 1974, This report – Chapter 2). Although Reeves County was recently surveyed by camera trap (Hewitt et al. 2022, This report – Chapter 2), *M. macroura* was not detected. To our knowledge, no structured or opportunistic camera trap surveys have been recently conducted or are ongoing on conserved properties in the area (e.g., Balmorhea State Park) that would contribute to local knowledge of the species' presence.

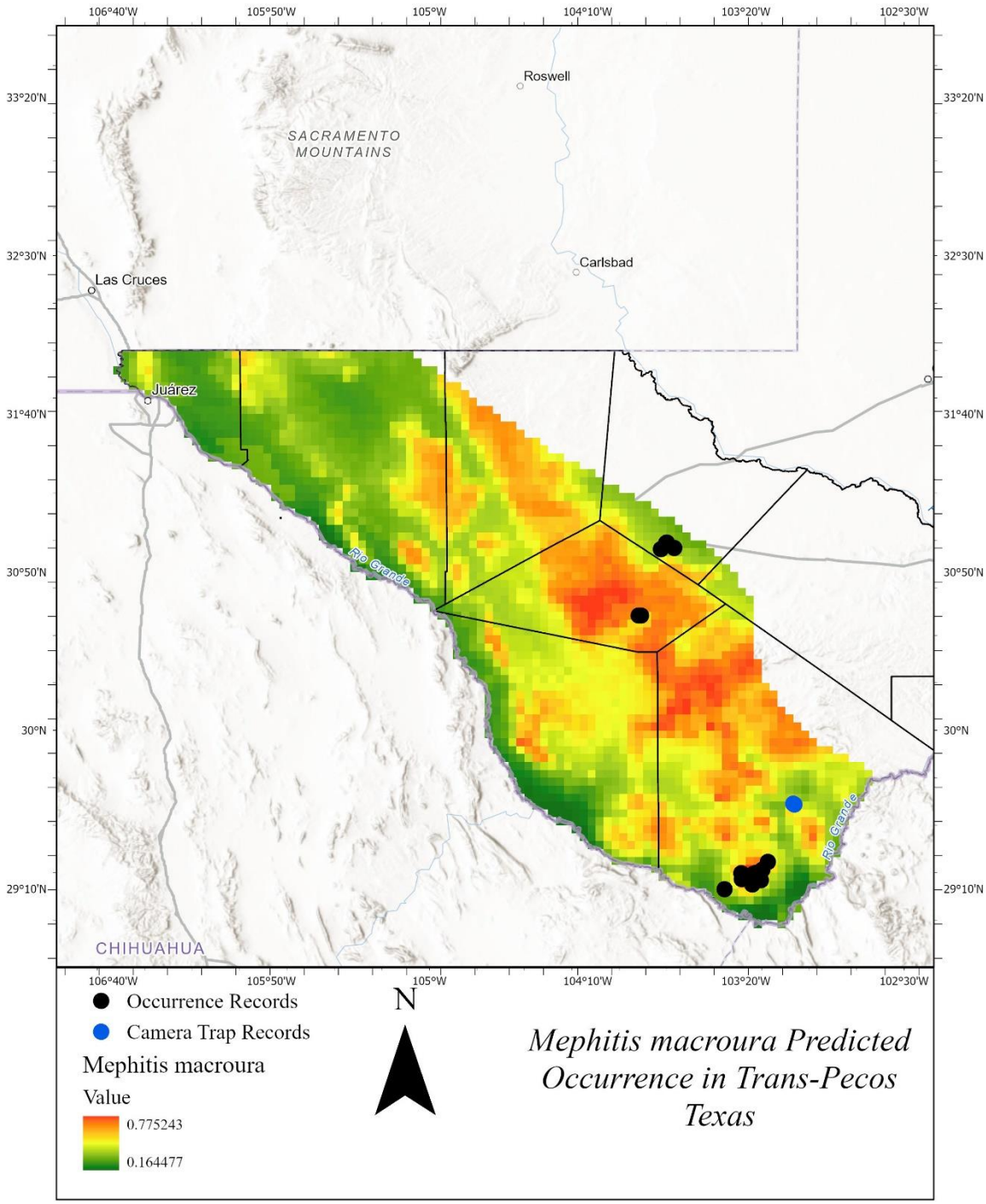


Figure 4.3 Complementary log-log transformed *Mephitis macroura* predictive occurrence probability in Trans-Pecos Texas. Camera trap records (blue) refer to the two *M. macroura* detected within Black Gap Wildlife Management area in 2025.

Distinguishing between genuinely high predicted occurrence and commission errors (false positives) remains challenging. While commission errors are inherent in species distribution models, they are particularly pervasive in overly generalized models (Peterson et al. 2011). Within southern Brewster County, the Chisos Mountains, Northern Rosillos, and the northern extent of the Sierra del Carmens showed moderate predictive probability. The latter two mountain ranges share vegetation types with the Chisos Mountains, where three occurrence records were used in the model (This report – Chapter 2). The two camera trap records from the Sierra del Carmens (This report – Chapter 3) were not used in modeling and not identified until after the SDM was complete (Figure 4.3). Thus, these records confirm model usefulness in identifying locations of previously unknown species presence. Broadly, the locations surveyed by camera trap (This report – Chapter 3) across the Big Bend region exhibited relatively lower predicted occurrence probability (mean: 0.33; range 0.2 – 0.64) with the highest predicted probability falling within the Chisos Mountain foothills. Due to historical and contemporary survey of this area (This report – Chapters 2,3) and the repeated lack of species presence, we propose that these low elevation, basin habitats are not supportive of *M. macroura* and low predicted probability reflects true lack of presence.

Additional areas of interest included moderate predictive occurrence extending north from the Davis Mountains through the Delaware Mountains (Figure 4.3). While species presence here would represent a range extension, we are unaware of any historical or contemporary surveys within this region. The Sierra Diablo Wildlife Management Area is located within this region and should be considered as a potential survey location in the future. The Chinati Mountains also had moderate to high predictive occurrence within Texas. While this region was

recently surveyed by camera trap (Yancey et al. 2019), the survey effort was low. We recommend survey of this region including TPWD's Chinati Mountains State Natural Area.

In Texas, predictive occurrence values ranged from 0.164 to 0.775, with the highest probabilities extending across the broader Davis Mountains region, although most of the Trans-Pecos region was characterized by low to moderate values (Figure 4.3). In the case of the Davis Mountains region, we are confident that these probabilities reflect true suitability, even though only a single record from the region was used in the model (DeBaca 2008, Yancey et al. 2017). Although no confirmed *M. macroura* records have been documented there in the 21st century, the region contained the most records during the 20th century (This report – Chapter 2). Based on both the historical evidence and the predictive outputs of our model, we recommend that future survey efforts to relocate the species in Texas focus on this region.

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