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White-tailed deer doe with the Sierra Azul in the background. Site RG2, 25 December 2016, 1343 hrs.

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Front cover photograph: Female Ocelot (*Leopardus pardalis*) crossing a log over the Río Cocóspera,
Rancho El Aribabi.

Back cover photograph: The narrows in Arroyo Las Palomas, Sierra Azul, Rancho El Aribabi.

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EDITOR'S NOTE

The Mammals of Rancho El Aribabi fills an important gap in the detailed knowledge of the diversity and abundance of the mammals in the Sky Island region of the U.S. and Mexico borderlands. The multiyear camera trapping effort captures a thorough inventory and baseline of this private protected area and conservation ranch in the heart of a migratory corridor that allows movement north and south in the high latitude portion of the Sierra Madre.

I have had the privilege to work with the authors as editor in the publication of this work for the past several years. First, as a future contribution of the Proceedings of the Desert Laboratory of the University of Arizona. In this capacity, I oversaw an external review process with two independent scientific reviewers as well as an editorial review. The authors undertook edits and modifications based on the reviews and submitted an updated manuscript addressing all changes made. Unfortunately, due to my departure from the University and the cessation of the Proceedings of the Desert Laboratory this work was not published in that venue. However, the fully edited and richly illustrated manuscript is presented in its entirety here for broad dissemination via a freely available digital version and on-demand hard copies.

On its own, this work provides careful and important site-specific data on dozens of mammal species that represent a portion of the rich fauna of the Sky Islands. At the regional and international level, linked with other robust camera trapping and observation-based studies, it illuminates continued connectivity across an increasingly fragmented landscape. The importance of protected areas and local leadership as exemplified by the Robles family and Rancho El Aribabi are some of the strongest approaches to lasting conservation. The careful documentation presented here adds another cornerstone to a network of efforts and individuals working to understand and protect the beautiful and wild places of the borderlands.

Benjamin T. Wilder
January 2023

SUMMARY

From 2006 to 2018, we inventoried and studied the ecology of mammals at Rancho El Aribabi, a conservation ranch located in the sky island region of northeastern Sonora about 60 km SSE of Nogales, Sonora/Arizona. The results are based on 4.5 years of camera trapping (2014–2018), small mammal live trapping, mist-netting for bats, a review of previous work in the region, and our visual observations. We documented 36 species of mammals in 20 families. A species accumulation curve suggests that we documented most, or all, of the medium to large wild mammals (20 species) after 2.5 years of camera trapping. One species, the jaguar (*Panthera onca*), was found by others during 2010–2011, but not by us. The North American porcupine (*Erethizon dorsatum*) has not been observed on the ranch for 20–30 years. Our limited surveys of small mammals and bats documented six species of small, terrestrial mammals and eight species of bats. Many other species of small mammals and bats are expected at the ranch based on previous work in the region and we plan to conduct future assessments for their presence. Camera trap images allowed us to study the ecological aspects of medium to large mammals, including among others, breeding chronology, litter size, group size, 24-hour activity patterns, monthly activity patterns, predation and other behaviors, naïve occupancy, and relative abundance. To examine associations of several species with various habitat features and human disturbance, we conducted binary logistic regression modeling for nine taxa: desert cottontail (*Sylvilagus audubonii*), rock squirrel (*Otospermophilus variegatus*), bobcat (*Lynx rufus*), puma (*Puma concolor*), hog-nosed skunk (*Conepatus leuconotus*), hooded skunk (*Mephitis macroura*), ringtail (*Bassariscus astutus*), white-nosed coati (*Nasua narica*), and common raccoon (*Procyon lotor*). At Arroyo Las Palomas in the Sierra Azul, we compared relative abundance of 11 medium to large mammals during periods without cattle versus often heavy cattle use to discern effects of livestock grazing on those species. Livestock had a negative effect on six of those 11 species. We also assessed the potential for competition between hog-nosed and hooded skunks, and bobcats and ocelots (*Leopardus pardalis*). Potential effects of puma on coyote (*Canis latrans*) populations were also examined.

The mammalian fauna of Rancho El Aribabi is similar to that found in other sky islands of northeastern Sonora and southeastern Arizona. In addition, it supports the northern-most known breeding population of ocelots, and relative abundance of other neotropical species, such as white-nosed coati and javelina are greater than in adjacent areas of Arizona. Human presence is less evident than in southeastern Arizona. On the other hand, relative abundance of black bear (*Ursus americanus*) is less than in southeastern Arizona and some ranges in northeastern Sonora. Many camera trap projects are short-term, often to assess density without violating assumptions of deaths, births, immigration, and emigration; however, we found large seasonal and yearly variations in relative abundance of some species that paints a cautionary tale for researchers. Short-term studies can create a snapshot in time that may not represent longer-term averages or variation.

Rancho El Aribabi is a conservation ranch designated as a private Protected Natural Area by the Mexican government. This designation and careful management of the property by the owners, the Robles family, create a safe environment for the mammals of the area. However, re-routing of Mexican Highway 2 through the ranch would fragment habitat and isolate some mammal populations, including that of the ocelot. The effects of climate change may eliminate seasonally important waters in the Sierra Azul and alter vegetation communities. Monitoring these changes within the context of our baseline work and the work of others at Rancho El Aribabi could yield findings important for future conservation actions in the sky island region.

En Español: Desde de 2006 hasta 2018, nosotros hicimos un inventario y estudiamos la ecología de los mamíferos en Rancho El Aribabi, un rancho de conservación localizada en la región de las islas del cielo (Sky Islands) en el noreste de Sonora aproximadamente 60 km al sur/sureste de Nogales, Sonora/Arizona. Los resultados son basados en 4.5 años de usar cámaras trampa (2014 -2018), la capturas en vivo de los mamíferos pequeños, incluyen los murciélagos, una revisión del trabajo anterior en la región, y nuestras observaciones visuales. Nosotros

documentamos 36 especies de mamíferos en 20 familias. Una curva de acumulación de especies sugiere que nosotros documentamos la mayoría, o todos, de los mamíferos silvestres medios hasta grandes (20 especies) después 2.5 años de usar cámaras trampa. Una especie, el jaguar (*Panthera onca*), fue encontrado por otras durante 2010-2011, pero no por nosotros, y otra – el puercoespín norteamericano (*Erethizon dorsatum*) no se ha estado documentado en el Rancho por 20-30 años. Nuestras encuestas limitadas de animales pequeños y murciélagos documentaron seis especies de mamíferos terrestres pequeños, y ocho especies de murciélagos. Es probable que muchas otras especies de mamíferos pequeños y murciélagos están presente en el rancho basado en el trabajo anterior en la región, y nosotros planeamos hacer evaluaciones futuras de su presencia. Las fotos de las cámaras trampa nos permitieron estudiar los aspectos ecológicos de mamíferos medios hasta grandes, incluyendo entre otros, cronología de cría, tamaño de camada, tamaño de grupos, patrones de actividad de 24 horas, depredación y otras conductas, estimación acumulativa (naive) de ocupación, y abundancia relativa. Para examinar las asociaciones de algunas especies con características de varios habitats y con alteraciones de humanos, nosotros usamos un modelado de regresión logística binaria para nueve taxones: conejo del desierto (*Sylvilagus audubonii*), ardillón de las rocas (*Otospermophilus variegatus*), gato montés (*Lynx rufus*), puma (*Puma concolor*), zorrillo de espalda blanca (*Conepatus leuconotus*), zorrillo listado (*Mephitis macroura*), cacomixtle norteño (*Bassariscus astutus*), coatí norteño (*Nasua narica*), y mapache (*Procyon lotor*). En el Arroyo Las Palomas en la Sierra Azul, nosotros comparamos la abundancia relativa de 11 mamíferos medios a grandes durante épocas cuando no hay ganado en contraste a cuando hay pastoreo intensivo para determinar los efectos deganado rozando por en estas especies. Nosotros evaluamos el potencial para la competición entre zorrillo de espalda blanca y zorrillo listado, y gatos montés y ocelotes (*Leopardus pardalis*). También evaluamos los efectos potenciales del puma en las poblaciones de coyotes (*Canis latrans*). La fauna mamífera del Rancho El Aribabi es similar a eso encontrado en otras islas del cielo de noreste de Sonora y sureste de Arizona. Además, se encuentra aquí la población reproductora de ocelotes situado más al norte que es conocida y una abundancia relative de otras especies neotropicales, así como coatí de nariz blanca y pecarí de collar (*Pecari tajuca*) son más numerosas que en áreas adyacentes en Arizona. La presencia humana es menos evidente que en sureste de Arizona. Por otra parte, la abundancia relativa de oso negro (*Ursus americanus*) es menos que en el suroeste de Arizona y algunos rangos en el noreste de Sonora. Muchos proyectos de cámaras trampa son de corto plazo, a menudo para evaluar a la densidad sin violar supuestos de muertes, nacimientos, inmigración y emigración, sin embargo, nosotros encontramos grandes variaciones estacionales y anuales en abundancia relativa de algunas especies que pintan una historia de advertencia para los investigadores. Estudios a corto plazo pueden representar un panorama que no representa promedios a largo plazo o la variación.

Rancho El Aribabi es un rancho de conservación y es designado como un área natural protegida por el gobierno mexicano. Esta designación y gestión cuidadosa de la propiedad por los dueños, la familia Robles, crean un medioambiente seguro para los mamíferos del área. Sin embargo, el desvió de la Carretera Mexicana 2 por el rancho va a fragmentar el hábitat y aislar algunas poblaciones de mamíferos, incluyendo lo del ocelote. Los efectos del cambio climático pueden eliminar aguas estacionales importantes en la Sierra Azul y cambiar comunidades de vegetación. Monitorear estos cambios dentro del contexto de nuestro trabajo de línea de base y el trabajo de otros en Rancho El Aribabi pueden producir hallazgos importantes para acciones futuras de conservación en la región de las islas del cielo.

INTRODUCTION

The documentation of mammals in the Mexican state of Sonora began with a collection of a North American deermouse (*Peromyscus maniculatus*) from "Santa Cruz" by J. H. Clark in 1851. Other minor collections occurred over the next three decades, but it wasn't until the Lumholtz Expedition in 1890, the boundary survey work in 1892–1894 (Mearns 1907), and the work of E. A. Goldman in 1898–1899, that biologists began to understand the diversity of the mammalian fauna of Sonora. Burt (1938) summarized these and other works and listed 94 species of mammals occurring in Sonora. His publication included an annotated checklist with notes on distribution, geographic variation, and natural history. The next significant state-wide treatment was a dissertation by W. Caire (1978) that was reprinted in 2019. Based on his own field work and perusal of 13,000 museum specimens, Caire reported the occurrence of 122 mammalian species in Sonora and hypothesized that another 28 species may occur in the state. His publication included species accounts, lists of localities and museum specimens, and distribution maps. Alvarez-Castañeda and Patton edited the Mamíferos del Noroeste México (Volume 1: 1999, Volume 2: 2000), which detailed the mammals of the states of Baja California, Baja California Sur, Sonora, Sinaloa, and Nayarit. Their treatment included species accounts and shaded distribution maps for all mammals in these states. Castillo-Gámez et al. (2010) listed 126 species of mammals for Sonora, with an additional 35 species that may occur in the state. Ceballos (2014) summarized the mammals of Mexico and presented species accounts and shaded distribution maps for all species, including 128 species in Sonora. That diversity was exceeded only by seven of Mexico's 32 federative entities. For a thorough review of the history of mammal studies in Sonora, refer to Castillo-Gámez et al. (2010).

The "sky island" region of northeastern Sonora, which includes a number of mostly isolated sierras or mountain ranges surrounded by desert grassland, desertscrub, or foothills thornscrub (Warshall 1995), was poorly studied in regard to its mammalian diversity until recently. With the advent of camera trapping - the use of battery-operated motion and infrared triggered remote cameras - our knowledge of Sonoran sky island medium to large mammals (from rock squirrel [*Otospermophilus variegatus*] to American black bear [*Ursus americanus*] in size) has increased dramatically in the last decade (Lara-Diaz et al. 2011, 2013; Avila-Villegas and Lamberton-Moreno 2013; Bermúdez-Enriquez et al. 2013; Bonillas-Monge and Valdez-Coronel 2013; Coronel-Arellano et al. 2016; Gómez-Ramírez et al. 2017; Rorabaugh et al. 2020). However, some of these studies targeted specific species and ignored or deferred to a later date publishing on the medium to large mammal community captured by their camera traps. Sky island biological expeditions hosted by GreaterGood or Sky Island Alliance from 2009 to the present, as well as GreaterGood's camera trap project in the Río Bavispe Valley (Project Wildcat), have also produced many observations of medium to large mammals. Many of the unpublished observations can be found in the Madrean Discovery Expedition (MDE) database (http://www.madreandiscovery.org/).

Small mammals and bats of Sonora's sky island region have rarely been studied. Perusal of Caire's (2019) distribution maps for these groups shows a paucity of records before 1978. Subsequently, little work has been done on these groups, although biologists at the Área de Protección de Flora y Fauna Bavispe conduct some monitoring of bats in the region (Elena-Jiménez et al. 2013).

In this study, using various methods described below from 2006 to 2018, we documented mammalian species occurring at Rancho El Aribabi, a ranch of the sky island region located about 25 km E of Ímuris and 60 km SSE of Nogales, Sonora/Arizona (Figure 1). In the species accounts, we explore aspects of the ecology of these species, including species associations with biotic communities and specific habitat features such as permanent water sources as well as describing interesting natural history anecdotes.

Study Area

Rancho El Aribabi is a 15,700-ha group of cattle-ranching properties situated in northern Sonora, Mexico (Figure 1). Our study area is shown in Figure 2, which encompasses 4046 ha of the ranch that is owned and managed by Carlos Robles Elías.

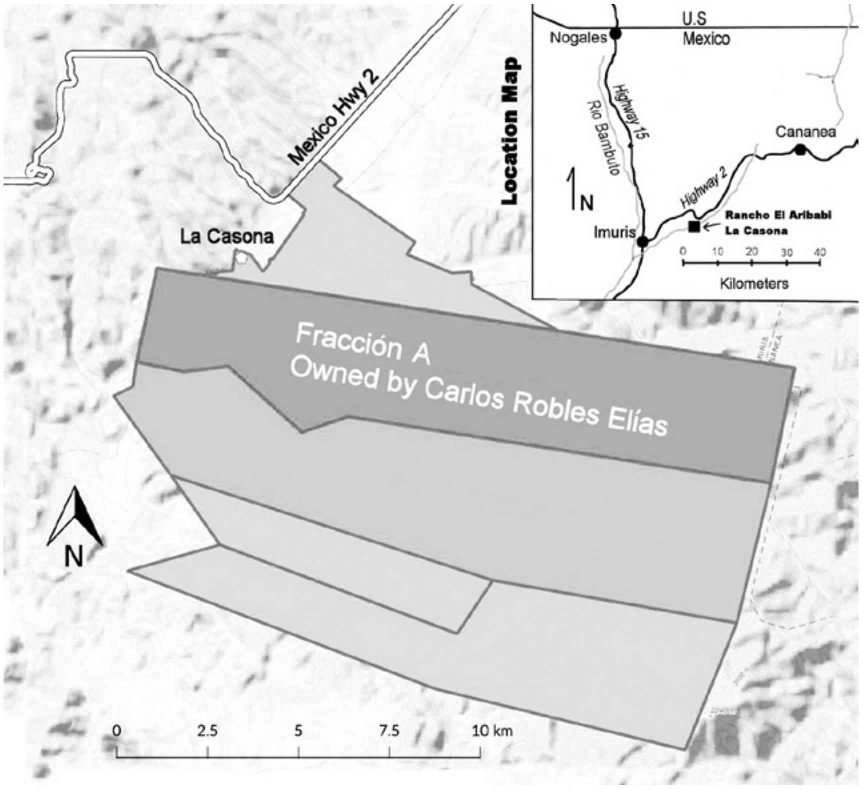

Figure 1. Rancho El Aribabi and its geographical context.

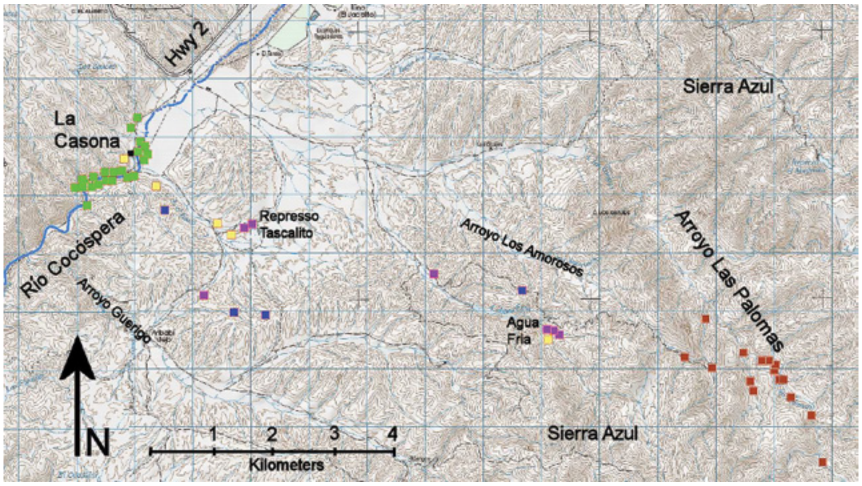

Figure 2. Our study area, place names, and camera locations at Rancho El Aribabi by site type. Green = Río Cocóspera, blue = ridgeline, purple = livestock waters, yellow = upland, rust = Arroyo Las Palomas and tributaries. La Casona headquarters is marked with a black square.

"La Casona", the ranch headquarters (Figure 3), is located 59 km SSE of the USA-Mexico border at Nogales, Sonora-Arizona. The study area includes the lower western slopes of the Sierra Azul and the eastern and southern lower slopes of the Sierra Los Pinitos. The Río Cocóspera, with a perennial reach that begins in a large ciénega (spring-fed wetland) adjacent to La Casona, runs through a river canyon between the Sierras Azul, Los Pinitos, and de la Madera and joins with the Río Bambuto to become the Río Magdalena just south of Ímuris. The river channel below La Casona carries a perennial flow that measures, on average, about 4 meters across and 0.3 meters in depth. Elevations in the study area extend from about 960 to 2000 m and the terrain is largely mountainous or rolling bajadas (alluvial fans at the base of mountains). Monthly average temperature in nearby Ímuris varies from a low of 14.2° C in December or January to 33.7° C in June. Temperatures are rarely above 41° C or below -0.6° C. Mean annual precipitation at Ímuris is about 407 mm with most rain falling from June through September, with a secondary peak from November to March and a dry period from April until the summer rains begin in June (Turner and Brown 1982, https://www.worldweatheronline.com/imuris-weather/sonora/mx.aspx). Rancho El Aribabi, which is at higher elevations, is likely slightly cooler and wetter than Ímuris, which sits at 867 meters elevation. Snow occasionally falls in the Sierra Azul and even at La Casona. The Río Cocóspera canyon below La Casona receives cool air off of the Sierra Los Pinitos and can be surprisingly cold in winter. We recorded a low of -5.6° C at La Casona in November 2016.

The primary land use in the study area and in this region of Sonora is cattle ranching. A system of cattle tanks, pipelines, and troughs provide water for livestock; pasture fences are maintained to manage grazing; and unpaved albeit rough roads provide access to much of the property. During inclement weather, some roads become impassable. Carlos Robles Elías primarily leases his rangeland for grazing by steers that typically spend about a year on the ranch before being rounded up and trucked off the ranch. The owners, the Robles family, have devoted numerous efforts to promote conservation of the ranch's ecosystems. In 2011, fracciones A and B of the ranch were designated a Protected Natural Area (Area Destined Voluntarily for Conservation) by the federal Mexican agency, CONANP (Comisión Nacional de Áreas Naturales Protegidas). This is the highest designation of environmental protection conferred by the Mexican government on private lands. Section A (Figure 1), owned and managed by Carlos Robles Elías, includes the Río Cocóspera canyon and extends eastward into the Sierra Azul to include Las Palomas and much of its watershed, an area where ocelots and jaguars (*Panthera onca*), among other species, were documented by Avila-Villegas and Lamberton-Moreno (2013) during a camera-trap project from 2007 to 2011. The Río Cocóspera and Las Palomas are included in a conservation zone with voluntary restrictions on human uses; limited cattle grazing and game hunting are allowed. The Robles family leads guided trophy white-tailed deer (*Odocoileus virginianus*) hunts during the winter months.


Figure 3. La Casona, the ranch headquarters, looking southeast across the Río Cocóspera to the Sierra Azul in the distance.

Biotic communities include a Sonoran desertscrub-foothills thornscrub ecotone at the lowest elevations and on south-facing slopes, upslope through velvet mesquite grasslands or semidesert grasslands, Madrean oak woodlands and savanna, and pine-oak forests at the highest elevations in the Sierra Azul (Brown and Lowe 1994; Felger et al. 2001; Figure 4a-k). Although the vegetation communities of the study area have not been formally mapped, we estimate the following percentages of land area on the ranch by vegetation community: oak woodlands and savanna (with small amounts of pine-oak woodland, 50%), semidesert or velvet mesquite grasslands (30%), and Sonoran desertscrub-foothills thornscrub ecotone (17%). The small percentage remaining is riparian woodland, primarily along the Río Cocóspera, composed mainly of Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), and velvet mesquite (*Prosopis velutina*). Our estimates are based on Google Earth imagery and on-the-ground reconnaissance. In the following paragraphs, we describe the floristic characters of these vegetation communities. In 2009 and 2011, Sánchez-Escalante et al. (2013) compiled a list of plants occurring at Rancho El Aribabi, which included 454 species in 87 families. The authors have recently updated that list, which now includes 467 species in 84 families: https://herbanwmex.net/portal/checklists/checklist.php?clid=3370&emode=0.

Sonoran Desertscrub-Foothills Thornscrub Ecotone. We describe this as an ecotone because it lacks species typical of Sonoran desertscrub, such as creosote (*Larrea tridentata*) and bursages (*Ambrosia dumosa* or *A. deltoidea*), but also lacks visually dominant plants of foothills thornscrub, such as tree ocotillo (*Fouquieria macdougalii*), elephant trees (*Bursera* spp.), and columnar cacti other than saguaro (*Carnegiea gigantea*). Organ pipe cactus (*Stenotherus thurberi*) is present in this community but very rare at Rancho El Aribabi. Instead, we find a mix of Sonoran desertscrub and foothills thornscrub species; those representative of the latter vegetation community are relatively frost-tolerant. This strongly drought-deciduous plant community is found on mostly south-facing slopes along the Río Cocóspera and on the bajada and foothills of the Sierra Azul to an elevation of about 1310 m where it is replaced by oak woodland and savanna or velvet mesquite grassland. This community is illustrated on a south-facing slope in the Río Cocóspera canyon (Figure 4a) and in the foothills of the Sierra Azul (Figure 4b).

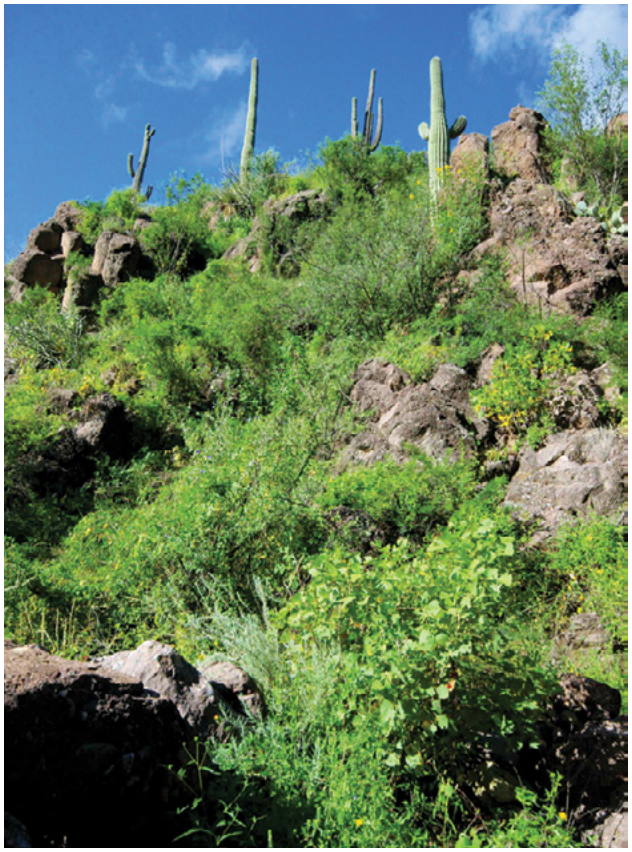

Figure 4a. Sonoran desertscrub-foothills thornscrub ecotone, south-facing slope of the Río Cocóspera canyon downstream of La Casona. 23 September 2006.

Figure 4b. Sonoran desertscrub-foothills thornscrub ecotone in the lower foothills of the Sierra Azul. 14 August 2007.

Figure 4a shows this ecotone plant community in late September, 2006. It is still quite green and lush from abundant rainfall during the summer rainy season. Saguaros, common sotol (*Dasylirion wheeleri*), Thurber's cholla (*Cylindropuntia thurberi*), and Goodding's ash (*Fraxinus gooddingii*) can be seen at or near the ridgeline. In the foreground are hopbush (*Dodonea viscosa*), featherbush (*Lysiloma watsonii*), and coralbean (*Erythrina flabelliformis*) among others. Additional plants in this scene are brittlebush (*Encelia farinosa*), kidneywood (*Eysenhardtia orthocarpa*), and canyon morning-glory (*Ipomoea barbatisepala*). Figure 4b shows ocotillo (*Fouquieria splendens*), a saguaro, abundant velvetpod mimosa (*Mimosa dysocarpa*), featherbush, hopbush, velvet mesquite, and Thurber's cholla. That picture was taken on 14 August 2007.

Velvet Mesquite Grasslands. This is "desert grassland" or "semidesert grassland" as described by Felger et al. (2001) and Brown and Makings (2014), but we add "velvet mesquite" to the designation because grasslands at Rancho El Aribabi always have variable numbers of these leguminous trees intermingled with the grasses. Native grasses are diverse, with at least eight species of grama grass (*Bouteloua* spp.), three species of lovegrass (*Eragrostis* spp.), three muhlies (*Muhlenbergia* spp.), and two species each of threeawns (*Aristida* spp.), tangleheads (*Heteropogon* spp.), switchgrasses (*Panicum* spp.), and foxtails (*Setaria* spp.). These are primarily warm season grasses, so in summer this vegetation community is quite green but is brown or yellow-brown in winter when the grasses are dormant. Arroyos through these grasslands are typically grown over with velvet mesquite, although at the lower elevations, tall specimens of Mexican ebony (*Havardia mexicana*) extend above the canopies of the mesquites. Velvet mesquite grasslands occur from about 1000 m elevation on north-facing slopes to about 1700 m on south-facing slopes. On lower elevation, north-facing slopes along the Río Cocóspera, velvet mesquite can reach densities approaching a bosque, but in the mountains it may be quite sparse and is often found with ocotillo, which can be abundant in places. At the higher elevations, velvet mesquite is gradually replaced with oaks as the community transitions to oak savanna or woodland.

Figure 4c. Velvet mesquite grassland, foothills of the Sierra Azul with the Sierras de la Madera (left) and los Pinitos (right) in the background. 14 October 2006.

Figure 4d. A mosaic of vegetation communities, with velvet mesquite grassland in the lower right, Sonoran desertscrub-foothills thornscrub ecotone in the lower-middle left, and oak woodland and savanna in the mountains in the background. 8 August 2007.

Figure 4c illustrates velvet mesquite grassland in the foothills of the Sierra Azul with a view of the Sierra de la Madera to the southwest. Numerous, small velvet mesquites can be seen amidst the grasses. The picture was taken 14 October 2006 when the grasses were dormant. Figure 4d shows three vegetation communities in the foothills of the Sierra Azul, including velvet mesquite grassland with ocotillo on the right, Sonoran desertscrub-foothills thornscrub ecotone on the left, and oak woodland and savanna on the higher slopes in the background. Grasses, shrubs, and trees are green as this picture was taken in August during the summer rainy season.

Oak Woodland and Savanna. This community is visually dominated by at least five species of Sierra Madrean oaks, including Arizona white oak (*Quercus arizonica*), Emory oak (*Q. emoryi*), gray oak (*Q. grisea*), Mexican blue oak (*Q. oblongifolia*), and Toumey oak (*Q. toumeyi*). Also present are junipers (*Juniperus arizonica* and *J. deppeana*), Arizona madrone (*Arbutus arizonica*), and velvet mesquite. Grasses are common, including many of the species listed above for velvet mesquite grasslands. Oaks occur as individual trees to elevations below 1000 m along the Río Cocóspera and elsewhere, but they only form a community as defined here above about 1300 m. Oak woodlands are most likely to occur on north-facing slopes. In the species accounts, we often refer to montane arroyos, which include Arroyo Las Palomas (Las Palomas hereafter, except when referring to a camera site name, in which case the acronym ALP is used) and its tributaries in the Sierra Azul that typically flow through oak woodlands or savanna. These arroyos host mostly ephemeral flow, but perennial pools occur in places, and groundwater is high enough to support some riparian trees such as Arizona sycamore (*Platanus wrightii*), Fremont cottonwood, Goodding willow (*Salix gooddingii*), and Arizona ash (*Fraxinus velutina*). Riparian trees are typically spaced out along the arroyo rather than forming dense stands such as along perennial reaches of the Río Cocóspera. Also in the species accounts, we sometimes refer to oak-velvet mesquite woodland or savanna, which is an ecotone between oak woodland or savanna and velvet mesquite grassland.

Figure 4e shows an arroyo through oak woodland in the Sierra Azul. Taken in August 2007, it illustrates the greenup associated with the summer rainy season. The predominant oak is Mexican blue oak. The slope on the left is south-facing and has velvet mesquite grassland and Sonoran desertscrub-foothills thornscrub ecotone species mixed in. On that slope, coralbean, Palmer's agave (*Agave palmeri*), common sotol, and velvet mesquite can be seen. On the right, under the oak, is a profusion of summer herbaceous plants.

Figure 4f shows an oak savanna in the Sierra Azul. Mexican blue oaks are in the foreground with an abundance of annual and perennial grasses. Common sotol and beargrass (*Nolina microcarpa*) occur on the right side of the frame. The picture was taken 11 July 2015 at 1410 m; the distant peaks rise to about 1800 m.

Figure 4e. Oak woodland, Sierra Azul. 10 August 2007.

Figure 4f. Oak savanna above Arroyo Las Palomas, Sierra Azul. 11 July 2015.

Pine-oak Woodland. This vegetation community occurs above oak woodlands and savanna, primarily in the two sections or "fracciones" of Rancho El Aribabi to the south of our study area and on the eastern edges of those fracciones in the Sierra Azul where elevations rise to about 2000 m. In section A (our study area) a few pines are found mixed with oaks on the hills above the upper reaches of Las Palomas. Pine-oak woodland occurs primarily in drainage bottoms and north-facing slopes at Rancho El Aribabi. Due to poor access, we did not work in this vegetation community. Apache pine (*Pinus engelmannii*) and Chihuahua pine (*Pinus leiophylla*), and possibly Arizona pine (*Pinus arizonica*) occur in these woodlands mixed in with other species typical of oak woodland and savanna. Figure 4g illustrates this community in the Sierra Azul of Rancho El Aribabi during the winter. A pine forest can be seen from La Casona with binoculars atop the Sierra Azul, which is southeast of the ranch boundary at about 2400 m.

Figure 4g. Pine-oak woodland in the Sierra Azul. 19 December 2020.

Riparian Woodland and Ciénega. This vegetation community is best-developed along the perennial reach of the Río Cocóspera downstream of La Casona. But it is also found in Arroyo Guerigo, a large tributary to the Río Cocóspera (see Figure 2), and in ephemeral reaches of the river upstream of La Casona. Two terraces along the river support vastly different plant assemblages. In the floodplain terrace, which regularly receives overbank flooding from the active river channel, Fremont cottonwood and Goodding willow are the visually and numerically dominant trees and form a multi-storied gallery forest as tall as 25 m. However, other willows (*S. bonplandiana, S. exigua,* and *S. exilifolia*), occasional Arizona sycamores, Arizona ash, and Arizona walnut (*Juglans major*) also occur in the floodplain terrace. A ciénega where the perennial flow of the Río Cocóspera originates is located just east of La Casona along the river corridor and probably extends over about 1.0 ha in which the ground is wet and plants are adapted to saturated or nearly saturated soils. Deep, quiet pools where much of the flow originates can be found about 90 m east of La Casona. Plants common in the ciénega include yerba mansa (*Anemopsis californica*), rough horsetail (*Equisetum hyemale*), sand spikerush (*Eleocharis montevidensis*), miner's lettuce (*Claytonia perfoliata*), and silver-sheath knotweed (*Polygonum argyrocoleon*). Huachuca water umbel (*Lilaeopsis shaffneriana* var. *recurva*), listed as endangered in the USA, occurs in the ciénega as well as downstream along the river. Goodding willow forms an overstory in the ciénega.

Velvet mesquites form bosques on a secondary terrace above the river that floods infrequently or not at all. Velvet mesquites along the Río Cocóspera can be quite tall (15+ m) with trunks nearly a meter in diameter at the base. In many places, netleaf hackberry (*Celtis reticulata*) is intermingled with velvet mesquite.

The understory throughout the riparian woodland community becomes full of herbaceous plants, grasses, and vines during the summer rainy season. Canyon grape (*Vitis arizonica*) twine through the trees and ball moss (*Tillandsia recurvata*) is present in the Río Cocóspera canyon below La Casona, often clinging to the trunks of netleaf hackberry. Figure 4h shows the floodplain terrace along the Río Cocóspera, whereas the secondary terrace communities are illustrated in Figure 4i - velvet mesquite bosque, and Figure 4j - velvet mesquite-netleaf hackberry woodland. The ciénega is shown in Figure 4k.

Figure 4h. Fremont cottonwood-Goodding willow riparian forest on the Río Cocóspera. 20 June 2007.

Figure 4i. Velvet mesquite bosque adjacent to the Río Cocóspera. 22 November 2011.

Figure 4j. Velvet mesquite-netleaf hackberry woodland adjacent to the Río Cocóspera. 30 August 2014.

*Figure 4k. In the Río Cocóspera ciénega. The large leafy plants are a dock (*Rumex *sp). Also in the picture are miner's lettuce (*Claytonia perfoliata*), sand spikerush (*Eleocharis montevidensis*), Goodding willow (*Salix gooddingii*), and various grasses, among others. 7 April 2014.*

Surveys for Medium to Large Mammals

Placement and Operation of Camera Traps

To document medium to large mammals, we placed camera traps at 50 sites in the study area (Figure 2, Table 1, Appendix 1) from July 2014 to December 2018. Cameras of a variety of manufacturers and capabilities were employed. We used primarily Stealthcam cameras with infrared night flash, but also employed Scoutguard, Cuddeback, and Moultrie white-flash cameras, as well as other infrared-flash cameras, including Bushnell, Moultrie, Reconyx, and Wildview. All cameras were set to record three images per trigger, followed by a 30-second delay before the camera could be triggered again. For short periods of time, three cameras were set on video mode. Cameras were not set in pairs, a strategy often used to photograph both sides of a spotted cat to enhance identification of individuals (Karanth et al. 2004). We used no bait, scents, or other attractants at our camera sites.

We did not randomize camera locations or set them in a grid. Rather, cameras were positioned mostly on trees or large shrubs and aimed at animal trails, roads, ridgelines, log crossings of the Río Cocóspera, and water sources that we anticipated would be frequented by medium to large wild mammals (Figure 5). For data analysis we grouped cameras by site type (riparian woodland on the Río Cocóspera, ridgeline, livestock water source [earthen cattle tank or trough], upland bajada, or Las Palomas and its tributaries in the Sierra Azul; Table 1, Figure 2). These site types also sort out fairly well into discrete vegetation community types (Table 1). Cameras were checked about every three months, except cameras deep into the Sierra Azul were loaded with lithium-ion, long-lasting batteries and checked every six months due to difficult access. All images obtained were reviewed and catalogued. If wildlife was photographed, we noted species, group size, behavior, time, and date. We grouped images into events, defined as a series of images of the same species with

Table 1. Camera site type and numbers, site descriptions, and medium to large mammal events.

Camera Site Type	# Cameras	# Camera Days	# Medium to Large Mammal Events	# Events/Camera Day	Macro Vegetation Community and Terrain
Río Cocóspera	22	9220	5018	0.544	Riparian forest, perennial stream
Ridgeline[1]	4	919	979	1.065	Tops of ridges in velvet mesquite grassland
Livestock water	7	2752	838	0.306	Velvet mesquite grassland, montane or bajadas
Upland	5	940	426	0.453	Velvet mesquite grassland, montane or bajadas
Arroyo Las Palomas and tributaries	12	7693	2846	0.370	Oak or oak-velvet mesquite savanna, montane, ephemeral to perennial stream

[1] These sites were either on unpaved roads (RG1 and 2) or immediately adjacent to unpaved roads (RG3 and 4)

no gaps between observations of more than 15 minutes (Rorabaugh et al. 2020). Our intent was to group images into independent animal events that consisted of an animal or group of animals that visited the area framed by a camera, then left for at least 15 minutes or was replaced in the camera's view by other individuals. Wildlife species other than medium to large mammals were noted as incidentals. Anthropogenic influences (people, dogs, horseback riders, horses, cattle, burros, and vehicles) were tallied by number of events, maximum group size in an event, and time in minutes of each event.

Figure 5. Placement of a camera trap by Timothy Flood in Arroyo Las Palomas.

Interpreting Camera Trap Data

Over the last two decades, camera traps have revolutionized the monitoring and study of medium to large mammals much as radio-telemetry did beginning in the 1960s (Boitani 2016; Rovero and Zimmermann 2016a). Commercially available wildlife cameras are designed primarily for hunters to monitor game animals at distances of about 3–20 m. Most use a passive infrared (PIR) sensor to detect animals based on a differential in heat and motion between a subject and the background. Once detected, most cameras take one or more still photographs or a video clip. Night images are illuminated with a white (LED or Xenon) or infrared (IR) flash.

Camera models differ in their capability to detect mammals and portray them with detailed images. Technical aspects, such as trigger speed, detection zone, field of view, recovery time until the next picture can be taken, and resolution vary and can be important in capturing an animal in an image with enough clarity and proper exposure to determine the species (Trolliet et al. 2014). Cameras with white flash take color night images with better clarity than cameras with IR flash, making it easier to distinguish between individuals or to determine gender; however, some animals may avoid or be scared away from white flash (Wegge et al. 2004).

Camera traps can be used to determine occupancy, density, home range, and various behaviors, such as feeding, reproduction, territoriality, and social interactions (Trolliet et al. 2014; Rovero and Zimmermann 2016b). However, density and home range estimates require identification of individuals, as does analysis of some types of behavior. For many mammalian species, individuals are difficult to distinguish on camera trap images. Spotted cats, such as ocelots and jaguars that possess distinctive, individual pelages, are an exception and lend themselves well to population studies (Culver 2016; Rorabaugh et al. 2020). In this study, we did not attempt to distinguish between individuals or determine gender. Although we used a number of camera models and makes, some with white flash and others with IR flash, all were capable of producing images adequate to determine the species photographed. That said, animals were sometimes too far away, blurred, or only a portion of the animal may have been captured in the photo. Such problems resulted in 185 events (1.1% of all events) in which the species could not be determined. In addition, and as discussed in the species accounts, some species, such as hooded skunk (*Mephitis macroura*) and hog-nosed skunk (*Conepatus leuconotus*), are similar in appearance, and in 43 events we could not tell which skunk species had been photographed (Table 2).

Table 2. Camera trap statistics for medium to large wild mammals and anthropogenic influences captured at our 50 camera trap sites by species/ type and ordered by number of events.

Wildlfie					
Wildlife Species	Events	Images	Camera Sites	Camera Days/ Events (all sites)	Camera Days/ Event (only sites where species were photographed
Odocoileus virginianus, White-tailed Deer	3841	15811	45	5.6	5.5
Pecari tajacu, Javelina	202	9099	43	10.7	10.2
Nasua narica, White-nosed Coati	781	3522	33	27.6	25.3
Canis latrans, Coyote	734	1890	37	29.3	26.0
Urocyon cinereoargenteus, Gray Fox	537	1132	39	40.1	34.5
Puma concolor, Puma	446	1270	35	48.3	44.2
Otospermophilus variegatus, Rock Squirrel	324	676	20	66.4	40.3
Lepus alleni, Antelope Jackrabbit	269	647	9	80.0	8.5
Sylvilagus audubonii, Desert Cottontail	245	478	15	87.9	29.6
Lynx rufus, Bobcat	198	506	32	108.7	76.3
Unidentified	185	288	37	116.3	107.4
Bassariscus astutus, Ringtail	150	247	19	143.5	66.3
Conepatus leuconotus, Hog-nosed Skunk	110	271	21	195.7	112.8
Leopardus pardalis, Ocelot	91	215	19	236.5	125
Mephitis macroura, Hooded Skunk	78	224	18	275.9	114.9
Procyon lotor, Common Raccoon	67	164	16	321.3	135.7

Table 2. (continued) Camera trap statistics for medium to large wild mammals and anthropogenic influences captured at our 50 camera trap sites by species/type and ordered by number of events.

Sciurus arizonensis, Arizona Gray Squirrel	47	138	7	458.0	67.8
Hooded or Hog-nosed Skunk	43	75	18	500.6	246.6
Didelphis virginiana, Virginia Opossum	20	49	8	1076.2	305.2
Ursus americanus, Black Bear	17	50	5	1266.1	238.7
Taxidea taxus, American Badger	11	24	6	1956.7	425.7
Spilogale gracilis, Western Spotted Skunk	3	8	3	7174.7	336.3

Anthropogenic Influences		
Type	Events	Camera Sites
Bos taurus, Cow	5557	43
Equus caballus & *Homo sapiens*, Horse and Rider	337	35
Vehicle	278	12
Canis lupus familiaris, Dog	178	30
Equus caballus, Horse	135	15
Equus africanus, Wild Burro	4	3

Distribution and density of camera traps in a study area affect the ability to make inferences or to draw broad conclusions from the results. Researchers often distribute cameras randomly or in a grid to obtain representative samples of their study area. However, cameras set along animal trails, at waters, on ridgelines, and other places animals frequent will be more productive. This sort of opportunistic sampling regime, which was employed in this study, is typically adequate and affordable for faunal surveys but less desirable for studies of home range, density, and other population parameters (Williams et al. 2002; Rovero and Spitale 2016a). To counter some of the problems of opportunistic camera placement, we stratified our sampling to some degree, in that we placed cameras in all the vegetation communities on Rancho El Aribabi (except pine-oak woodland) and the various types of terrain and sites (e.g. Sierra Azul, the bajada, the river corridor, cattle waters, ridgelines, animal trails, and roads). Our camera trap project also ran for 4.5 years, which overcomes problems associated with short-term studies, including seasonal or yearly changes in detectability and activity patterns, not detecting rare species, and underestimating occupancy (Rovero and Spitale 2016a&b).

Naïve occupancy is defined as the proportion of camera sites where a species was detected relative to the total number of camera sites (Rovero and Spitale 2016). That proportion ranges from 0 to 1. For instance, the puma was photographed at 35 of 50 camera sites (Table 2), so naïve occupancy for that species is 35/50 = 0.7. It is a measure of the distribution of a species across the area covered by the cameras. Naïve occupancy usually underestimates true occupancy because the species is likely present at some camera sites but was never photographed by those cameras (MacKenzie et al. 2002). This sort of detection error is reduced but not eliminated by running the cameras for long periods of time.

We used a 15-minute interval to define an independent animal event. Independent event intervals are often defined as 30 to 60 minutes in camera trap studies (Culver 2016; Rovero and Spitale 2016), although some have used intervals as long as 24 hrs (Coronel-Arellano et al. 2016). Longer event intervals will maximize independence of events while sacrificing sample size or numbers of events. However, researchers rarely evaluate their data to optimize event independence and sample sizes. In a study of mammals in a suburban landscape, Kays and Parsons (2014) evaluated the temporal autocorrelation of detections for each species-camera combination and determined that an event interval of 1 minute produced independent events. Our use of a 15-minute interval is consistent with Rorabaugh et al (2020). Perusal of ocelot data from that study shows that ocelots spent up to 14 minutes in front of cameras (an event) but in 136 events, defined with the 15-minute interval, no additional ocelots were detected for more than an hour. So, use of a 15, 30, or 60-minute interval would produce the same number of events. But this is not true of all species detected by our cameras. A sampling of white-tailed deer images from May through August 2017 showed that 100 events using the 15-minute interval would have resulted in 89 and 88 events with 30 and 60 minute intervals, respectively. Using the same data, 100 javelina events using the 15-minute interval would have resulted in 95 and 93 events with 30 and 60 minute intervals, respectively. However, for the gray fox, 100 events using the 15-minute interval would produce 99 events with the 30 and 60-minute intervals. For the bobcat, 100 events were tallied whether a 15, 30, or 60-minute interval is employed. Rarer species and carnivores, in particular, tended to be moving through the camera's view and rarely lingered, whereas common gregarious species, such as white-tailed deer, javelina, and white-nosed coati often spent time foraging or lounging in front of the cameras. It is likely that use of a 15-minute event interval overestimated to a small degree the relative abundance of these species. We estimate that error was much less or non-existant for other species.

Camera trapping rate, or the mean number of camera days per species event, provides a rough estimate of relative abundance, with larger numbers indicating lower abundance and smaller numbers indicating greater abundance (O'Brien 2011). For 15 species in the species accounts, we present mean camera days per event by camera site type (riverine, upland, ridgeline, cattle water, tributaries to Las Palomas, and Las Palomas) to compare relative abundance among those types. In Table 2, we present the camera trapping rate for all the camera sites and also for only those sites where a species was photographed. The former provides relative abundance estimates for the study area, whereas the latter estimates relative abundance at those camera sites and subsets of the study area in which a species was documented. Some species, such as the antelope jackrabbit (*Lepus alleni*), were moderately abundant over the study area, but commonly photographed in the habitats and camera sites they frequented.

These relative abundance estimates are affected by factors unrelated to animal abundance, such as time and space-related factors, body size, daily range, trail use, and behavior (Rovero and Spitale 2016b). For instance, the Arizona gray squirrel (*Sciurus arizonensis*) has a relatively small body size and is largely arboreal. Animals with small body size are less likely to be detected by camera traps, particularly if they are far from the camera. Our cameras were not set to detect and photograph animals up in the canopy of trees, further reducing the likelihood that we would photograph the Arizona gray squirrel. That said, because these biases are fixed, changes in the camera trapping rate over time or among site types may indicate real differences in relative abundance. As our data reveal, camera trapping rate varied for some species monthly and annually, so drawing conclusions about relative abundance based on short-term studies is problematic.

In the species accounts, we quantify the percentage of events in which the discussed species crossed a log spanning the Río Cocóspera. This can be considered an index to the species' ability for arboreal activity and or an aversion to wading or swimming across the river. For example, javelina (*Pecari tajacu*) and white-tailed deer (*Odocoileus virginianus*), the two most commonly photographed species, were never photographed crossing over the river on a log, but we regularly photographed them wading in or crossing the river. In contrast, 57% of Arizona gray squirrel events were of animals traversing a log over the river.

Habitat Characterization at Camera Sites

Vegetation, terrain, elevation, and straight-line distances to the nearest permanent water, unpaved road, paved road (Highway 2), human habitation, and a vegetation community that included Fremont cottonwood, Goodding willow, or Arizona sycamore, were calculated for each of the fifty camera sites. Vegetation community at each camera site was characterized at the macro level (biotic community: riparian woodland, Sonoran desertscrub-foothills thornscrub ecotone, velvet mesquite grassland, or oak savanna with scattered riparian trees), and site-specific level (line-intercept transects [Bonham 1989]). Site-specific vegetation measurements included two transects that began at the focal point of the camera and extended for 10 m from that focal point along randomly-selected compass directions. Percent cover of each plant species or barren ground along the transects was measured in three vertical strata: ground cover (< 0.3 m), shrub layer (0.3-1.8 m), and canopy (> 1.8 m). Cover for each plant species was measured using distance of intercepts along the transect and then summed over all species and divided by the transect length (10 m) to determine percent cover, which sometimes exceeded 100% because of overlapping canopies. Our transects were run in May 2018. May is during the dry season at Rancho El Aribabi. If measurements had been taken in August or September toward the end of the rainy season, percent cover at $\leq$ 1.8 m would have been greater, and perhaps much greater due to seasonal growth of herbaceous plants. Canopy cover (> 1.8 m) probably would have remained the same or similar.

Activity Patterns and Relationships of Mammals with Habitat Variables

To determine 24-hr activity cycles, we tallied and graphed counts of events in each hour of the day for species. We also tallied counts of events by species for each month of the year. But those tallies were adjusted to reflect events per unit effort by dividing them by the total number of camera days in the target month and then multiplying the resulting figure by 100. Both 24-hr activity cycles and monthly adjusted events are presented in detail for species with at least 45 events over the course of the study. Selection of 45 events as a threshold was arbitrary, but we wanted a sample size large enough so that there was the potential for at least one observation in each hour of the day. Larger sample sizes better characterize hourly and monthly activity.

For species with adequate camera trap sample sizes ($\geq$ 60 events) we calculated the mean number of camera days per event over the course of the study in each of the camera site types (riparian, upland, ridgeline, cattle water, Las Palomas, and tributaries to Las Palomas). The resulting numbers provide a measure of relative abundance in those site types (see Interpreting Camera Trap Data above). The 60 event threshold was selected so there was a potential for at least 10 events in each site type, if the relative abundance of a species exhibited no difference among those types. Larger sample sizes reduce sampling error and result in better relative abundance estimates.

Organisms are not randomly distributed on the landscape; rather, they distribute themselves according to physiological needs, distribution of necessary resources, intra- and interspecific interactions, evolutionary history, and a variety of other biotic and abiotic habitat variables (Pianka 1978; May 1984). The field of ecology attempts to unravel and quantify these relationships. To explore the relationship between habitat variables and medium to large mammal presence or absence at Rancho El Aribabi, we conducted binary logistic regression modeling for species with 60 or more events, at least 10 camera sites where the species was photographed, and 10 where it was not photographed. Camera sites where the species was not found were removed from the analysis if the camera was not operated for a number of days that equaled or exceeded the mean number of days necessary to obtain an image of the target species at camera sites where the species was photographed. This practice reduces errors associated with false negatives. Sample points were the 2014–2018 camera locations and we pooled our data across the duration of the study for each camera site. The dependent variable was species presence/absence (1/0). The independent variables were distance (km) to permanent water, distance (km) to a paved road, distance (km) to an unpaved road, distance (km) to a human habitation, distance (km) to a vegetation community that included Fremont cottonwood, Goodding willow, or Arizona sycamore, percent canopy cover (> 1.8 m), percent cover in the shrub and ground vegetation layer (≤ 1.8 m), and an anthropogenic influences index. The latter index was calculated separately for seven anthropogenic influences (people, dogs, horseback riders, horses, cattle, burros, and vehicles) at each camera site by adding the count of events, maximum group size of each event, and number of minutes of each event for the duration any camera was operating. Those resulting numbers were converted into an index by summing the totals for all seven anthropogenic influences and dividing by the number of camera days the subject camera was operated. Logistic regression calculations were run in XLSTAT (version September 2020, www.xlstat.com).

We further explored the effects of cattle by comparing species counts of all events in months with and without cattle at Las Palomas and vicinity camera sites where a species was detected. Our null hypothesis was that there is no difference in numbers of species events at our Las Palomas camera sites with or without cattle presence. We tested the null hypothesis with a two-tailed z statistic test and a 95% confidence interval. The null hypothesis is rejected if the z statistic > 1.96. This analysis assumes a normal distribution of the sample proportions of events with cattle versus events without cattle. We chose the Las Palomas and vicinity sites for this analysis because those cameras were in a single pasture and the grazing practice typically stocked large numbers of cattle or none at all. In contrast, along the Río Cocóspera, cattle numbers fluctuated, but cattle were almost always present.

Surveys for Small Terrestrial and Flying Mammals

Sherman Trap Lines

Sherman live traps were employed as a means to inventory terrestrial small mammals. Traps were set in pairs (a station) that included one 23x8x9 cm and one 30x9x10 cm Sherman trap that were baited with bird seed. Stations were positioned about 15 m apart. Traps were opened at or around dusk and checked early the next morning. The following trap lines were monitored:

1. Velvet mesquite grassland just west of La Casona (30 stations, 19–20 June 2007).
2. Sonoran desertscrub-foothills thornscrub ecotone about 2 km S of La Casona (24 stations, 19–20 June 2007).
3. Velvet mesquite-netleaf hackberry woodland about 0.28 km SSW of La Casona (14 stations, 20–21 June 2007).
4. Fremont cottonwood-Goodding willow riparian forest about 0.5 km NE of La Casona (16 stations, 20–21 June 2007).
5. Velvet mesquite grassland about 1.7 km southeast of La Casona (24 stations, 7–8 August 2007).

Mist Nets

On 21 September 2006, four mist nets (one 12-m net, two 6-m nets, and one 3-m net) were placed in a Fremont cottonwood-Goodding willow riparian forest across the Río Cocóspera approximately 0.25 km SE of La Casona. Nets were placed about 40 m apart and opened from about 1830 to 2030 hrs.

On 19 and 20 June and 7 August 2007, two 6-m mist nets were placed across the Río Cocóspera in a "V" shape approximately 0.3 km SE of La Casona where a road crosses the river. One net in the "V" was set perpendicular to the river crossing and the other was set at a diagonal. Nets were opened for 1-2 hours beginning shortly after dark.

Incidental Observations and Previous Work

In the course of other work, which included herpetological inventories (Rorabaugh et al. 2013), aquatic animal surveys, and hiking on trails and in canyons, we noted mammals we observed visually, as well as sign and other evidence of mammals.

We reviewed publications, records in VertNet and the MDE databases (accessed April to October 2020), and contacted others who had worked at Rancho El Aribabi to collect credible records that would enhance our understanding of the mammals occurring in this area. "Credible records" were published records, museum or photo/observational vouchers, and other direct observations of the animal in which the observer could discern diagnostic characters.

THE MAMMALS OF RANCHO EL ARIBABI

Table 3 lists all mammals documented at Rancho El Aribabi, the vegetation communities and landscape features in which they were found, and the source of the records. The list includes 36 species in 20 families. The vast majority of the mammal records for Rancho El Aribabi come from our work. We found no mammal records for Rancho El Aribabi in VertNet. Alvarez-Castañeda and Patton (1999, 2000) and Ceballos (2014) provided shaded distribution maps, some of which cover the Rancho El Aribabi area, and the Alvarez-Castañeda and Patton publications listed specific localities for some species. Caire (2019) included shaded distribution maps with point localities and lists of localities. However, Rancho El Aribabi was not among the 339 Sonora collection localities in his gazetteer, and we find no mention of Rancho El Aribabi in that publication. Based solely on Caire's (2019) gazetteer, no collecting had occurred between the Río Magdalena/Bambuto Valley and the Río Santa Cruz, an area that includes Rancho El Aribabi.

Table 3. Wild mammals documented by us or other workers at Rancho El Aribabi and their conservation status under Mexico's NOM-059 (SEMARNAT 2019) and the IUCN Red List (version 2020-2).

Family/Species	**Vegetation Community**[1]	**Landscape Feature**	**Source**[2]	**NOM-059 Status/IUCN**[3]
Didelphidae				
Didelphis virginiana Virginia Opossum	C-W, M-N, MB, MA	Riparian river corridor, montane arroyos	Camera traps, MDE database	None/LC
Leporidae				
Lepus alleni Antelope Jackrabbit	MG, MB, M-N, NHA	Bajadas, riparian river corridor, cattle waters	Camera traps, visual observations, MDE database	None/LC
Sylvilagus audubonii Desert cottontail	C-W, MB, M-N, MG, MA, M-O	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations	None/LC
Sciuridae				
Otospermophilus variegatus Rock Squirrel	C-W, MA, MB, MG, M-O, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Sciurus arizonensis Arizona Gray Squirrel	C-W, M-N, OW	Riparian river corridor, montane arroyos	Camera traps, visual observations, MDE database	A/DD
Heteromyidae				
Dipodomys merriami Merriam's Kangaroo Rat	MB, MG	Riparian river corridor, bajadas	Camera traps	None/LC
Chaetodipus penicillatus Desert Pocket Mouse	C-W, MB, MG	Riparian river corridor and adjacent bajadas	Sherman traps	None/LC

Table 3. (continued) Wild mammals documented by us or other workers at Rancho El Aribabi and their conservation status under Mexico's NOM-059 (SEMARNAT 2019) and the IUCN Red List (version 2020-2).

Geomyidae				
Thomomys bottae Botta's Pocket Gopher	C-W, MA, MB, MG, M-O, NHA	Riparian river corridor, bajadas, montane arroyos	Visual observations	None/LC
Cricetidae				
Neotoma albigula White-throated Woodrat	MA, MB, MG, M-N, M-O	Riparian river corridor, bajadas, montane arroyos	Camera traps, visual observations, Sherman traps	None/LC
Peromyscus maniculatus North American Deermouse	C-W, MB, MG	Riparian river corridor, bajadas	Sherman traps	None/LC
Soricidae				
Notiosorex sp. Cockrum's Gray Shrew (*N. cockrumi*) or Crawford's Gray Shrew (*N. crawfordi*)	C-W, MG	Riparian river corridor, bajadas	Visual observations, MDE database	A (*N. crawfordi*)/LC (both species)
Erethizontidae				
Erethizon dorsatum North American Porcupine	C-W, OW, ST	Riparian river corridor, bajadas	Recollections from a vaquero and Robles family members	P/LC
Felidae				
Leopardus pardalis Ocelot	C-W, MA, MB, M-N, ST	Riparian river corridor, bajadas, montane arroyos	Camera traps, literature, MDE database	P/LC
Lynx rufus Bobcat	C, C-W, MA, MB, MG, M-N, ST, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Puma concolor Puma	C, C-W, MA, MB, MG, M-N, NHA, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observation, MDE database	None/LC
Panthera onca Jaguar	MA	montane arroyos	Literature, MDE database	P/NT
Canidae				
Canis latrans Coyote	C, C-W, MA, MB, MG, M-N, M-O, NHA, ST	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual and auditory observations, MDE database	None/LC
Urocyon cinereoargenteus Gray Fox	C, C-W, MA, MB, MG, M-N, M-O, NHA, ST, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC

Table 3. (continued) Wild mammals documented by us or other workers at Rancho El Aribabi and their conservation status under Mexico's NOM-059 (SEMARNAT 2019) and the IUCN Red List (version 2020-2).

Ursidae				
Ursus americanus American Black Bear	MA, OW	Montane arroyos	Camera traps, MDE database	Pr/LC
Mustelidae				
Taxidea taxus Badger	C, C-W, MB, M-N	Riparian river corridor	Camera traps	None/LC
Mephitidae				
Conepatus leuconotus Hog-nosed Skunk	C-W, MA, MB, MG, M-O, ST	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observation, MDE database	None/LC
Mephitis macroura Hooded Skunk	C-W, MA, MB, MG, M-O, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, MDE database	None/LC
Spilogale gracilis Western Spotted Skunk	C-W, MB, MG	Riparian river corridor, cattle water	Camera traps	None/LC
Procyonidae				
Bassariscus astutus Ringtail	C-W, MA, MB, M-N, ST, OW	Riparian river corridor, bajadas, montane arroyos	Camera traps, MDE database	None/LC
Nasua narica White-nosed Coati	C, C-W, MA, MB, MG, M-N, ST, M-O, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Procyon lotor Common Raccoon	C, C-W, MA, MB, MG, M-N, M-O, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Tayassuidae				
Pecari tajacu Javelina	C, C-W, MA, MB, MG, M-N, M-O, NHA, ST, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Cervidae				
Odocoileus virginianus White-tailed Deer	C, C-W, MA, MB, MG, M-N, M-O, NHA, ST, OW	Riparian river corridor, bajadas, montane arroyos, cattle waters	Camera traps, visual observations, MDE database	None/LC
Emballonuridae				
Macrotus californicus California Leaf-nosed Bat	CW, MG	Riparian river corridor	Mist nets	P/LC

Table 3. (continued) Wild mammals documented by us or other workers at Rancho El Aribabi and their conservation status under Mexico's NOM-059 (SEMARNAT 2019) and the IUCN Red List (version 2020-2).

Molossidae				
Tadarida brasiliensis Mexican Free-tailed Bat	CW, MG	Riparian river corridor, La Casona	Mist nets, visual observations	None/LC
Vespertilionidae				
Eptesicus fuscus Big Brown Bat	C-W	Riparian river corridor	Mist nets	None/LC
Myotis velifer Cave Myotis	C-W	Riparian river corridor	Mist nets	None/LC
Lasiurus blossevillii Western Red Bat	C-W	Riparian river corridor	Mist nets	None/LC
Lasiurus cinereus Hoary Bat	C-W	Riparian river corridor	Mist nets	None/LC
Parastrellus hesperus Canyon Bat	C-W	Riparian river corridor	Mist nets, visual observations	None/LC
Antrozoidae				
Antrozous pallidus Pallid Bat	MG	La Casona	Visual observations	None/LC

[1] C = ciénega on the Río Cocóspera, C-W = Fremont Cottonwood, Goodding Willow riparian forest on the Río Cocóspera, MA = montane arroyos in the Sierra Azul with mostly ephemeral flow and scattered riparian trees in an oak savanna, MB = velvet mesquite bosque, usually in the 2nd terrace of the Río Cocóspera, MG = velvet mesquite grassland, M-N = velvet mesquite and netleaf hackberry woodland, usually on the 2nd terrace of the Río Cocóspera, M-O = velvet mesquite and oak woodland or savanna, OW = oak woodland or savanna, NHA = arroyo on the bajada dominated by netleaf hackberry and velvet mesquite, ST = Sonoran desertscrub-foothills thornscrub ecotone.

[2] All of the medium to large mammals were also reported in Rorabaugh et al. (2020).

[3] NOM-059: P = endangered, A = threatened, Pr = species of special protection. IUCN: DD = data deficient, LC = least concern, NT = near threatened.

The MDE database included 135 mammal records for Rancho El Aribabi. All of these are relatively recent, since Caire's 1978 work, and all involved observations, sometimes photo-documented with camera traps, rather than collections and subsequent deposition of specimens into museum collections. Seventeen of the 135 MDE records were from the current study, and we have submitted over 200 additional Rancho El Aribabi mammal records to the MDE. Many of the 135 medium to large mammal records come from the 2007–2011 camera trap project by Avila-Villegas and Lamberton-Moreno (2013). That study includes the only jaguar records for the ranch. Additional mammal records for Rancho El Aribabi, particularly for ocelot, are found in Rorabaugh et al. (2020).

We documented mammals via camera traps, visual observations, mist nets, Sherman traps, and discussions with others that yielded credible observations (Table 3). Our camera traps yielded 398,989 images, 1033 video clips, 36,131 images of wildlife (excluding incidentals), and 10,104 wildlife events over 21,535 camera-trap days from July 2014 to December 2018. Most of the cameras were removed in May 2018, but we still operated four cameras through December of that year (Appendix 1). Twenty species of medium to large wild mammals were recorded via camera trap (Table 2). Appendix 2 lists species by camera site and includes all wild mammals photographed by our camera traps. Additional vertebrate and invertebrate species were photographed incidentally (Table 4). Representative images of all medium to large mammals photographed by our camera traps as well as selected small mammals and bats are presented in the species accounts.

Table 4. Animals photographed incidentally with our camera traps.

Invertebrates	Great Horned Owl or Long-eared Owl, *Strix nebulosa* or *Asio otus*
Wasp, possibly *Sphecius grandis*	Western Screech Owl, *Megascops trichopsis*
Sulphur butterfly, Coliadinae	Buff-collared Nightjar, *Antrostomus ridgwayi*
Lady butterfly, *Vanessa* sp.	Violet-crowned Hummingbird, *Amazillia violiceps*
Amphibians	Elegant Trogon, *Trogon elegans*
Sonoran Desert Toad, *Incilius alvarius*	Gila Woodpecker, *Melanerpes erythrocephalus*
Reptiles	Northern Flicker, *Colaptes auratus*
Sonora Mud Turtle, *Kinosternon sonoriense*	Western Wood Pewee, *Contopus sordidulus*
Sonoran Spotted Whiptail, *Aspidoscelis sonorae*	“Western” Flycatcher, *Empidonx difficilis* or *E. occidentalis*
Clark’s Spiny Lizard, *Sceloporus clarkii*	Black Phoebe, *Sayornis nigricans*
Ornate Tree Lizard, *Urosaurus ornatus*	Vermillion Flycatcher, *Pyrocephalus rubinus*
Sonoran Whipsnake, *Masticophis bilineatus*	Ash-throated Flycatcher, *Myiarchus tuberculifer*
Birds	Brown-crested Flycatcher, *Myiarchus tyrannulus*
Mexican Duck, *Anas diazi*	Cassin’s Kingbird, *Tyrannus vociferous*
American Wigeon, *Anas americana*	Mexican Jay, *Aphelocoma wollweberi*
Green-winged Teal, *Anas crecca*	Common Raven, *Corvus corax*
Bufflehead, *Bucrephala albeola*	Bewick’s Wren, *Thryomanes bewickii*
Montezuma Quail, *Cyrtonyx montezumae*	Western Bluebird, *Sialia mexicana*
Wild Turkey, *Meleagris gallopavo*	Hermit Thrush, *Hylocichlia mustelina*
Great Blue Heron, *Ardea herodias*	Northern Mockingbird, *Mimus polyglottos*
Great Egret, *Ardea alba*	Canyon Towhee, *Melozone crissalis*
Black-crowned Night Heron, *Nycticorax nycticorax*	Black-throated Sparrow, *Amphispiza bilineata*
Turkey Vulture, *Cathartes aura*	Five-striped Sparrow, *Amphispiza quinquestriata*
Black Vulture, *Coragyps atratus*	Summer Tanager, *Piranga rubra*
Cooper’s Hawk, *Accipiter cooperii*	Tanager sp., *Piranga* sp.
Common Black Hawk, *Buteogallus anthracinus*	Northern Cardinal, *Cardinalis cardinalis*
Gray Hawk, *Buteo plagiatus*	Pyrrhuloxia, *Cardinalis sinuatus*
Red-tailed Hawk, *Buteo jamaicensis*	Varied Bunting, *Passerina versicolor*
Golden Eagle, *Aguila chrysaetos*	Blue Grosbeak, *Passerina caerulea*
American Coot, *Fulica americana*	Oriole sp., *Icterus* sp.
Sandhill Crane, *Grus canadensis*	House Finch, *Haemorhous mexicanus*

Table 4. (continued) Animals photographed incidentally with our camera traps.

White-winged Dove, *Zenaida asiatica*	**Mammals**
Mourning Dove, *Zenaida macroura*	White-throated Woodrat, *Neotoma albigula*[1]
White-tipped Dove, *Leptotila verreauxi*	Merriam's Kangaroo Rat, *Dipodomys merriami*[1]
Common Ground Dove, *Columbiana passerina*	Deermouse, *Peromyscus* sp.
Greater Roadrunner, *Geococcyx californianus*	Bat sp.

[1] Identification to species is tentative; see the species account for more information.

The cameras captured 6706 events of anthropogenic influences (Table 2), which were dominated by cattle. Bovine events (*Bos taurus*, 5557) exceeded those of even the most commonly photographed medium to large wild mammal (white-tailed deer [3870 events]) reflecting land use at Rancho El Aribabi as an active cattle ranch. Table 1 lists camera days, medium to large wild mammal events, and events per camera day by camera site type. The most productive sites in terms of events per camera day were along ridgelines, all of which were in velvet mesquite grassland. The least productive sites were cattle waters, which were also in velvet mesquite grassland.

Figure 6 is a species accumulation curve, showing the cumulative number of medium to large mammalian species captured by our camera traps over the course of the study. It is a measure of the completeness of our faunal inventory for these categories of mammals. It shows that the cumulative number of species leveled out at 20 by the July-December 2016 sampling period, after which no additional species were added. The last species added to the cumulative total was the western spotted skunk (*Spilogale gracilis*) on 27

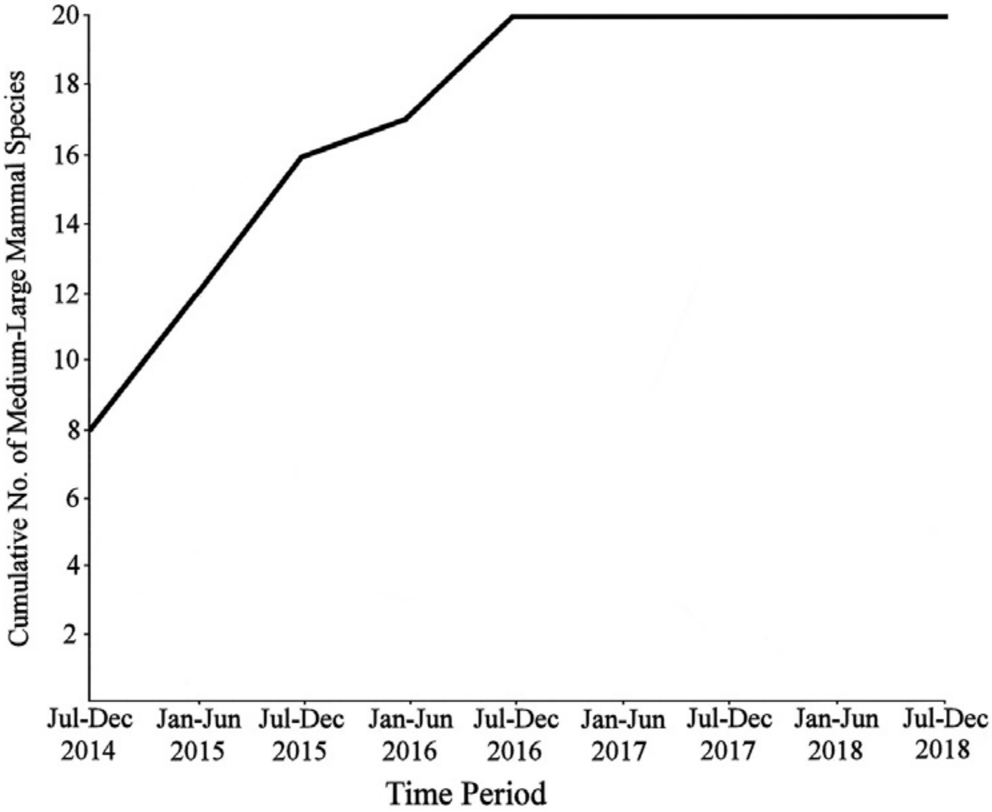

Figure 6. Species accumulation curve.

November 2016. The jaguar was detected via camera traps in a previous study at Rancho El Aribabi (Avila-Villegas and Lamberton-Moreno 2013) and, as discussed toward the end of this article, other medium to large mammalian species could occur on the ranch that eluded detection in spite of our 4.5-year effort.

Seven species of bats were captured in mist nets. Two of those were also recorded visually by us, as well as one other that was not captured in nets. Bats were often photographed by our camera traps, but identification to species was not possible due to lack of details in the images. Three species of rodents were captured in the Sherman traps. One of those was also recorded visually and via camera trap. A fourth rodent species was recorded visually and another was detected solely via camera traps. We visually detected one species of shrew (Table 3).

Statistical Analyses

Effects of Cattle on Species Events. Our analyses of whether cattle presence affects mammal events at the Las Palomas and vicinity camera sites involved 12 camera sites operated for 255 camera months. Two hundred and two (80%) of those months were without cattle while 53 had cattle. A single, stray cow was photographed occasionally from January 2016 to June 2017; we included images from those months in the without-cattle category. To reduce statistical limitations associated with small sample size, we only tested for effects of cattle if we had 20 or more events for a species at the Las Palomas and vicinity camera sites. That limited the analysis to 12 species, the results of which are detailed in the species accounts.

Identification of Important Habitat Variables via Logistic Regression Models. Logistic regression to identify important habitat variables was run for nine species: desert cottontail, rock squirrel, bobcat, puma, hog-nosed skunk, hooded skunk, ringtail, white-nosed coati, and common raccoon. All other camera-trapped species lacked the minimum number of events (60), minimum number of sites where the species was photographed (10), and or minimum number of sites where the species was not photographed (10) used in this study as an adequate sample size for analysis. Details of logistic regression modeling for the ocelot can be found in Rorabaugh et al. (2020).

Habitat variables by camera site are listed in Appendix 3. Results of the logistic regression are presented in Tables 5 and 6. Table 5 lists mean values for each variable at camera sites where a species was photographed versus camera sites where it was not photographed. These data provide a snapshot of the magnitude of differences for each variable between sites with and without species documentation. They also provide a quick assessment of whether a species was associated with greater or lesser values of a particular variable as compared to sites where the species was not photographed. For example, for the desert cottontail, it was found on average 0.5 km from permanent water (variable A), whereas sites where it was absent were, on average, 0.38 km from permanent water. A summary table is also presented (Table 6) that lists the following statistics for each species: Model equation, area under the curve (AUC), percentage of a training sample that correctly predicts presence or absence of the target species, and Pr > LR (probability > likelihood ratio) for variables where that statistic is < 0.05. In the model equation as presented in Table 6, we dropped variables if their coefficients were less than 0.01. AUC is a measure of goodness of fit, where 0.5 is what is expected of a random model and 1.0 is a perfect fit. Generally, models with AUCs > 0.7 are considered useful, 0.87-0.9 is needed for discriminating models, and an AUC > 0.9 is considered excellent. Percentage of a training sample correctly categorizing presence or absence is another measure of model usefulness, with 0.5 being the expected value for a random model. For each model variable, we set the significance level of the Pr > LR statistic at 0.05.

Variables with Pr > LR statistics lower than that value are listed in the table; however, other variables are often discussed in the species accounts. The smaller the Pr > LR value and the larger the coefficient for a variable in the model, the more statistically valuable that variable is in terms of contributing to model goodness of fit and predicting presence and absence. Statistical value, however, may or may not translate into biological significance. The difference (from Table 5) between a variable at sites where a species was photographed versus where it was not photographed may achieve a Pr > LR value less than 0.05, but actual difference between those two values may be small, suggesting little biological significance. Statistical versus biological significance and other details of the results for each species are discussed in the species accounts.

Table 5. Comparison of binary logistic regression model variable means at sites where a species was present or absent.

Desert Cottontail

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.50	5.59	0.25	4.35	0.29	56.93	27.11	2.37
Absent	0.38	4.55	0.24	3.24	0.37	79.04	38.05	5.44

Rock Squirrel

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.35	7.38	0.27	6.18	0.05	74.50	21.66	2.38
Absent	0.39	3.06	0.18	1.64	0.52	70.38	41.94	4.95

Ocelot[2]

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.22	6.32	0.36	4.91	0.95	79.10	23.40	4.41
Absent	0.50	4.66	0.15	3.40	0.55	67.80	37.00	3.38

Bobcat

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.38	4.42	0.24	3.04	0.36	72.92	35.38	3.80
Absent	0.29	5.99	0.21	4.79	0.14	80.05	33.00	5.84

Puma

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.39	5.51	0.28	4.17	0.19	72.03	31.04	2.38
Absent	0.48	5.11	0.17	3.90	0.38	81.69	30.48	5.98

Table 5. (continued) Comparison of binary logistic regression model variable means at sites where a species was present or absent.

Hog-nosed Skunk

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.33	5.51	0.28	4.17	0.19	72.03	31.04	2.38
Absent	0.48	5.11	0.17	3.90	0.38	81.69	30.48	5.98

Hooded Skunk

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.64	5.66	0.19	4.20	0.62	59.22	30.21	4.69
Absent	0.22	4.84	0.24	3.64	0.11	88.12	28.82	4.60

Ringtail

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.27	6.27	0.34	4.92	0.09	76.83	21.07	3.78
Absent	0.44	4.29	0.18	3.00	0.48	75.54	38.55	5.31

White-nosed Coati

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.31	5.70	0.25	4.44	0.15	79.33	28.51	2.78
Absent	0.61	2.97	0.16	1.56	0.86	51.68	46.25	9.25

Common Raccoon

Logistic Regression Model Variables[1]								
	A	B	C	D	E	F	G	H
Present	0.40	5.49	0.35	4.22	0.26	71.44	33.22	3.21
Absent	0.34	4.88	0.17	3.67	0.20	84.70	29.20	4.73

[1] Model variables are as follows: A = distance to permanent water (km), B = distance to paved road (km), C = distance to unpaved road (km), D = distance to human habitation (km), E = distance to a vegetation community that included Fremont cottonwood, Goodding willow, or Arizona sycamore (km), F = percent canopy cover (> 1.8 m), G = percent cover in the shrub layer and ground layer (≤ 1.8 m), and H = anthropogenic influences index.

[2] From Rorabaugh et al. (2020).

Table 6: Results of binary logistic regression to identify important habitat variables.

Species	Model Equation[1]	Area Under the Curve (AUC)	% Correct—Present/Absent/Total[2]	Pr >LR[3]
Desert Cottontail, *Sylvilagus audubonii*	P = 1/(1+exp(-(1.45+2.62xA+0.24xB+0.61xC-0.39xD-2.05xE-0.02xF-0.01xG-0.20xH))	0.794	53.3/87.1/76.1	F (0.023), H (0.045)
Rock Squirrel, *Otospermophilus variegatus*	P = 1/(1+exp(-(-0.83+2.05xA-0.12xB+3.23xC=0.49xD -2.18xE-.01xG-0.31xH))	0.912	90.0/83.3/86.4	None
Bobcat, *Lynx rufus*	P = 1/1+exp(-(1.79+3.96xA+0.27xB+1.46xC-0.56xD-0.15xE-0.18xH))	0.789	93.7/25.0/75.0	H (0.043)
Puma, *Puma concolor*	P = 1/1+exp(-(-1.67+11.92xA+2.92xB-3.73xC-2.77xD-8.74xE-0.02xG+0.04xH))	0.857	91.43/40.00/80.00	A (0.002) E (0.001)
Hog-nosed Skunk, *Conepatus leuconotus*	P = 1/(1+exp(-(-1.85-0.04xA+2.54XB+1.34xC -2.40xD-1.47xE-0.01xE+0.01xG-0.27xH))	0.807	85.71/62.50/75.68	H (0.042)
Hooded Skunk, *Mephitis macroura*	P = 1/1+exp(-(-2.44+3.62xA+0.06xB+1.74xC+0.01xD+3.44xE +0.02xG-0.27xH))	0.831	72.22/78.95/75.68	H (0.01)
Ringtail, *Bassariscus astutus*	P = 1/1(1+exp(-(1.95-0.35xA-0.48xB+3.34xC+0.56xD-1.38xE-0.01xF-0.03xG-0.08xH))	0.809	70.83/63.16/67.44	None
White-nosed Coati, *Nasua narica*	P = 1/1+exp(-(1.88+0.83xA-0.25xB +0.63xC+0.46xD-1.46xE-0.01xG-0.13xH))	0.859	90.91/58.33/82.22	None
Common Raccoon, *Procyon lotor*	P = 1/(1+exp(-(-8.65-0.40xA+3.78xB+5.56xC -3.39xD+2.27xE+0.039xD+2.27xE+0.03xG-0.09xH))	0.819	68.75/90.00/80.56	C (0.023)

[1] The model categorizes the species as present for the dependent variable ≥ 0.5 and not present when the dependent variable < 0.5. P = presence. Independent variables are as follows: A = distance to permanent water (km), B = distance to paved road (km), C = distance to unpaved road (km), D = distance to human habitation (km), E = distance to a vegetation community that included Fremont cottonwood, Goodding willow, or Arizona sycamore (km), F = percent

canopy cover (>1.8 m), G = percent cover in the shrub layer and ground layer (≤ 1.8 m), and H = anthropogenic influences index.

[2] Percent of the training sample that categorizes the dependent variable correctly.

[3] For variables where that statistic is < 0.05.

In summarizing the results of the logistic regression in the species accounts, we discuss how some variables are likely related to or correlated with other variables and how that may affect the interpretation of the results. For instance, distance to permanent water is likely related to canopy cover, in that places with high canopy cover tend to be riparian woodlands along streams or rivers. However, distance to permanent water may not be well correlated with vegetation communities that include the riparian trees, Fremont cottonwood, Goodding willow, or Arizona sycamore (see species account for the common raccoon). Distance to human habitation and roads is not a surrogate for the anthropogenic influences index because that index is dominated by cattle, and presence of cattle is a function of cattle management across the study area. Cattle tend to cluster around permanent water sources during the dry season, and thus the anthropogenic influences index and distance to permanent water would be negatively correlated at that time, but cattle spread out during wet periods.

One of the habitat variables used in the logistic regression models is the anthropogenic influences index. This index and the analysis of effects of cattle at the Las Palomas and vicinity sites both measure human disturbance and human-related disturbance; however, species may have in some cases reacted differently to the varying components of these parameters. The index is dominated by cattle events, but other forms of disturbance (people, dogs, horseback riders, horses, burros, and vehicles) are also included that may affect species differently than cattle alone. The manner in which cattle manifested on the landscape also differed. The index was calculated over all camera sites for logistic regression versus evaluating only Las Palomas and vicinity sites in the test of cattle effects on presence/absence. In particular, on the Río Cocóspera, cattle were present in low densities throughout the study. At the Las Palomas and vicinity sites, when they were present, cattle were typically concentrated in the canyon bottoms where our cameras were located and, particularly during the arid months before the summer rainy season, cattle tended to concentrate at the limited perennial water sources. We had cameras at those water sources. Those periods of heavy cattle use were punctuated with long periods when no cattle were present at the Las Palomas and vicinity sites. Consequently, if concentrations of cattle affect wildlife, we would expect that conclusion to emerge from our analysis of the Las Palomas and vicinity sites. Because of the more dispersed nature of cattle grazing and abundance of water on the Río Cocóspera, wildlife might respond to cattle differently there. The other forms of human and human-related disturbance in the anthropogenic influences index may also affect response of wildlife to that index. These relationships are discussed by species in the species accounts that follow.

In the species accounts, we present a qualitative analysis of 24-hr activity patterns, including winter-summer comparisons for some species, and adjusted events per month for species with at least 45 events. Using the 45-event criterion limited those analyses to 16 species.

Species Accounts of Rancho El Aribabi Mammals

The following accounts summarize our findings by species, including activity patterns, habitat use, group size, prey and predators, and the results of binary logistic regression modeling. Taxa are arranged in taxonomic order consistent with Ceballos (2014). Mexican common names are presented in the title in parentheses.

DIDELPHIDAE

Didelphis virginiana, Virginia Opossum (Tlacuache)

Babb et al. (2004) summarized the status of *Didelphis virginiana* in Arizona and, based on pelage color, tail length, and other characters, concluded that opossums in southeastern Arizona represent the native subspecies *D. v. californicus*, an extension of the range in northeastern Sonora. However, Babb et al. (2004) reported non-native *D. v. virginiana* from the Phoenix metropolitan area and suggested that subspecies could turn up in other areas of Arizona. Caire (2019) shows Rancho El Aribabi within the range of the Virginia opossum, but the nearest record he lists is "Llano" near Santa Ana. Babb et al. (2004) observed numerous road-killed Virginia opossums in northeastern Sonora, including one 22 km south of the international border, but they did not provide specific localities. The MDE database includes five records from Rancho El Aribabi, including one from Las Palomas, two from Arroyo Guerigo – a tributary to the Río Cocóspera, and one from "Agua Fría", which is near a spring-fed cattle tank in the foothills of the Sierra Azul (see Figure 2). Elevations ranged from 987 to 1327 m. All five of these records are from the 2007–2011 camera trap project (Avila-Villegas and Lamberton-Moreno 2013).

Relative Abundance and Local Distribution: Our only detections of *Didelphis* were by camera trap. At Rancho El Aribabi we only detected opossums that matched the descriptions of *D. v. californicus* (Figure 7). This subspecies was photographed at eight camera sites for a total of 20 events. Most (15 events) were photographed along the Río Cocóspera downstream of La Casona in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, and velvet mesquite-netleaf hackberry woodland. One Virginia opossum was photographed in a velvet mesquite bosque 0.43 km SE of the Río Cocóspera. Four other events were photographed at Las Palomas in the Sierra Azul, an area characterized by scattered riparian trees along an ephemeral arroyo in oak savanna. Elevations of our records ranged from 989 to 1333 m. Babb et al. (2004) noted that "free water is commonly present within 100 m" of Virginia opossum localities. As most of our localities were along the Río Cocóspera, we would concur with that finding. However, the above-mentioned record from 0.43 km SE of the Río Cocóspera places that animal 0.43 km from permanent water. Records from the MDE database for Rancho El Aribabi all are close to perennial water.

Figure 7. Virginia opossum, site U2, 20 Nov 16, 0345 hrs.

Behavior: All of our events occurred after dark except for one in the late afternoon (1714 hrs, 6 Apr 2015 at Las Palomas). We photographed Virginia opossums in every month of the year except for February, March, May, and September. Virginia opossums were always solitary, events were of short duration (animals walking through the camera's view), and we did not photograph any crossings of logs over the river, feeding, predation, or other notable behaviors.

Interaction with Cattle and Important Habitat Variables: Due to limited sample size, we neither evaluated effects of cattle on Virginia opossum occurrence, nor conducted binary logistic regression to identify important habitat variables.

LEPORIDAE

***Lepus alleni*, Antelope Jackrabbit (Liebre Blanca)**

Brown et al. (2014) summarized the ecology of the antelope jackrabbit and found it to be essentially a savanna species but it also occurred in velvet mesquite bosques and other thornscrub-like vegetation so long as open landscape was nearby. Elevational range was found to be from sea level to 1200 m, but most were found below 460 m. Alvarez-Castañeda and Patton (1999), Ceballos (2014), and Caire (2019) show Rancho El Aribabi squarely within the range of the antelope jackrabbit with the nearest localities (from Caire 2019) at 23 km S of Nogales and at Magdalena. The MDE database includes a single antelope jackrabbit record from Rancho El Aribabi, and it comes from this study. Where images were clear and detailed we are certain we photographed antelope jackrabbits. However, black-tailed jackrabbits (*Lepus californicus*) may have been photographed where photos lacked detail and clarity to distinguish between the two species (Table 7). If black-tailed jackrabbits occur at Rancho El Aribabi, they will likely be found at low elevations in scrub vegetation.

Local Distribution: We recorded 269 antelope jackrabbit events at nine camera sites. We also occasionally observed this species during the day in a large velvet mesquite grassland arroyo approximately 2 km NE of La Casona (Figures 8 and 9). Antelope jackrabbits were photographed in velvet mesquite grassland, in a velvet mesquite-netleaf hackberry arroyo in velvet mesquite grassland, and in a velvet mesquite bosque along the Río Cocóspera. Two-hundred and twenty eight events were recorded at two cameras sites in velvet mesquite grassland. Only three events were in a velvet mesquite bosque, but that site was close (0.1 km) to velvet mesquite grassland. Most localities were in rolling terrain on the bajada of the Sierra Azul, including ridgelines, but we did not photograph this species at Las Palomas or its tributaries. Antelope jackrabbits were photographed at two cattle tanks, but were not photographed or observed drinking there or at other sites. Elevational range of our records was 995 to 1305 m.

Figure 8. Antelope jackrabbit, arroyo ~2 km NE of La Casona, 16 Jul 08, 1906 hrs.

Figure 9. Antelope jackrabbit, arroyo ~2 km NE of La Casona, 7 Mar 15, 1712 hrs.

Relative Abundance: We calculated the mean number of camera days per antelope jackrabbit event for each of the camera site types as follows: riverine = 4610.0, cattle waters = 917.3, uplands = 33.6, and ridgelines = 3.9. Antelope jackrabbits were not photographed at Las Palomas or its tributaries. Those numbers are an index to the relative abundance of the antelope jackrabbit in those site types, with the smallest number indicating greatest abundance and the largest number indicating least abundance. Antelope jackrabbits were abundant on ridgelines and moderately so in upland sites, but rare or absent elsewhere.

Behavior: In our study, this species was primarily nocturnal (Figure 10), which is consistent with Ceballos (2014). Peaks of activity occurred from 0000 to 0100 hrs and just before or at dawn (0600-0700 hrs). For unknown reasons, most (87%) of monthly adjusted events were from December through March. No antelope jackrabbits were photographed in September and October, and only one was photographed in August and June.

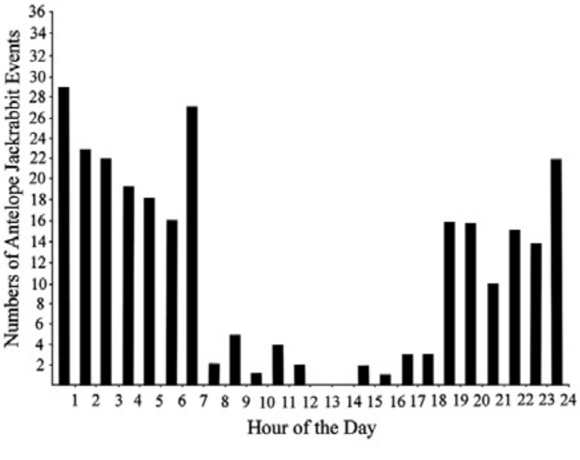

Figure 10. Antelope jackrabbit 24-hr activity pattern.

A coyote with an antelope jackrabbit in its mouth was recorded on 22 December 2017 at 1141 hrs on the Río Cocóspera in Fremont cottonwood-Goodding willow riparian forest downstream of La Casona. Although antelope jackrabbits are reportedly gregarious and have been seen in groups as large as 35 (Brown et al. 2014), 267 of our photo captures were of a single animal. More than one animal was photographed only twice, and in both instances the group size was two. Most photo captures were of short duration – a minute or less, but antelope jackrabbits sometimes lingered in front our cameras for as long as 21 minutes. No crossings of logs over the river or other notable behaviors were captured by our cameras.

Interaction with Cattle and Important Habitat Variables: Due to the limited number of sites where antelope jackrabbits were photographed (nine) and absence of events at Las Palomas, we neither evaluated effects of cattle on antelope jackrabbit occurrence, nor conducted binary logistic regression to identify important habitat variables.

Sylvilagus audubonii, Desert Cottontail (Conejo del Desierto)

The differences between the external identifying characters of the desert cottontail and the eastern cottontail (*Sylvilagus floridanus*) are subtle. With the former, the ears are somewhat longer with little fur on the outside, the front legs are long, and the hind legs are thin and lack the dense fur of other members of the genus. Additional pelage color differences at the nape or back of the neck and on the tail help distinguish between the two species (Hoffmeister 1986; Ceballos 2014). Caire (2019) lists only three records for the eastern cottontail in Sonora: one from Álamos in the southeast and two from mountains to the east of Rancho El Aribabi. He does not include Rancho El Aribabi within the range of the eastern cottontail and suggests the species is probably more common in high inaccessible portions of the Sierra Madre Occidental. In Sonora, the eastern cottontail has been reported from the Sierras Los Ajos, El Tigre, La Madera, and San Luis (Coronel-Arellano et al. 2016) and the Sierra Madre Occidental (Lorenzana-Piña et al. 2004) to the east and southeast of Rancho El Aribabi. In southeastern Arizona, the eastern cottontail is generally high in the mountains whereas the desert cottontail is a lower elevation species, being found from the deserts upslope into the lower oak zone at elevations as high as 1524 m (Hoffmeister 1986).

Local Distribution: The only *Sylvilagus* MDE database records for Rancho El Aribabi are observations (without accompanying photographs) for the eastern cottontail. We obtained 245 events and 478 images at 15 camera sites of cottontails (Figure 11). Although in most of those images key characters cannot be seen, no cottontails were clearly identified as eastern cottontails, but based on some clear images and occasional visual observations of this species on the ranch, we believe we did detect desert cottontails. That said, we cannot rule out the presence of eastern cottontails at Rancho El Aribabi. In particular, the species may occur high in the Sierra Azul.

Figure 11. Desert cottontail, site R1, 24 Jan 17, 0355 hrs.

Cottontails (assumed here to be desert cottontails) were photographed in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland, oak-velvet mesquite woodland, and along a mostly ephemeral montane arroyo in oak savanna at elevations of 982 to 1406 m. Terrain in which desert cottontails were detected ranged from a river floodplain to rolling hills and bajadas, and montane arroyos. It was photographed at two cattle tanks, but was never observed or photographed drinking water.

Relative Abundance: We calculated the mean number of camera days per desert cottontail event for each of the camera site types as follows: Las Palomas = 930.7, cattle waters = 917.3, tributaries to Las Palomas = 703.0, riverine = 288.1, ridgelines = 11.6, and upland = 7.7. Those numbers are an index to the relative abundance of the desert cottontail in those site types. Desert cottontails were relatively abundant on ridgelines and at upland sites but rare elsewhere.

Behavior: Activity of this species was strongly nocturnal at Rancho El Aribabi based on camera trapping (Figure 12), although we occasionally observed it during daylight hours. The greatest activity occurred from 0400 to 0500 hrs. Monthly adjusted events varied greatly. During December through March, monthly adjusted events varied from 1.58 (December) to 3.96 (February), while from April through November, the monthly adjusted events never exceeded 0.56 (May), and no events were recorded in September or October. We can think of no biological explanation for these monthly fluctuations.

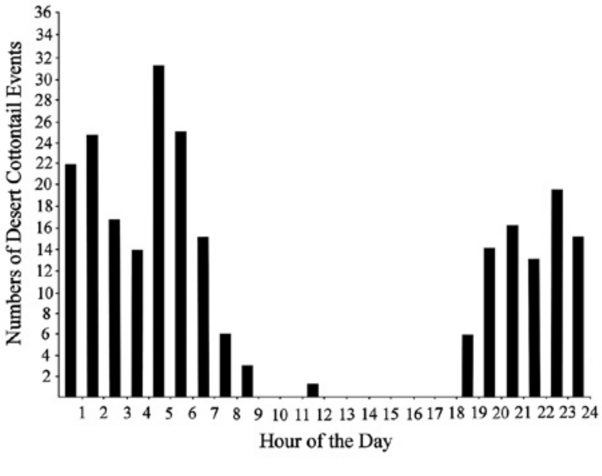

Figure 12. Desert cottontail 24-hr activity pattern.

Desert cottontails were largely solitary (242 of 245 events, or 99%). Three events documented two apparently adult animals based on size. On 11 Nov 2015 at 1722 hrs, a bobcat was photographed with what was probably a small desert cottontail in its mouth on a dirt road adjacent to the Río Cocóspera and La Casona (camera site R21). No desert cottontails were photographed crossing logs over the river.

Interaction with Cattle and Important Habitat Variables: Desert cottontails were photographed at 15 camera sites and not photographed at 31 sites where the camera was operated for at least 29.6 days (the mean number of camera days necessary to photograph a desert cottontail at the 15 sites where they were photographed). The logistic regression model fits the data moderately well. The model is a reasonably good predictor of sites where desert cottontails are absent, but predicts presence much less accurately (Table 6). Two variables had significant effects on desert cottontail presence: 1) percent canopy cover, and 2) the anthropogenic influences index. Sites where desert cottontails were photographed had a mean percent canopy cover of 56.93 versus 79.04 at sites where the species was not photographed. Sites with desert cottontails had a mean anthropogenic influences index of 2.37 versus 5.44 at sites without the species. These data show that desert cottontails are more likely to be found at relatively open sites with small percentages of vegetation cover in the canopy (> 1.8 m) and that exhibit low levels of anthropogenic disturbance. We did not analyze the effects of cattle on desert cottontail due to the small number (6) of desert cottontail events at Las Palomas; however, the anthropogenic influences index was dominated by cattle and presence of desert cottontails was significantly associated with lower values of that index.

SCIURIDAE

Otospermophilus variegatus, Rock Squirrel (Ardillón de las Rocas)

Rock squirrels are typically found in rocky areas, although they may shelter amidst cottonwood roots, in old cabins, and other human structures (Hoffmeister 1986; Oaks et al. 1987). In Arizona, they are found in a wide variety of environmental situations, from desertscrub upslope to above timberline, well over 3350 m (Hoffmeister 1986). They occur to an elevation of 3600 m in Mexico (Ceballos 2014). The MDE database includes seven records of rock squirrel from Rancho El Aribabi, mostly from areas, vegetation communities, and terrain in which we also found them. The exception is an MDE record from the Sierra Azul in oak woodland at 1442 m.

Local Distribution: At Rancho El Aribabi, we photographed rock squirrels at 20 of our 50 camera trap localities and occasionally we observed this species during daylight hours (Figure 13). They were photographed in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland, oak-velvet mesquite woodland, and a montane arroyo in an oak savanna. Terrain where this species was found included a river floodplain, rolling terrain and bajadas, and a montane arroyo. Rock squirrels were photographed at three cattle tanks and we have pictures of them drinking water from a montane arroyo. Only three events document this species using ridgelines. Elevations ranged from 968 to 1406 m. Nine of 324 events (3%) showed rock squirrels crossing a log over the Río Cocóspera. Rock squirrels are colonial (Oaks et al. 1987); however, 98% of our events captured only one squirrel. Eight events involved two rock squirrels. They were occasionally heard vocalizing, which consisted of a loud, bird-like peep.

Figure 13. Rock squirrel, site ALP5, 23 Sep 16, 1652 hrs.

Relative Abundance: We calculated the mean number of camera days per rock squirrel event for each of the camera site types as follows: ridgelines = 306.3, cattle waters = 275.2, tributaries to Las Palomas = 117.2, riverine = 64.0, and Las Palomas = 37.5. Rock squirrels were not photographed at upland sites. Rock squirrels were relatively abundant along the Río Cocóspera and Las Palomas, moderately abundant in tributaries to Las Palomas, and uncommon or absent elsewhere.

Behavior: The species was strongly diurnal and activity peaked from 1200 to 1400 hrs (Figure 14), but some activity occurred at dusk. No rock squirrels were photographed or observed after dark. Peak monthly activity occurred in April (2.68 monthly adjusted events) and September (3.97 monthly adjusted events). Only one event (0.05 monthly adjusted events) was recorded in February and relatively few were tallied in December (0.50 monthly adjusted events) and January (0.40 monthly adjusted events). High levels of activity in April might result from males searching over large areas for estrous females (Ortega 1990). Rock squirrels are thought to reduce activity or become dormant in winter (Hoffmeister 1986), which would explain low monthly adjusted events from December through February. On 21 December 2015 at 1357 hrs, a bobcat was photographed at Las Palomas (site ALP4) carrying what was probably a rock squirrel in its mouth.

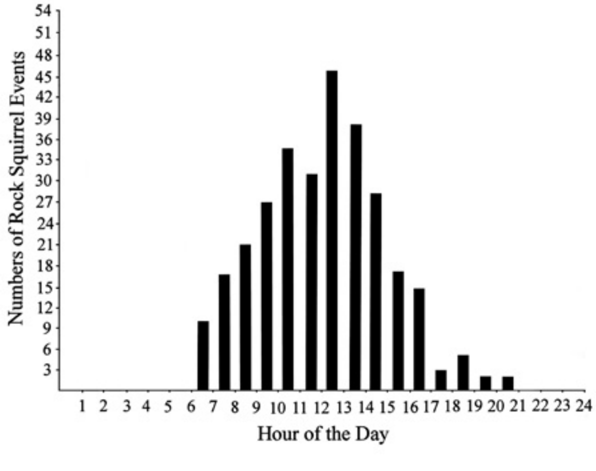

Figure 14. Rock squirrel 24-hr activity pattern.

Interaction with Cattle and Important Habitat Variables: We recorded 132 rock squirrel events during 202 camera months without cattle and 22 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a rock squirrel event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on rock squirrel events, or the difference between the two ratios equals zero), we would expect 122 events during months without cattle and 32 with cattle. The calculated z statistic is 1.51, thus we cannot reject the null hypothesis and our data provide no evidence that cattle presence affects rock squirrel events.

Rock squirrels were photographed at 20 camera sites and not photographed at 24 sites where the camera was operated for at least 40.3 days (the mean number of camera days necessary to photograph a rock squirrel event at the 20 sites where they were photographed). The logistic regression model fit the data excellently. The model is a good predictor of sites where rock squirrels are present and predicts absence only slightly less well (Table 6). Less accuracy in predicting absence is to be expected as some of the sites at which rock squirrels were not photographed were probably suitable for the species, and if we had extended the camera-trapping effort longer, the species may have been detected at those sites. None of the habitat variables individually had a significant effect on rock squirrel presence, making it difficult to determine which variables were most important to the model's predictive ability. The three variables in the model that came closest to significance were the anthropogenic influences index, distance to a dirt road, and distance to a riparian vegetation community. Sites where rock squirrels were photographed had a mean anthropogenic influence index of 2.38 versus 4.95 at sites where the species was not photographed (Table 5). These data would suggest that rock squirrels may be sensitive to human disturbance; however, the analysis from the Las Palomas and vicinity sites above suggests they are not sensitive to concentrations of cattle. The anthropogenic influences index includes types of disturbance other than cattle, and perhaps rock squirrels are more sensitive to those than cattle alone. Sites with rock squirrels were, on average, 0.27 km from an unpaved road versus a mean of 0.18 km for sites where the species was not photographed (Table 5), which is suggestive, but not conclusive that rock squirrels may avoid areas around unpaved roads. Sites where rock squirrels were photographed were, on average, only 0.05 km from a riparian vegetation community, whereas sites where they were not photographed were, on average, 0.52 km from riparian communities. This is consistent with the site type analysis, above, which showed rock squirrels to be relatively abundant at riverine and Las Palomas sites, which have riparian trees. Rock squirrels appear to be associated with riparian habitats at Rancho El Aribabi. Percent canopy cover had a very small model equation coefficient; the means were similar between sites with and without photo captures, and it did not approach significance, indicating it had very little influence on rock squirrel presence. As a result, it was removed from the equation as presented in Table 6.

Sciurus arizonensis, Arizona Gray Squirrel (Ardilla de Arizona)

The Arizona gray squirrel has a limited distribution in Mexico and is known only from northeastern Sonora (Ceballos et al. 2014; Caire 2019). Caire (2019) lists only four Sonoran localities for this species. The nearest to Rancho El Aribabi are "30 mi E Magdalena" and "27 mi S Nogales". The former is in the Sierra Azul south of Rancho El Aribabi, whereas the latter is likely in the Sierra Los Pinitos to the west of the ranch. Arizona gray squirrels tend to use unburned riparian woodland or forest in montane settings (Brown 1984; Hoffmeister 1986; Ketcham et al. 2017). The MDE database contains three Rancho El Aribabi records for this species, two from the Río Cocóspera and one from Arroyo Los Amorosos in the foothills of the Sierra Azul (Figure 2). The latter site is in an area of oak woodland. One of the Río Cocóspera records includes a notation that the squirrel was eating Arizona walnut (*Juglans major*) nuts.

Relative Abundance and Local Distribution: We photographed Arizona gray squirrels at seven of the 50 camera trap locations (Figure 15). All were along the Río Cocóspera. Of 47 events, 46 were in Fremont cottonwood-Goodding willow riparian forest. One was in a velvet mesquite-netleaf hackberry woodland.

Figure 15. Arizona gray squirrel, site R17, 18 Dec 16, 1537 hrs.

Behavior: Twenty-seven of 47 events (57%) showed Arizona gray squirrels traversing downed logs that crossed the river. All of our camera trap records of this species were during daylight hours with peaks from 0900 to 1100 hrs and 1500 to 1600 hrs (Figure 16). Gurnell (1987) found that Arizona gray squirrels have activity peaks in the morning and late afternoon during summer. No Arizona gray squirrels were photographed in September or October. Peak numbers (0.55 monthly adjusted events) were in February. We occasionally visually observed this species during the day, usually in large trees along the river in Fremont cottonwood-Goodding willow riparian forest (Figure 17).

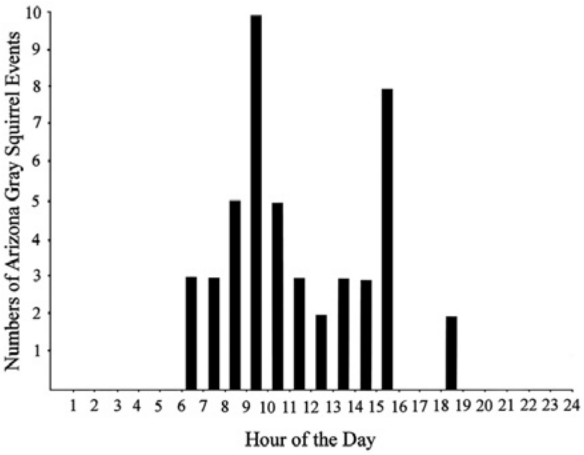

Figure 16. Arizona gray squirrel 24-hr activity pattern.

Figure 17. Arizona gray squirrel, Río Cocóspera, 20 Nov 16, 1046 hrs.

Interaction with Cattle and Important Habitat Variables: Due to the limited number of sites where Arizona gray squirrels were photographed (seven) and absence of events at Las Palomas, we neither evaluated effects of cattle on Arizona gray squirrel occurrence, nor conducted binary logistic regression to identify important habitat variables.

HETEROMYIDAE

Dipodomys merriami, Merriam's Kangaroo Rat (Rata Canguro de Merriam)

This species is locally abundant and widely distributed in northern Mexico and the southwestern USA (Burt and Grossenheider 1980; Ceballos 2014). The nearest records to Rancho El Aribabi according to Caire (2019) are in the Río Bambuto Valley to the west of the ranch, although most records are from the western deserts (Alvarez-Castañeda and Patton 1999). Neither of those publications nor the MDE database list any Merriam's kangaroo rat records for Rancho El Aribabi.

Local Distribution: We include it on our list based on two camera trap events: (1) 28 November 2016 at 0346 hrs in a velvet mesquite bosque on the Río Cocóspera (3 images, site R7), and (2) 15 August 2017 at 2347 hrs from a ridgeline in velvet mesquite grassland about 1.1 km SE of La Casona (6 images, site RG2). The images are not adequate to see key diagnostic species-specific characters, but the only other kangaroo rats in northeastern Sonora are Ord's kangaroo rat (*Dipodomys ordii*) and the bannertail kangaroo rat (*Dipodomys spectabilis*) (Ceballos 2014; Caire 2019). Ord's kangaroo rat is typically a grassland species with a limited distribution in Sonora, and the bannertail kangaroo rat has a distinctly bicolored tail that we likely would have seen in our images. Also, bannertail kangaroo rats build distinctive burrow complexes (Hoffmeister 1986) that we have not observed at Rancho El Aribabi.

Chaetodipus penicillatus, Desert Pocket Mouse (Ráton de Abazones Desértico)

This species is distributed widely in a variety of open and typically arid vegetation communities in Sonora (Caire 2019) and southern and western Arizona (Hoffmeister 1986), with high densities in riparian woodlands (Stamp and Ohmart 1979). Elevational range in Mexico is 70 to 1800 m (Ceballos 2014). We are not aware of any previous records for Rancho El Aribabi.

Local Distribution: We captured 13 desert pocket mice in our Sherman traps, including eight in a velvet mesquite bosque along the Río Cocóspera and five in velvet mesquite grassland. Four females captured on 8 August 2007 in a velvet mesquite bosque, five females captured in velvet mesquite grassland on 21 June 2007, and one female from a velvet mesquite bosque captured on 22 September 2006 were all in a non-reproductive (non-lactating) state. All of our captures were near La Casona at elevations of 982 to 995 m, but this species likely occurs throughout much of the ranch, including fairly open vegetation communities such as Sonoran desertscrub-foothills thornscrub ecotone.

GEOMYIDAE

Thomomys bottae, Botta's Pocket Gopher (Tuza Norteña)

This is the common pocket gopher throughout much of northwestern Mexico south to Sinaloa and in much of the Baja California peninsula (Ceballos 2014). We found no previous records for the ranch, but it is the pocket gopher expected at Rancho El Aribabi (Alvarez-Castañeda and Patton 1999; Caire 2019).

Local Distribution: Although we did not capture or directly observe this species, its distinctive mounds at the entrances to burrows were noted in many places, particularly where soils are deep and friable, allowing for burrow construction. Although we often found burrows on the higher terraces of the Río Cocóspera where velvet mesquite and netleaf hackberry are dominant, burrows in the active floodplain were rare and pocket gophers there are subject to periodic flooding and drowning. Vegetation communities in which Botta's pocket gopher burrows and mounds were found include Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland, velvet mesquite-oak savanna, montane arroyos, and a netleaf hackberry arroyo in velvet mesquite grassland.

CRICETIDAE

Neotoma albigula, White-throated Woodrat (Rata Cambalachera Garganta Blanca)

The white-throated woodrat is widely distributed in northwestern Mexico and adjacent Arizona, and in Sonora it occurs in a variety of vegetation communities from low, arid deserts upslope into woodlands at moderate elevations (Hoffmeister 1986; Alvarez-Castañeda and Patton 1999; Ceballos 2014; Caire 2019). It is the only *Neotoma* expected throughout most of Rancho El Aribabi; however, the Mexican woodrat (*Neotoma mexicana*), typically found at higher elevations in the eastern portions of Sonora, could conceivably occur high in the Sierra Azul. We found no previous records of *Neotoma* from Rancho El Aribabi. A Río San Pedro record for the white-throated woodrat is roughly 60 km NE of the ranch (Burt 1938), and Alvarez-Castañeda and Patton (1999) list records for Nogales and Magdalena, 60 km NNW and 38 km SW of Rancho El Aribabi, respectively.

Local Distribution: One male and one lactating female identified as white-throated woodrats were captured in Sherman traps 21 June 2007 in a velvet mesquite grassland just west of La Casona at 995 m elevation. The female had a botfly cyst on her neck. *Neotoma* were photographed by two of our camera traps, both on the Río Cocóspera; one in a velvet mesquite bosque (site R7), the other in a velvet mesquite-netleaf hackberry woodland (site R3). The distinctive nests of *Neotoma* were often observed in a variety of vegetation communities, particularly around rock outcrops, downed woody debris, and large prickly pear (*Opuntia* spp.) and cholla (*Cylindropuntia* spp.) cacti. In addition to the two riverine vegetation communities and velvet mesquite grassland captures noted above, we observed *Neotoma* nests in a montane arroyo and velvet mesquite-oak savanna. Elevations of our observations ranged from 985 to 1346 m.

Peromyscus maniculatus, North American Deermouse (Ráton Norteamericano)

Although widely distributed in Mexico and the USA, in Sonora the North American deermouse is restricted to the northeastern portion of the state near the international border, along the Río Colorado, and possibly in desert portions of northwestern Sonora (Ceballos 2014; Caire 2019). This species is similar to *P. leucopus*, which also occurs in northeastern Sonora; however, based on a more distinctly bicolored tail and shorter head and body length of the mice we captured, we believe the animals we trapped were *P. maniculatus*.

Local Distribution: Three individuals of this species were captured in Sherman traps, including a male in a velvet mesquite bosque on 21 June 2007 (Figure 18), another male in a velvet mesquite bosque on 8 August 2007, and a lactating female trapped on the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest on 21 June 2007. All captures were within 2 km of La Casona. A *Peromyscus* that may have been this species was photographed at camera site R18 in Fremont cottonwood-Goodding willow riparian forest on the Río Cocóspera.

Figure 18. Deermouse, velvet mesquite bosque, Río Cocóspera, 21 June 2007.

ERETHIZONTIDAE

***Erethizon dorsatum*, North American Porcupine (Puercoespín Norteamericano)**

We are aware of only four previous records of the North American porcupine from Sonora. Caire (2019) lists three, including two from the deserts west of Hermosillo, one from "13 miles N of Ímuris" (Jones and Genoways 1968), and the MDE database lists one from the northern end of the Sierra Los Ajos ENE of Cananea. The latter record is the only camera-trapped North American porcupine of which we are aware in Sonora. We did not photograph this species and none of the camera trap studies discussed elsewhere in this report for Sonora reported North American porcupines, although Ceballos (2014) shows this species occurring throughout the state. Culver (2016) recorded no North American porcupines in her camera trap studies from 2012 to 2015 in southeastern Arizona and southwestern New Mexico. That project has continued as a citizen science project and, as of December 2020, still no American porcupines have been documented (Susan Malusa, pers. comm. 2020). Yet, Hoffmeister (1986) lists six records for Cochise County in and near areas where Culver worked. In addition, in 2020 several North American porcupine images were obtained during a Sky Island Alliance camera trap project along the U.S./Mexico border from the Patagonia Mountains east to the Huachuca Mountains in Arizona (E. Burns, pers. comm., 2020). Hoffmeister (1986) characterizes the distribution of this species as "throughout much of Arizona in forested mountainous areas as well as riparian areas at lower elevations; absent or rare in desert areas." One of us (Scott Richardson) captured and relocated a North American porcupine from a residence in the Sonoran Desert of northwestern Tucson in 1994.

Local distribution: Our only records of this species from Rancho El Aribabi and adjacent areas come from the recollections of Robles family members and ranch staff. A vaquero at El

Aribabi recalled seeing this species in the Río Cocóspera Valley, both at Rancho El Aribabi and in adjacent areas. Carlos Robles Elías remembered seeing one in the Los Amorosas-Agua Fría area, and his dogs came back from that area with porcupine quills in their noses. Carlos Armando Robles saw one on the ranch when he was a child. All of these observations are 20 to 30 or more years old. In the Rincon Mountains of southeastern Arizona, Swann (2011) believed the North American porcupine was declining and might be extirpated. However, North American porcupines may not be easily captured by camera traps. It reportedly spends much of its time in trees where it would not be captured by our cameras. It is unknown if this species still occurs at Rancho El Aribabi.

SORICIDAE

Notiosorex sp., Cockrum's Gray Shrew or Crawford's Gray Shrew (Muraraña Desértica Morteña)

Notiosorex cockrumi was split from *N. crawfordi* by Baker et al. (2003) who noted various subtle morphological differences between the two. Caire (2019) noted only four localities for *N. "crawfordi"* in Sonora, which could have included *N. cockrumi*, including two in the Río Bambuto-Río Magdalena Valley to the west of Rancho El Aribabi. At one of those sites, the remains of 35 specimens were recovered from owl pellets (Bradshaw and Hayward 1960). The MDE database includes five records of *N. "crawfordi"* for Sonora, including two also listed by Caire (2019). Two records, both from this study, are listed in the MDE database for Rancho El Aribabi.

Local distribution: On 20 June 2007, we found a *Notiosorex* shrew under a log on the edge of the floodplain of the Río Cocóspera in Fremont cottonwood-Goodding willow riparian forest 0.46 km SW of La Casona at an elevation of 990 m. On 28 November 2015, another shrew was found under a board at an old corral in velvet mesquite grassland about 2.3 km SE of La Casona at 1031 m (Figure 19). Unfortunately, we cannot determine which species of *Notiosorex* these two observations represent. Diagnostic characters, such as overall body length and percentage of total body length represented by the claw on the middle digit of the manus, are best assessed with specimens, rather than live individuals (Carraway 2007). We did not have required permits to collect mammals.

*Figure 19. Shrew (*Notiosorex crawfordi *or* N. cockrumi*), velvet mesquite grassland, 28 Nov 15, 1555 hrs.*

FELIDAE

Leopardus pardalis, Ocelot (Ocelote)

The ocelot is a medium-sized spotted cat distributed from southern Texas and southern Arizona to South America and adjoining islands. The species is well-distributed in eastern Sonora, mostly at middle to lower elevations (López-González et al. 2003; Ragan et al. 2022; Van Devender et al. in press; MDE database). During 2007 to 2011 and in our work from 2014 to 2018, at least 18 different ocelots, including males and females and a kitten that was trailing behind an adult female, were photographed (Rorabaugh et al. 2020). This population is the northern-most known breeding population of ocelots (Rorabaugh et al. 2020), although breeding may occur even farther north in areas not well studied.

Local Distribution: Ocelots were first documented at Rancho El Aribabi by Avila-Villegas and Lamberton-Moreno (2013) at Las Palomas and adjacent drainages in the Sierra Azul during a camera trap project from 2007 to 2011. They photographed ocelots at five camera sites. We photographed them at 19 of 50 camera sites (Figures 20 and 21). Ninety-one ocelot events were documented by us. Ocelots were detected in two discrete areas of the ranch, including the Río Cocóspera riparian corridor and at Las Palomas and its tributaries in the Sierra Azul. One individual was also photographed in the foothills of the Sierra Azul (camera site U1) between those areas. Vegetation communities in which we photographed ocelots included Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, montane arroyo, and Sonoran desert-foothills thornscrub ecotone. The elevational range of our detections was 972 to 1406 m. This species was not photographed at cattle tanks, although proximity of permanent water was an important factor in predicting ocelot presence according to a logistic regression model (Rorabaugh et al. 2020). Fourteen of 91 events (15%) showed ocelots traversing a fallen log over the Río Cocóspera.

Figure 20. Ocelot, site R1, 24 Mar 17, 0312 hrs.

Figure 21. Ocelot, site ALP5, 24 Sep 16, 0836 hrs.

Relative Abundance: We calculated the mean number of camera days per ocelot event for each of the camera site types as follows: upland = 470.2, riverine = 384.2, tributaries to Las Palomas = 210.9, and Las Palomas = 159.5. Ocelots were not photographed on ridgelines or at cattle waters. Relative abundance of ocelots was greatest at Las Palomas and its tributaries.

Behavior: No ocelots were documented moving between the Río Cocóspera and the Las Palomas area, and no individual ocelots were photographed in both of the time periods (2007 to 2011 and 2014-2018) studied by Avila-Villegas and Lamberton-Moreno (2013) and Rorabaugh et al. (2020). Maximum documented movements by Rancho El Aribabi ocelots was 2.38 km (Rorabaugh et al. 2020). However, in other areas, movements of up to 50 km have been documented (Booth-Binczik 2007; Culver 2016). Although we photographed ocelots most hours of the day and night, activity was primarily nocturnal with an activity peak from 0100 to 0300 (Figure 22)

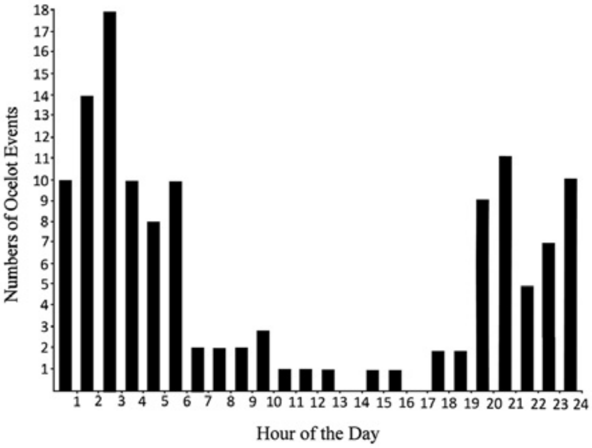

Figure 22. Ocelot 24-hr activity pattern.

Interactions with Cattle and Important Habitat Variables: Ocelots were sensitive to various forms of human disturbance at Rancho El Aribabi, including concentrations of cattle (Rorabaugh et al. 2020). Means for logistic model variables at sites where ocelots were and were not photographed are displayed in Table 5. Further details of our work on ocelots at Rancho El Aribabi can be found in Rorabaugh et al. (2020).

Lynx rufus, Bobcat (Gato Montés)

The bobcat is a medium-sized cat that is widely distributed in North America from southern Canada to Oaxaca, Mexico. It occurs in a broad range of vegetation communities and types of terrain, and from sea level to 3600 m elevation (Ceballos 2014). Although based on relatively few records, Alvarez-Castañeda and Patton (2000) and Caire (2019) depicted the range of the bobcat to include all of Sonora. The MDE database contains 233 bobcat records for Sonora, mostly from the northeastern portion of the state. Many of those records are from camera trap projects. The database includes seven bobcat records from Rancho El Aribabi, all of which are in the lower portions of the Sierra Azul at elevations of 1012 to 1442 m in velvet mesquite-oak savanna, oak woodland, and Sonoran desertscrub-foothills thornscrub ecotone. Most of those records are from the 2007 to 2011 camera trap project by Avila-Villegas and Lamberton-Moreno (2013).

Local Distribution: Our camera traps yielded 198 bobcat events at 32 of our 50 camera sites (Figures 23 and 24). Camera sites where bobcats were photographed were characterized by Fremont cottonwood-Goodding willow riparian forest, the ciénega, velvet mesquite bosque, velvet mesquite-hackberry woodland, Sonoran desertscrub-foothills thornscrub ecotone, velvet mesquite grassland, and montane arroyos. Bobcats were found along the Río Cocóspera corridor, on the bajada, and in the Sierra Azul. They also frequented cattle tanks and were photographed on ridgelines. We also visually observed this species twice – once late at night walking along the road adjacent to La Casona and once along the Río Cocóspera. The latter individual was during the day, and when it spotted us, it ran away, splashing through the river on its way. Elevational range of our bobcat localities was 972 to 1406 m. Bobcats were photographed in 25 events (13% of the total events) traversing logs that crossed the river.

Figure 23. Bobcat, site R17, 22 Nov 16, 1651 hrs.

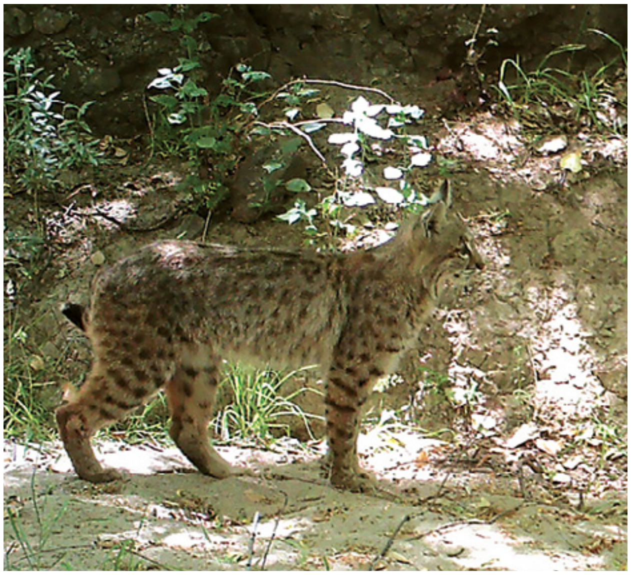

Figure 24. Bobcat, site R1, 26 May 17, 1102 hrs.

Relative Abundance: We calculated the mean number of camera days per bobcat event for each of the camera site types as follows: cattle waters = 250.2, Las Palomas = 159.5, upland = 134.3, tributaries to Las Palomas = 124.1, riverine = 87.0, and ridgelines = 43.8. Bobcats were relatively abundant along the Río Cocóspera and on ridgelines, moderately abundant at upland sites and Las Palomas and its tributaries, and uncommon at cattle waters.

Behavior: At Rancho El Aribabi, the bobcat was a solitary animal; we never photographed more than one bobcat in an event. A juvenile, noticeably smaller than the adults, was photographed crossing a log over the Río Cocóspera at 1754 and 2314 hrs on 20 November 2016. The same or similar juvenile was photographed crossing the same log on 14 December 2016 at 0313 and 0539 hrs. Kittens are dependent on their mother for about the first seven months of life and then spend progressively more time away from their mother (Griffith et al. 1980; Sunquist and Sunquist 2002); however, they do not attain adult size until age 2.5–3.5 years (Parker and Smith 1983; Rolley 1987). The juvenile(s) we photographed were likely kittens old enough to roam without their mother but had not yet attained adult size.

Two events showed bobcats carrying prey in their mouths. On 11 November 2015 at 1722 hrs, a bobcat was photographed along the road adjacent to La Casona (camera site R21) carrying what appeared to be a small desert cottontail. On 21 December 2015 at 1357 hrs, a bobcat was photographed at Las Palomas carrying what was probably a rock squirrel (site ALP4). Bobcats were active day and night with no clearly discernable hourly activity peaks (Figure 25). November through January yielded the greatest number of monthly adjusted events (4.21). Only 0.06 bobcat adjusted event was tallied in August and 0.50 was recorded in July.

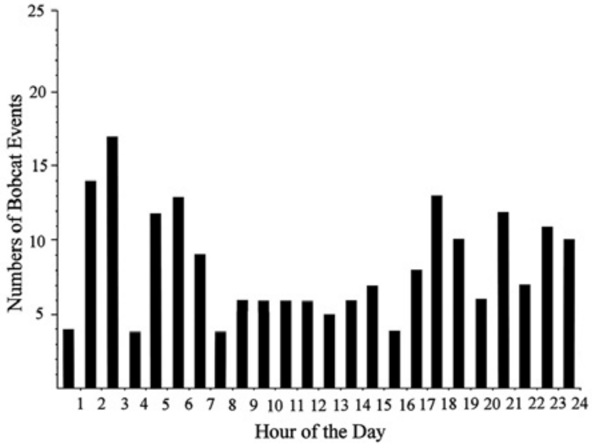

Figure 25. Bobcat 24-hr activity pattern.

Interaction with Cattle and Important Habitat Variables: We recorded 43 bobcat events during 202 camera months without cattle and nine events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a bobcat event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on bobcat events, or the difference between the two ratios equals zero), we would expect 41 events during months without cattle and 11 with cattle. The calculated z statistic is 1.10, thus we cannot reject the null hypothesis and our data provide no evidence that cattle presence at the Las Palomas and vicinity sites affected bobcat events.

Bobcats were photographed at 32 camera sites and not photographed at 12 sites where the camera was operated for at least 76.3 days (the mean number of camera days necessary to photograph a bobcat event at the 32 sites where they were photographed). The logistic regression model is a reasonably good fit to the data. The model is a good predictor of sites where bobcats are present but a very poor predictor of where they are absent. The only dependent variable in the model that rose to the level of significance was the anthropogenic influences index (Table 6). The mean value for that index was 3.80 at sites where bobcats were photographed versus 5.84 where they were not photographed, indicating bobcats tend to occur at sites with less human disturbance (Table 5). The anthropogenic influences index was dominated by cattle events, but the Las Palomas analysis above showed no evidence of cattle concentrations at the Las Palomas and vicinity sites affecting bobcat events. The index includes other types of human disturbance and possibly the bobcat is sensitive to those. As discussed elsewhere, cattle at Las Palomas were often concentrated around waters whereas on the Río Cocóspera grazing was more dispersed. Bobcats may have responded to those grazing regimes differently. In the model equation, the coefficients for percent canopy cover and shrub cover were both less than 0.01, thus they were removed from the equation as presented in Table 6. These two variables also did not approach significance and their means were similar at sites where bobcats were or were not photographed (Tables 5 and 6), further indicating very little effect on bobcat presence or absence.

Bobcat and Ocelot Interactions: Bobcats and ocelots are similar in size and have similar diets (Sunquist and Sunquist 2002), so there is a potential for competition for prey and habitat space. In areas of southern Texas where bobcats and ocelots are sympatric, there was substantial evidence for habitat partitioning with ocelots selecting areas with greater than 75% canopy cover, while bobcats selected areas with less than 75% canopy cover, where canopy was defined as vegetation more than one meter above the ground (Horne et al. 2009). The authors worked in a thornscrub community in which most of the canopy was relatively short. Mesquite was often the tallest shrub or tree.

At Rancho El Aribabi, ocelot and bobcat were often photographed at the same camera sites. Of the 19 camera sites where ocelots were photographed, bobcats were photographed at 15 of them (Appendix 2). The four ocelot sites without bobcat images included one on the Río Cocóspera in Fremont cottonwood-Goodding willow riparian forest and three at Las Palomas. Bobcats were photographed at 32 sites, 16 of which also yielded ocelot images. Bobcats were photographed at cattle tanks (3 sites) and ridgelines (4 sites), two camera site types where ocelots were not photographed. Our analyses of site types showed the bobcat to be most abundant in riverine sites and on ridgelines, whereas ocelots were most abundant at Las Palomas and its tributaries. The ocelot was primarily nocturnal (Figure 22) compared to the bobcat, which was active by day and night (Figure 25). We did not characterize canopy cover the same as in the

Texas study mentioned above; however, canopy (> 1.8 m) and shrub/ground layer (≤ 1.8 m) vegetation cover were similar for bobcat and ocelot camera sites (Table 5). Mean percent canopy cover where ocelots were photographed (79.10) was only slightly higher than sites where bobcats were photographed (72.92). As described above for the logistic regression model, vegetation cover had a negligible effect on predicting bobcat presence or absence. The same was true for ocelots (Rorabaugh et al. 2020). If numbers of bobcat affected numbers of ocelot, or vice versa, we might expect bobcat and ocelot events per camera day to be inversely correlated over time. However, numbers of bobcat and ocelot events per camera day varied similarly across the four years of the study (Figure 26). Those numbers are correlated (r = 0.766) and the correlation is significant (p = 0.027). Consequently, we find no evidence that ocelots and bobcats competed for resources at Rancho El Aribabi. As described above, our data indicate bobcats and ocelots use site types on the ranch to differing degrees and their activity periods differ somewhat, possibly allowing spatial and temporal avoidance of each other.

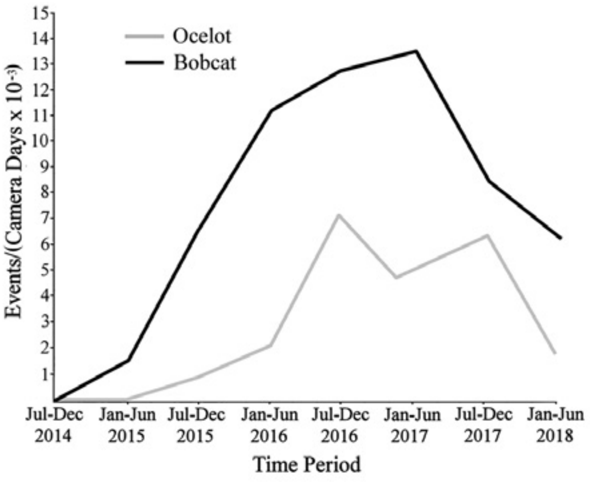

Figure 26. Ocelot and bobcat events per camera days (x10^{-3}) plotted over the course of the study. We omitted data from July to Dec 2018 because few cameras were operated in that period.

Puma concolor, Puma (Puma)

The puma has the largest range of any terrestrial mammal in the Western Hemisphere, from northern British Columbia south to near the southern tip of South America (Sunquist and Sunquist 2002). In Arizona and Sonora, it inhabits a wide variety of biotic communities from low, hot deserts to high in the mountains (Hoffmeister 1986; Alvarez-Castañeda and Patton 2000; Shaw et al. 2007; Caire 2019). Although Caire's (2019) shaded distribution map shows pumas inhabiting the entire state of Sonora, he only lists five localities. Camera traps have provided an efficient means to document this otherwise secretive predator, and as a result, the MDE database contains 209 puma records for Sonora, including 10 for Rancho El Aribabi. All but one of those latter records come from the 2007–2011 camera trap study by Avila-Villegas and Lamberton-Moreno (2013). Puma localities from the MDE database include Las Palomas, Arroyo Los Amorosos, Agua Fría, the Sierra Azul, and on the bajada of the Sierra Azul at elevations of 1022 to 1442 m. Those records were in Sonoran desertscrub-foothills thornscrub ecotone, velvet mesquite grassland, oak woodland, and oak-velvet mesquite savanna.

Local Distribution: Our cameras captured 446 puma events at 35 of 50 camera sites (Figures 27 and 28). These sites were in Fremont cottonwood-Goodding willow riparian forest, the ciénega, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland, a velvet mesquite-hackberry arroyo in velvet mesquite grassland, and montane arroyos at elevations of 968 to 1406 m.

Relative Abundance: We calculated the mean number of camera days per puma event for each of the camera site types as follows: cattle waters = 917.3, upland = 313.3, ridgelines = 70.7, riverine = 44.8, Las Palomas = 36.3, and tributaries to Las Palomas = 33.0. Pumas were relatively abundant

Figure 27. Puma, site R17, 18 June 17, 1144 hrs.

Figure 28. Puma, site ALP5, 2 September 2015, 1710 hrs.

at Las Palomas and its tributaries and along the Río Cocóspera, moderately abundant on ridgelines, and uncommon elsewhere.

Behavior: Sixteen events (4%) showed pumas crossing logs over the Río Cocóspera. One of those pictures showed a puma clawing at the log with its front paws. Scent marking and or urination was frequently photographed, with animals squatting and depositing urine or scent. At a tributary to Las Palomas, pumas used the same small rock as a scent marking station four times from 22 July to 13 November 2016. Others walked by and sniffed at that rock, as did javelina. A javelina scent-marked the rock on 25 August 2016. However, no other scent marking was observed at that rock or otherwise within the camera's view for the remainder of the camera's operation from 28 November 2015 to 4 November 2017. A puma was photographed drinking from ephemeral flow in a tributary to the Río Cocóspera on 8 July 2016 and from the stream in Las Palomas on 21 January 2018. We visually observed puma only once; an individual in the morning drinking from the Río Cocóspera near camera site R8.

Twice we obtained video clips of pumas interacting with each other in what appeared to be play. On 28 March 2016, 0537-0547 hrs, we video recorded an adult walking along a trail toward the camera (site ALP7). A subadult jumped from nearby vegetation and tackled the adult. They rolled off the trail into tall herbaceous vegetation and grasses. On 26 August 2017, 1756 hrs, we video recorded a subadult walking along an arroyo (site R3). Another subadult emerged from adjacent vegetation; the two tussled briefly and then ran off together.

Puma activity peaked during 0700-0800 and 1900-2100 hrs, but the species was active both day and night. Minimal activity occurred during the middle of the day at 1200-1300 hrs (Figure 29). Similar crepuscular activity peaks were documented at the Northern Jaguar Reserve and surrounding ranches in east-central Sonora (Gutiérrez-González and López-González 2017). Puma events were fairly well-distributed throughout the year. The fewest numbers of monthly adjusted events were in February (1.01), August (1.61), and September (1.46), whereas the greatest numbers were tallied in November (3.05), January (2.83), and March (2.77).

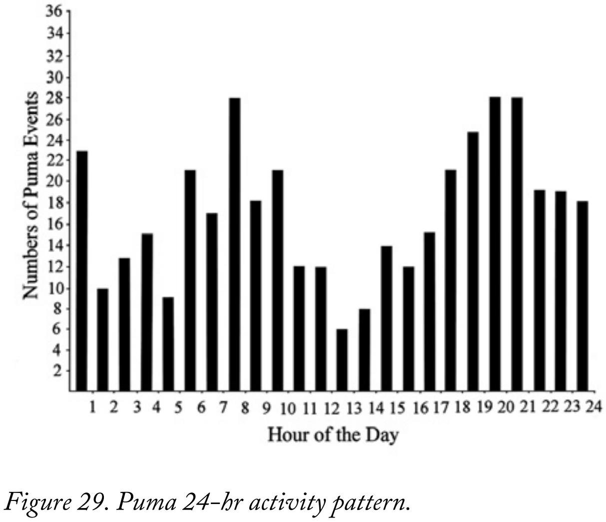

Figure 29. Puma 24-hr activity pattern.

Most puma events were of single animals; however, 19 events captured two, seven captured three, and one captured four pumas. Although male and female pumas associate for mating, typically the only prolonged contact is between females and their kittens or subadult offspring (Sunquist and Sunquist 2002). In most cases where more than one puma was photographed, it was clearly an adult with kittens or subadults. Young pumas remain with their mothers for 10 to 21 months (Ross and Jalkotzy 1992), becoming independent usually before reproductive maturity (Sunquist and Sunquist 2002). Kittens have spots that begin to fade at at an age of three or four months and become obscure at about 10 months (Toweill 1986; Sunquist and Sunquist 2002; Shaw et al. 2007). Spotting and the size of kittens can provide estimates of reproductive timing. On 30 September 2015, we photographed a female with three quite small and strongly spotted kittens at Las Palomas. We estimate the kittens were no more than two months old, suggesting parturition early in the summer rainy season. These were the only strongly spotted kittens we photographed. However, on 6 October 2015 and also in Las Palomas, we photographed a female with two larger kittens with faint spotting. The kittens were probably 5-10 months old suggesting an extended breeding season.

We documented predation by a puma once (Figure 30a-k). In the narrows at Las Palomas (camera site ALP6), at 1242 hrs on 18 January 2018, we obtained a picture of a puma atop a white-tailed deer buck and holding the deer's nape of the neck in its jaws (Figure 30a). The pair rolled and fought at the edge of a stream. The deer used its right hind hoof to push or kick at the puma, but by 1253 hrs the deer was incapacitated or dead. At 1320 hrs the puma dragged the carcass about 3 m away from the stream bottom and began to feed on it through the abdomen (Figure 30c). Beginning at 1419 hrs, the puma attempted to cover the carcass with leaves and soil, scratching at the ground with its front paws (Figure 30e). At 1815 hrs, it moved the carcass another meter or so from the water and again attempted to bury it with leaves and soil. Soils were shallow over the granite bedrock in this canyon and fallen leaves were in relatively short supply, but photographs at 0800 hrs on the 19th show the carcass to be fairly well hidden. The puma returned from 1705 to 1751 hrs on the 19th to feed on the carcass again, this time focusing on the breast and muscles of the front legs and shoulder (Figure 30f). The puma returned to feed again at 0254-0314, 0754-0811, and 1019-1020 hrs on the 20th. The camera did not document feeding on the 21st, but the carcass was moved slightly and covered again with soil and leaves. The puma was photographed drinking from the stream at 1104 hrs on the 21st (Figure 30j). On the 22nd, the puma fed again on the carcass from 1615 to 1629 hrs. Feeding occurred again at 0711 hrs on the 23rd and the puma drank from the stream again at 0903 hrs. From 1411-1429 hrs on 23 January a coyote was photographed investigating the carcass. At 1429 hrs the coyote tugged at the carcass with its jaws (Figure 30k). The carcass was gone in subsequent photos. In total, from the kill to the scavenging of the carcass by the coyote, we captured 29 events and 215 images of this predation event. When not feeding,

Figures 30a-k. Predation of an adult white-tailed deer buck by a puma in the Arroyo Las Palomas narrows (camera site ALP6), 18-23 January 2018.

Figure 30a. First picture in the series, showing the puma biting the neck of the adult white-tailed deer buck.

Figure 30b. The deer is dead or immobilized 11 minutes after the first image.

Figure 30c. The deer has been dragged away from the water and the puma is feeding through the abdomen.

Figure 30d. 91 minutes after the initial attack, the puma is still feeding.

Figure 30e. Burying the carcass, a day after the kill.

Figure 30f. The puma (in the right, lower corner) has been feeding on the breast and muscles of the front legs and shoulder region of the deer.

Figure 30g. Puma feeding on the carcass two days after the kill.

Figure 30h. Puma possibly guarding the carcass two days after the kill.

Figure 30i. Puma feeding on the carcass about 58 hours after the kill.

Figure 30j. Puma drinking, deer carcass in foreground. About four and a half days after the kill.

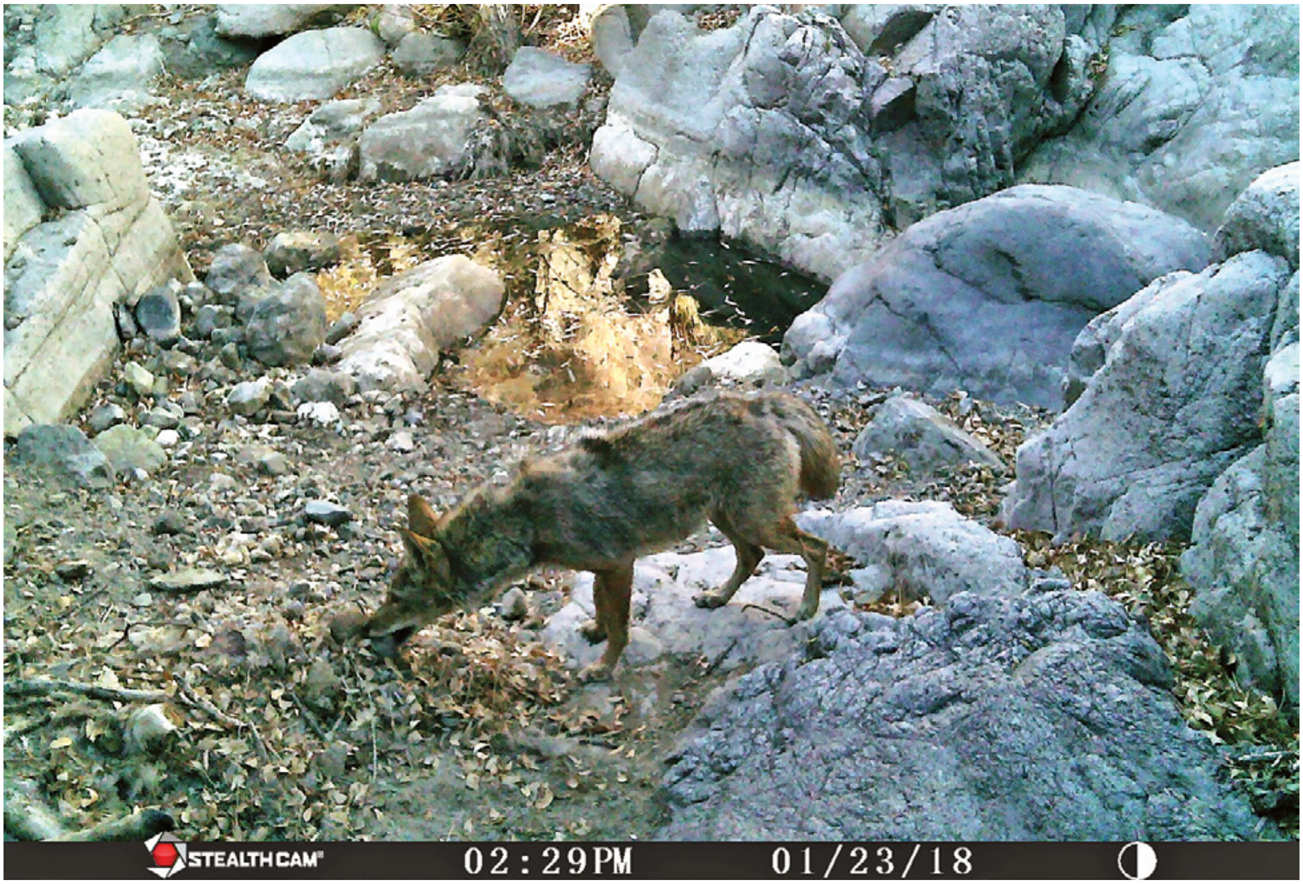

Figure 30k. Coyote tugging at the carcass on day six of the predation event. The carcass was gone in subsequent images.

drinking, or covering the carcass, the puma was often sitting on its haunches nearby looking in various directions, perhaps guarding the kill (Figure 30h).

For about four months after the predation event, other animals came to sniff at and investigate the spot where the carcass had been buried or partially buried. Javelina visited the site numerous times from 24 January to 27 April 2018. A group of four white-nosed coatis investigated and sniffed at the carcass site on 24 February 2018. A puma sniffed at the site on 8 and 13 May 2018.

Interaction with Cattle and Important Habitat Variables: We recorded 192 puma events during 202 camera months without cattle and 26 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a puma event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on puma events, or the difference between the two ratios equals zero), we would expect 173 events during months without cattle and 45 with cattle. The calculated z statistic is 3.07, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on puma events. This is interesting, because at the Northern Jaguar Reserve and surrounding ranches, Gutiérrez-González and López-González (2017) found puma distribution overlapped with calves more than white-tailed deer and javelina, suggesting a dietary preference. The difference in these results may be due to how cattle are managed at Rancho El Aribabi. All cattle in the Las Palomas area during our work were steers that were brought in to grow and fatten for approximately one year. No calves were present. In their study area north of the Northern Jaguar Reserve, Rosas-Rosas et al. (2008) found that puma predated cattle only less than one year of age and cattle comprised 9% of the prey biomass consumed by pumas. As a result, the steers at Rancho El Aribabi (which are larger and older than calves) were probably unlikely to be preyed upon by puma. Cattle are also concentrated at the limited waters in the Las Palomas area from about April through June, which may deter use by puma and other wildlife.

Puma were photographed at 35 camera sites and not photographed at 10 sites where the camera was operated for at least 44.2 days (the mean number of camera days necessary to photograph a puma event at the 35 sites where they were photographed). The logistic regression model was a good fit with the data. It predicted presence well, but was a poor predictor of sites where pumas were absent (Table 6). Two model variables rose to the level of significance in predicting puma presence: distance to water and distance to a riparian vegetation community. However, sites at which pumas were photographed were farther from water but closer to riparian trees than sites at which they were not photographed. This seems counterintuitive, because places with permanent water tend to also support riparian vegetation. But some camera sites with riparian trees, particularly at Las Palomas and its tributaries, were at some distance from permanent water, and some sites with permanent water, such as water troughs and some cattle tanks, did not support riparian trees. From the camera site analysis above, pumas were most abundant at Las Palomas and its tributaries and at riverine sites along the Río Cocóspera, all of which have riparian trees that form a forest on the river but occur as scattered individuals at Las Palomas and its tributaries. The Río Cocóspera and reaches of Las Palomas have permanent water. The canopy cover variable had a coefficient less than 0.01, so it was dropped from the model equation. This suggests canopy cover has very little effect on puma presence.

Panthera onca, Jaguar (Jaguar)

The largest felid in the western hemisphere (Seymour 1989), the jaguar has an extensive distribution ranging from the southwestern USA south to northern Argentina; however, it has been eliminated by humans in some areas and is rare in others (Sunquist and Sunquist 2003; U.S. Fish and Wildlife Service 2018). It occurs across a broad range of terrain and vegetation communities. The species is often associated with streams and other watercourses (Sunquist and Sunquist 2003). Alvarez-Castañeda and Patton (2000) mapped its distribution as throughout Sonora, but Caire (2019) more conservatively considered it as only occurring in the wetter and more topographically complex eastern portion of the state. In Arizona, only male jaguars have been detected in recent years. The last female reported was in 1963 (Brown and López-González 1999; but see Johnson et al. 2011). Immigration of jaguars from Mexico into Arizona is threatened by the U.S. Customs and Border Protection's construction of a 10-m tall border wall designed to prevent pedestrian entry (Peters et al. 2018).

Local Distribution: During our camera trap work from 2014 to 2018, we documented no jaguars at Rancho El Aribabi. However, two different adult male jaguars were photographed by camera traps in the Sierra Azul during 2010-2011 (Avila-Villegas and Lamberton-Moreno 2013). One of the jaguars was subsequently identified as an animal also photographed at the Northern Jaguar Reserve, about 200 km southeast of Rancho El Aribabi (MDE database).

CANIDAE

Canis latrans, Coyote (Coyote)

The coyote is a habitat and dietary generalist, ranging from Canada to Panama (Hall 1981, Ceballos 2014). It is the largest canid throughout most of its range; its size only exceeded by that of the wolf (*Canis lupus*), which has been eliminated from most of its range by humans (Thiel and Ream 1995). The coyote is likely distributed across the entire state of Sonora, from its hyper-arid deserts to high into the mountains (Alvarez-Castañeda and Patton 2000; Ceballos 2014; Caire 2019). The nearest locality to Rancho El Aribabi reported by Caire (2019) is "Alamo Wash", roughly 78 km to the northwest. The MDE database contains 291 coyote records for Sonora, mostly from the sky island region of the northeastern portion of the state. Seven records are listed for Rancho El Aribabi, but three plot north of the ranch boundary. On the ranch, one was near La Casona and the other three were recorded during the 2007–2011 camera trap study (Avila-Villegas and Lamberton-Moreno 2013) at Las Palomas and Arroyo Los Amorosos. Elevational range of the four valid records for the ranch is 1017–1327 m. Coyotes are often considered a pest in Sonora, and despite campaigns to control or eliminate them (Molina 1964), they are a persistent and common predator throughout much of their range.

Local Distribution: We amassed 734 coyote events at 37 of 50 camera sites. Coyotes were photographed along the Río Cocóspera, in the Sierra Azul, on the bajada, on ridgelines, and at cattle tanks and troughs at elevations of 972 to 1406 m. Vegetation communities at these sites included Fremont cottonwood-Goodding willow riparian forest, the ciénega, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, Sonoran desertscrub/foothills thornscrub ecotone, velvet mesquite grassland, a velvet mesquite-hackberry arroyo in velvet mesquite grassland, montane arroyos, and velvet mesquite and oak woodland or savanna. We occasionally visually detected coyotes in the same areas where we photographed them. Their distinctive vocalizations were often heard along the Río Cocóspera at dusk or after dark from La Casona, particularly in the last year of our work. Coyotes did not appear to avoid human habitations. Seven events were captured at a compost pile 30 m south of La Casona (site U5) and 16 events were recorded on a dirt road 20 m east of La Casona (site R21).

Relative Abundance: We calculated the mean number of camera days per coyote event for each of the camera site types as follows: tributaries to Las Palomas = 105.4, Las Palomas = 66.5, riverine = 36.4, uplands = 18.1, cattle waters = 12.3, and ridgelines = 9.3. The relative abundance of coyotes was highest on ridgelines and lowest in tributaries to Las Palomas.

The vast majority (90%) of coyote events were of single animals. Fifty-six were of two coyotes, 14 of three, and one event included five coyotes. None of the coyotes photographed were identified as juveniles or pups.

Behavior: We obtained two images (0.3% of all coyote events) of a coyote crossing a log over the Río Cocóspera, but a coyote was also photographed walking through shallow ($\leq$ 0.25 m deep) water to cross the Río Cocóspera. In an image showing three coyotes in the Río Cocóspera ciénega (site R9), one coyote was bedded down while another coyote was grooming (licking) the third coyote about the head or neck (Figure 31). We have images of coyotes drinking water, defecating and subsequent coyotes sniffing at the scat, and nine events documenting coyotes carrying prey items. Five of those prey events showed coyotes carrying pieces of a white-tailed deer, three of which were the hindquarters with an attached leg (Figure 32). Another showed a coyote carrying an antelope jackrabbit. One event showed a coyote gnawing on a bone. In two events, the prey could not be identified. We also photographed a coyote investigating a compost heap adjacent to La Casona (site U5), but the animal was not photographed feeding or carrying anything away from the site. As discussed in the puma account, a coyote investigated and then dragged away the remnants of a white-tailed deer puma kill at ALP6. Coyotes are capable of killing adult white-tailed deer, but they are more likely to kill fawns (Chitwood et al. 2015). As demonstrated here and by others, coyotes will scavenge deer carcasses (Schrecengost et al. 2008), including those killed by puma (Logan and Sweanor 2001). As a result, it is impossible to say how many of the events showing coyotes carrying white-tailed deer parts were predator kills versus scavenging. A javelina drowned in a cattle trough (site CW1) and a coyote was photographed gazing at the carcass floating in the trough, but it made no effort to retrieve it.

Figure 31. Coyotes, site R9, 26 March 2018, 0857 hrs.

Figure 32. Coyote with hindquarters of a white-tailed deer, site ALP4, 7 October 2017, 0930 hrs.

When cattle were in our images, we rarely photographed wildlife in the same photographs. Twice we photographed a coyote with cattle – once with five cows in an arroyo (site U4), and once with a single cow in the Río Cocóspera ciénega (site R9). Coyotes were active by day and night, with peak activity from 0800 to 1200 hrs and 1800 to 2000 hrs (Figure 33). Monthly activity varied considerably, with high adjusted event counts (4.89-6.30) from October through March, dropping somewhat in April (3.79) and May (2.97), and then declining precipitously in June (0.68), July (1.11), August (0.25), and September (0.32). This variability could be associated with reproduction. In Arizona, breeding probably extends from mid-January to mid-March. Young are born about two months later and they are cared for in a den for 2–2.5 months, after which the female and young move about in their habitat (Hoffmeister 1986). Presumably, females rearing their pups in a den would be less active and stay closer to the den until the young begin to move about. During this time they would likely be more difficult to capture on our cameras. The low numbers of events recorded from June through September could represent the denning period, but it would be somewhat later than that described by Hoffmeister (1986) in Arizona.

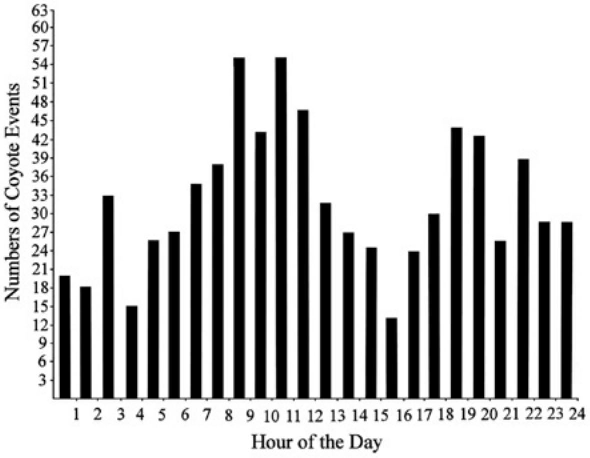

Figure 33. Coyote 24-hr activity pattern.

Coyotes were photographed infrequently in the first year of our project, but by the end of the study, numbers of coyote events per camera day had increased by 25 fold (Figure 34). This increase was noticeable in that we qualitatively heard more coyotes from La Casona late in the project. Pumas are known to prey upon coyotes (Logan and Sweanor 2001), so we would expect puma and coyote events per camera day to be negatively correlated if puma predation on coyotes affected coyote numbers, and in turn, coyote events per camera day. One of the Robles family members also told us that in the last year or so of the project, a rancher on an adjacent property was attempting to control puma numbers in order to reduce predation on calves. We plotted puma and coyote events per camera day over the course of the study in Figure 34. The two were negatively correlated (r = 0.339), but not significantly so (p = 0.412). In the last year of the project when coyote events per camera day greatly increased, puma events per camera day were relatively low, but not dramatically so. That number had been similarly low at the beginning of the project (Figure 34). Consequently, we cannot conclude from our data that puma affected coyote relative abundance, or vice versa. Although both species were photographed at most of our camera sites (37 for the coyote and 35 for the puma), they differed in relative abundance at site types. Both were relatively common at riverine sites, but the coyote was least abundant at Las Palomas tributaries where the puma was most abundant. Relative abundance of the coyote was high at cattle tanks, which is where the puma was least abundant. As a result, there appears to be some spatial segregation at Rancho El Aribabi that may reduce effects of one on the other. There is no evidence of 24-hour temporal segregation (Figures 29 and 33).

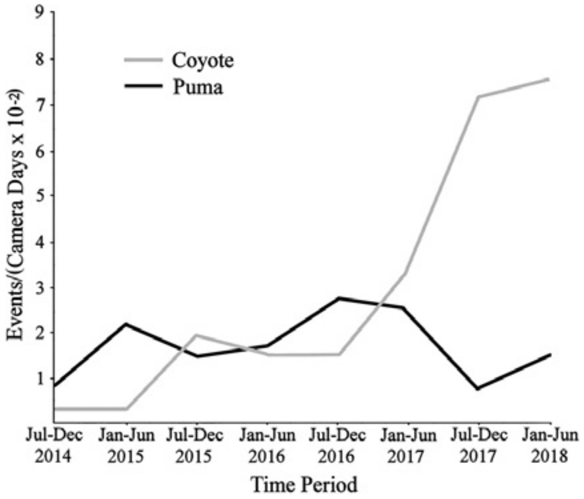

Figure 34. Coyote and puma events per camera days ($x10^{-2}$) plotted over the course of the study. We omitted data from July to Dec 2018 because few cameras were operated in that period.

Interaction with Cattle and Important Habitat Variables: We recorded 82 coyote events during 202 camera months without cattle and 18 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a coyote event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on coyote events, or the difference between the two ratios equals zero), we would expect 79 events during months without cattle and 19 with cattle. The calculated z statistic is 0.97, thus we cannot reject the null hypothesis. These data provide no evidence that cattle presence affects coyote events.

Coyotes were photographed at 37 camera sites and not photographed at nine sites where the camera was operated for at least 26.0 days (the mean number of camera days necessary to photograph a coyote event at the 37 sites where they were photographed). Because we had only nine of the latter sites, we did not conduct a binary logistic regression to determine important habitat variables for the coyote.

Urocyon cineroargenteus, Gray Fox (Zorra Gris)

The gray fox is found in a variety of vegetation communities from southern Canada south to northern Venezuela and Columbia (Fritzell and Haroldson 1982). It likely occurs throughout the state of Sonora (Alvarez-Castañeda and Patton 2000; Ceballos 2014). Caire (2019) lists records from the Río Bambuto Valley north of Ímuris and near Magdalena to the west and southwest of Rancho El Aribabi, respectively. The MDE database contains 371 records of gray fox from Sonora, mostly from the sky island region of the northeast. The MDE database lists 13 gray fox records for Rancho El Aribabi, four of which were visual observations by James Rorabaugh along the Río Cocóspera during this study. Seven others were obtained during the 2007–2011 camera trap project by Avila-Villegas and Lamberton-Moreno (2013). MDE records at the ranch are from Arroyo Guerigo – a tributary to the Río Cocóspera, Las Palomas, Arroyo Los Amorosas, the Sierra Azul, and Agua Fría. Two other MDE records plot north of the Rancho El Aribabi boundary. The 11 valid MDE records from the ranch are in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite grassland, Sonoran desertscrub-foothills thornscrub ecotone, oak woodland, and montane arroyos at elevations of 996 to 1442 m.

Local Distribution: The gray fox was the fifth-most common species photographed by our camera traps and the third most widespread species. The cameras captured 537 gray fox events at 39 of 50 camera sites (Figure 35). We photographed them in Fremont cottonwood-Goodding willow riparian forest, at the ciénega, in velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite-oak savanna, velvet mesquite grassland, Sonoran desertscrub-foothills thornscrub ecotone, a netleaf hackberry arroyo in velvet mesquite grassland, and montane arroyos at elevations of 968 to 1406 m. Gray foxes were photographed along the river corridor, on the bajada, and in the Sierra Azul, at cattle tanks and troughs, on unpaved roads, and on ridgelines. Only one gray fox event was captured at the two camera sites closest to La Casona: a compost pile 30 m south of La Casona (site U5) and a dirt road 20 m east of La Casona (site R21). Thirteen events (2% of all events) documented gray foxes crossing over the Río Cocóspera on a fallen log. The species was occasionally detected visually by us as it crossed dirt roads after dark.

Figure 35. Gray fox, site R2, 7 April 2018, 2305 hrs.

Relative Abundance: We calculated the mean number of camera days per gray fox event for each of the camera site types as follows: riverine = 90.4, cattle waters = 72.4, tributaries to Las Palomas = 54.1, Las Palomas = 29.1, uplands = 15.4, and ridgelines = 9.0. Relative abundance of gray foxes was greatest on ridgelines and at uplands sites and lowest at riverine sites along the Río Cocóspera and at cattle waters.

Behavior: Gray foxes were typically solitary, but seven events pictured two individuals. Six were in September-January and one was in late May. No noticeably smaller or juvenile individuals were seen among these pairs, nor in any other event. Gray foxes were detected every hour of the day, but tended to be nocturnal-crepuscular with activity peaks during 0400-0500 and 2000-2200 hrs (Figure 36). Monthly adjusted events peaked in November (4.04) and December (3.83) and were lowest during July (1.11), August (1.05), April (1.78), and September (1.94). Totals in other months ranged from 2.43 to 3.13. The reproductive cycle in Arizona and Sonora are not well known (Hoffmeister 1986; Ceballos 2014). However, throughout their range, the gray fox breeds from January to May, gestation takes 45-63 days, and the pups are raised in dens by the female for 10-13 weeks before they disperse (Carey 1982; Fritzell and Haroldson 1982). Given this chronology, the smaller number of gray fox events in the July-September period could have resulted from females staying in or near dens with their pups, followed by an increase in events in November and December as the young began to move about and became subject to capture by our camera traps.

Six events showed gray foxes carrying prey, including a rock squirrel (1), unidentified small animal (2), probably a Montezuma Quail (1, *Cyrtonyx montezumae*), and a mouse or kangaroo rat (1, Rodentia or *Dipodomys* sp.). Dates of these predation events ranged from 8 January to 16 August.

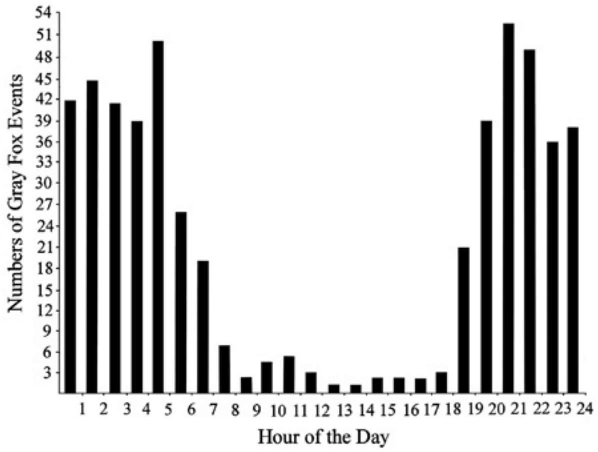

Figure 36. Gray fox 24-hr activity pattern.

Interaction with Cattle and Important Habitat Variables: We recorded 180 gray fox events during 202 camera months without cattle and 50 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a gray fox event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on gray fox events, or the difference between the two ratios equals zero), we would expect 182 events during months without cattle and 48 with cattle. The calculated z statistic is 0.27, thus we cannot reject the null hypothesis. These data provide no evidence that cattle presence affects gray fox events.

Gray foxes were photographed at 39 camera sites and not photographed at seven sites where the camera was operated for at least 34.5 days (the mean number of camera days necessary to photograph a gray fox event at the 39 sites where they were photographed). Because we had only seven of the latter sites, we did not conduct a binary logistic regression to determine important habitat variables for this species.

URSIDAE

Ursus americanus, American Black Bear (Oso Negro)

The American black bear occurs from Alaska and northern Canada southward into the Sierras

Madre Occidental and Oriental and associated ranges as far south as Zacatecas, Nayarit, and Tamaulipas, Mexico (Burt and Grossenheider 1980; Ceballos 2014). Uncontrolled hunting and poisoning reduced bear populations and distribution in Mexico into the 1970s. Recent governmental protection and land-owner conservation programs, such as what has occurred at Rancho El Aribabi, have allowed the species to recover in many areas (Ceballos 2014). However, logging of forested habitat and other land use changes, and fragmentation of habitat as a result of human development continue to threaten this species in Mexico (Wooding and Ward 1997; Delfín-Alfonso et al. 2012). Caire (2019) lists only four American black bear records for Sonora, all in the northeastern portion of the state near the international border. Delfín-Alfonso et al. (2012) list 31 American black bear records for Sonora, all from the northeast, with a cluster in the Sierra San Luis. Coronel-Arellano et al. (2016, 2018) reported American black bears from the Sierras Los Ajos, El Tigre, La Madera, and San Luis in northeastern Sonora.

The MDE database includes 128 records of American black bear from Sonora, all from the northeast. Precise localities are not listed in the online MDE database, which includes a note that says the practice is done to protect locations of rare or threatened species. However, Thomas R. Van Devender, the administrator of the site, granted us temporary access to inspect the records in more detail. The records span elevations of 1002 to 2481 m, and are almost all from sky islands. Four records are from Rancho El Aribabi, all from the 2007-2011 camera trap study by Avila-Villegas and Lamberton-Moreno (2013). Three are from Las Palomas or adjacent areas in the Sierra Azul at elevations of 1327 to 1442 m. The fourth is in the foothills of the Sierra Azul, about 1.9 km SE of the Río Cocóspera. All four were recorded in oak woodland.

Local Distribution: The American black bear was our third least-photographed mammal, with only 17 events at five camera sites, all in the Sierra Azul at Las Palomas or tributaries thereof (Figure 37, Appendix 2). These camera sites were in oak savanna along montane arroyos at elevations of 1333 to 1347 m.

Figure 37. Black bear, site ALP5, 29 August 2016, 0910 hrs.

Relative Abundance: In southeastern Arizona and southwestern New Mexico, numbers of American black bear camera trap detections varied dramatically from one mountain range to the next, but overall, the American black bear was the fifth most commonly detected wild mammal during 2012-2015 (Culver 2016). The American black bear registered the sixth highest photographic capture rate in four Sonora sky islands to the east of Rancho El Aribabi (Coronel-Arellano et al. 2016), and a healthy population exists in the Sierra San Luis of extreme northeastern Sonora (Lara-Díaz et al. 2013). We assume here that photographic events serve as a proxy for relative abundance (O'Brien 2011). With only 17 events, our data suggest that the American black bear is considerably less common at Rancho El Aribabi, relative to other wild mammals, than in adjacent sky island mountains ranges in Arizona and New Mexico, as well as in Sonora sky islands to the east of the ranch.

Behavior: Because of limited data points, we did not create a graph of hourly activity, but American black bears were photographed at night and during the day, with a peak of activity from 1300 to 1600 hrs. Sixteen of 17 events pictured one animal; however, on 29 August 2016, two bears were photographed in the same frame at site ALP2 (Figure 38). One animal was very close to the camera, peering into the lens, while the other was in the background. It was impossible to determine relative size or whether it might have been a female with a cub. No American black bears were photographed on the Río Cocóspera; hence, none were documented crossing logs over the river.

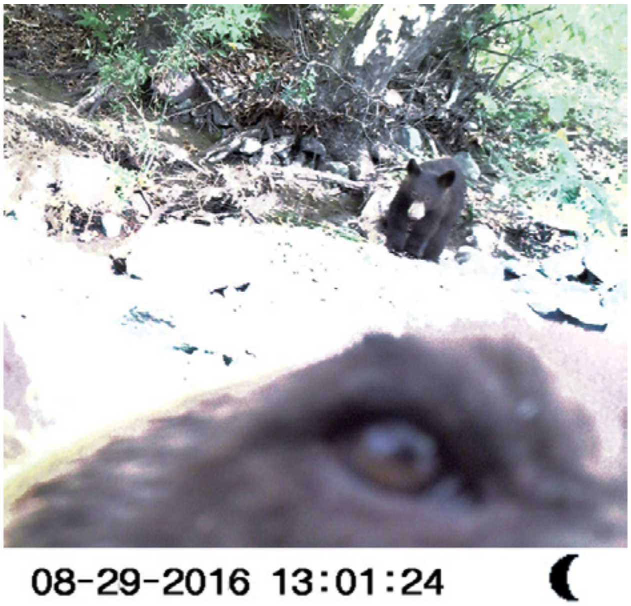

Figure 38. Black bears, site ALP2, 29 August 2016, 1301 hrs. One bear is peering into the camera, another can be seen in the background.

Throughout most of its range, American black bears become inactive during the winter months and spend that time in dens that may take the form of hollow logs, holes dug into hillsides or under boulders, or other secure locations (LaCount 1983). However, in warmer areas, such as Florida, they remain active in winter (McDaniel 1979). Hoffmeister (1986) notes that some American black bears remain active through the winter in Arizona. Our photographs of American black bears at Rancho El Aribabi are all from 15 March to 20 September, thus we have no evidence of winter activity. However, two of the records documented by Avila-Villegas and Lamberton-Moreno (2013) were dated 1 November and 1 January. Of the 94 American black bear records in the MDE with dates from Sonora, five are from November, and one each was recorded in December and January. There are no records for February. These records prove there is some American black bear activity in Sonora and at Rancho El Aribabi during the winter, but records are few in number, suggesting that activity is limited. Outside of our study, we do not know how well American black bears reported in the MDE database were sampled month by month, so it is possible the dearth of winter records could be an artifact of sampling.

Interaction with Cattle and Important Habitat Variables: Due to the limited number of sites where black bears were photographed (five) and small event sample size at Las Palomas and vicinity (17), we neither evaluated effects of cattle on black bear occurrence, nor conducted binary logistic regression to identify important habitat variables.

MUSTELIDAE

Taxidea taxus, Badger (Tejón)

The badger occurs from the central and western Canadian provinces south through the USA to the Mexican mainland state of Puebla, as well as the entirety of the Baja California peninsula (Burt and Grossenheider 1980; Ceballos 2014). Caire (2019) lists 15 localities throughout Sonora, but notes a particular absence from the foothill region and higher elevations of the eastern mountains. The nearest record to Rancho El Aribabi provided by Caire (2019) is on the Río San Pedro about 70 km to the northeast. The MDE database contains 25 badger records for Sonora, mostly in the northeast, but also elsewhere throughout the state. Elevations of these records range from 78 to 1510 m, although elevations are not provided for all records. The MDE database contains no records for Rancho El Aribabi or the Municipio of Ímuris in which Rancho El Aribabi occurs.

Local Distribution and Relative Abundance: The badger was the second least-photographed medium to large mammal in our study. We obtained 11 badger events at six camera sites, all of which were along the Río Cocóspera at elevations of 972 to 995 m (Figure 39). Vegetation types in which we photographed badgers included the ciénega, Fremont cottonwood-Goodding willow riparian forest, velvet mesquite-netleaf hackberry woodland, and velvet mesquite bosque. We did not collect enough photographs of this species to assess relative abundance.

Figure 39. Badger, site R3, 1 June 2018, 0032 hrs.

Behavior: All events were of a solitary badger. We did not plot activity, but nine of 11 events occurred from 0400 to 0900 hrs. The other two were at 0032 and 2153 hrs. None of our images showed a badger traversing a log over the Río Cocóspera. We never visually detected a badger, but we saw what we believe were holes and diggings created by badgers at a riverine camera site (ALP6) where we photographed the species.

Interaction with Cattle and Important Habitat Variables: Due to the limited number of sites where badgers were photographed (six) and lack of events at Las Palomas and vicinity, we neither evaluated effects of cattle on badger occurrence, nor conducted binary logistic regression to identify important habitat variables.

MEPHITIDAE

Conepatus leuconotus, Hog-nosed Skunk (Zorillo de Espalda Blanca)

The hog-nosed skunk occurs from west-central Arizona, southern Colorado, and southern Texas south through mainland Mexico to Nicaragua (Burt and Grossenheider 1980; Hoffmeister 1986, Ceballos 2014). Alvarez-Castañeda and Patton (2000) and Caire (2019) mapped the range of this species as occurring in eastern and southern Sonora outside of the desert. The closest record to Rancho El Aribabi listed by Caire (2019) is a specimen from the Río Bambuto Valley to the northwest of the ranch. The MDE database includes 121 records of the hog-nosed skunk, all from eastern Sonora, and mostly from the northeast. Elevational range of those records is 240–2326 m. The database includes three records for Rancho El Aribabi, including Arroyo Guerigo - a tributary to the Río Cocóspera at 1022 m elevation, and two other localities that plot outside the ranch boundaries.

Local Distribution: Our camera traps recorded 110 hog-nosed skunk events at 21 of 50 camera sites (Figures 40 and 41). The species was recorded in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite grassland, velvet mesquite-oak woodland or savanna, Sonoran desert-foothills thornscrub ecotone, and montane arroyos.

Figure 40. Hog-nosed skunk, site R1, 3 May 2017, 2026 hrs.

Figure 41. Hog-nosed skunk, site R2, 18 March 2018, 1958 hrs.

Relative Abundance: We calculated the mean number of camera days per hog-nosed skunk event for each of the camera site types as follows: cattle waters = 2752.0, tributaries to Las Palomas = 421.0, Las Palomas = 349.0, upland = 313.3, ridgelines = 229.7, and riverine = 116.7. Relative abundance of the hog-nosed skunk was greatest at riverine sites along the Río Cocóspera and lowest at cattle tanks where only one event was recorded.

All of our skunk images that could be identified as a hog-nosed skunk show a consistent pattern of white atop the head and back, black sides, and a tail that is white but shorter than that of the hooded skunk (Figures 40 and 41). A color morph of the hooded skunk with a white back and tail is similar in appearance to the hog-nosed skunk. In 43 events at 18 camera sites we obtained images of skunks for which we could not determine the species. Therefore, our data likely underestimate the relative abundance and naïve occupancy of the hog-nosed skunk. Although not documented by us, the striped skunk (*Mephitis mephitis*) may occur at Rancho El Aribabi (Alvarez-Castañeda and Patton 2000; Caire 2019; Table 7) and could account for some of the unidentified skunk images.

Behavior: This species was strongly nocturnal with an extended activity peak from 2100 to 0600 hrs (Figure 42). We never photographed this species during daylight hours. Hog-nosed skunks were photographed every month of the year with the most monthly adjusted events (1.12) in May and the least (0.20) in January. Fifteen events (14% of all events) documented a hog-nosed skunk crossing a log over the Río Cocóspera (Figure 41). The relatively high percentage of events showing log-crossings by this species suggests a good climbing ability, and in fact, hog-nosed skunks climb trees to avoid predators (Brashear et al. 2010). On 29 October 2015 at 2215 hrs, we photographed a hog-nosed skunk drinking from the stream at Las Palomas. No other notable behavior was photographed. This species was solitary; we never captured more than one hog-nosed skunk in an event.

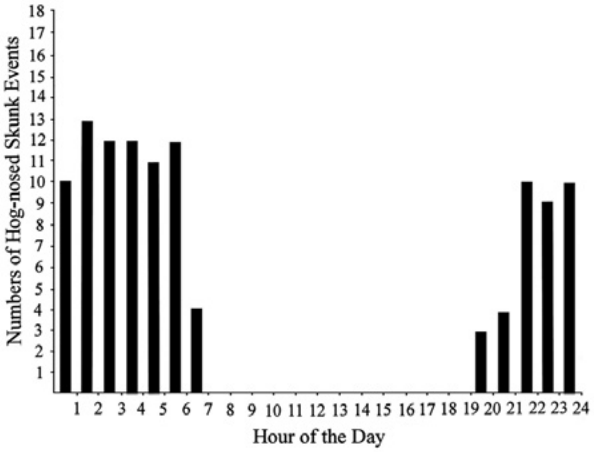

Figure 42. Hog-nosed skunk 24-hr activity pattern.

Interaction with Cattle and Important Habitat Variables: We recorded 15 hog-nosed skunk events during 202 camera months without cattle and seven events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a hog-nosed skunk event is equal in all months, regardless of cattle presence (null hypothesis: cattle have no effect on hog-nosed skunk events, or the difference between the two ratios equals zero), we would expect 17 events during months without cattle and five with cattle. The calculated z statistic is 0.23, thus we cannot reject the null hypothesis. These data provide no evidence that cattle presence affects hog-nosed skunk events.

Hog-nosed skunks were photographed at 21 camera sites and not photographed at 16 sites where the camera was operated for at least 112.8 days (the mean number of camera days necessary to photograph a hog-nosed skunk event at the 21 sites where they were photographed). The logistic regression model was a reasonably good fit with the data. It predicted presence fairly well, but less so for sites where hog-nosed skunks were absent (Table 6). The anthropogenic influences index was the only variable that rose to the level of significance; its mean at sites where hog-nosed skunks were photographed was 2.38 versus 5.98 at sites where they were not photographed (Table 5). These data suggest hog-nosed skunks are sensitive to human disturbance. The anthropogenic influences index was dominated by cattle. The Las Palomas analysis above did not provide any evidence that hog-nosed skunks are sensitive to concentrations of cattle. However, the anthropogenic influences index measures a variety of human disturbances, and cattle at sites outside of Las Palomas were often dispersed, so hog-nosed skunks could be responding to these two variables in a different manner. The coefficients in the model equation for percent canopy cover and shrub cover were both 0.01 (Table 6) and their mean values were similar at sites where hog-nosed skunks were and were not photographed (Table 5), indicating these two variables had only a very small effect on hog-nosed skunk presence.

Mephitis macroura, Hooded Skunk (Zorillo Listado)

The hooded skunk ranges from the southwestern USA to Costa Rica (Reid 1997; Hwang and Larivier 2003) and occurs throughout Sonora except for the most arid portions of the Sonoran Desert (Alvarez-Castañeda and Patton 2000; Caire 2019). The MDE database includes 98 records for Sonora, mostly from the northeast. Elevational range for the MDE records is 250–2223 m. Included in those records are six for Rancho El Aribabi, all from the 2007–2011 camera trap project conducted by Avila-Villegas and Lamberton-Moreno (2013). Those records are from Las Palomas and vicinity and Arroyo Los Amorosos at elevations of 1022 to 1327 m in velvet mesquite-oak savanna and oak woodland.

Local Distribution: We obtained 78 hooded skunk events at 18 camera sites along the Río Cocóspera, on the bajada, and in the Sierra Azul at elevations of 984 to 1406 m. The species was photographed in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite grassland, and montane arroyos. In 43 events at 18 camera sites we obtained images of skunks that could not be identified to species (hooded and hog-nosed skunks are similar and not always distinguishable in camera trap images). As a result, our data likely underestimate the relative abundance and naïve occupancy of this species.

Relative Abundance: We calculated the mean number of camera days per hooded skunk event for each of the camera site types as follows: riverine = 1317.1, tributaries to Las Palomas = 527.2, Las Palomas = 372.3, cattle waters = 144.8, uplands = 117.5, and ridgelines = 34.0. Relative abundance of the hooded skunk was greatest on ridgelines and upland sites and lowest at riverine sites along the Río Cocóspera and tributaries to Las Palomas.

Behavior: We photographed four basic color patterns of the hooded skunk: (1) white tail, back, and dorsally on the head with black low on the sides of the body; underside of tail sometimes showed some black fur (Figure 43); (2) black body and head, mostly black tail with some traces of white or a white tuft at the end, (3) all black except for a white hood at the back of the head, which corresponds to Hass's (2003) "star" pattern, and (4) black sides except for a lateral white stripe low on each side of the body that usually continued onto the tail (Figure 44). Pattern morph 4 varied considerably. Many had a black back and head, and a black tail except for the white lateral stripe and often a white tuft at the end of the tail. Some individuals with the white lateral stripes had a white tail with a black tip. One animal showed the "combo" pattern (Hass 2003) that was essentially a mix of morphs 1 and 4, in that the back and tail were white, the sides and top of the head were black, and there was a white lateral stripe low on the sides. Another animal was all black with white lateral stripes and a diffuse mid-dorsal light stripe on the body and tail. Most hooded skunks we photographed had a thin white stripe that ran from the top of the head to the tip of the snout - a character that hog-nosed skunks lack. The one possible exception is the #2 black morph, for which we could not see the white stripe, but we might have missed it due to the position of the animal or image quality. Hass (2003) includes a picture of a black hooded skunk that lacked the snout stripe and we have seen images from southeastern Arizona of black individuals that also lacked that stripe.

Figure 43. Hooded skunk, pattern morph 1, site U2, 4 March 2017, 0320 hrs.

Figure 44. Hooded skunk, pattern morph 4, site RG1, 19 December 2017, 0305 hrs.

The hooded skunk was solitary in our images but for one event that featured two similarly-sized individuals on 10 December 2015 at 0206 hrs. We never photographed an individual we could identify as a juvenile (based on size). One event showed a hooded skunk with a ringtail (*Bassariscus astutus*) at Las Palomas and another included two white-tailed deer and a hooded skunk at a dirt cattle tank. The species was strongly nocturnal (Figure 45); although one event showed this species illuminated by pre-dawn light at 0523 hrs on 18 June 2017. In another hooded skunk picture at 0650 on 23 January 2017, pre-dawn light could be seen in the sky to the east. Peak activity occurred from 0300-0600 and 2000-2200 hrs.

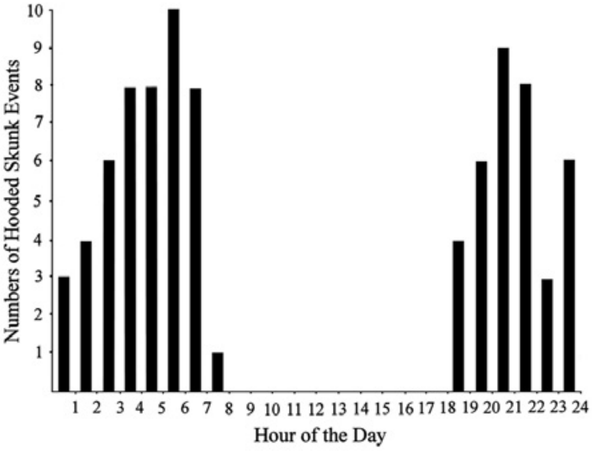

Figure 45. Hooded skunk 24-hr activity pattern.

Monthly differences in events were extreme. Fifty-one percent of monthly adjusted events (2.07) were in December, while from June through October we only recorded a total of 0.23 hooded skunk monthly adjusted events. We are not able to explain the large percentage of events in December; however, it likely does not reflect males searching for mates. In southeastern Arizona, hooded skunks give birth during the summer, from June to perhaps as late as the end of August (Hass 2003). Gestation takes about eight weeks (Ceballos 2014), so mating would occur from April to June. A high proportion of

December events also probably does not reflect dispersing juveniles, as most young hooded skunks become independent from their mothers in August in southeastern Arizona (Hass 2013).

Similar to the situation in southeastern Arizona (Hass 2013), we found no evidence of winter dormancy. This species was never photographed traversing logs across the Río Cocóspera suggesting it is not a particularly good climber. No other notable behaviors were recorded.

Interaction with Cattle and Important Habitat Variables: We only recorded 19 hooded skunk events at Las Palomas and vicinity, so we did not analyze effects of cattle on hooded skunk presence there.

Hooded skunks were photographed at 18 camera sites and not photographed at 19 sites where the camera was operated for at least 114.9 days (the mean number of camera days necessary to photograph a hooded skunk event at the 18 sites where they were photographed). The logistic regression model predicted both presence and absence reasonably well (Table 6). The anthropogenic influences index was the only variable that rose to the level of significance. Its mean at sites where hooded skunks were photographed was 4.69 versus 4.60 at sites where they were not photographed (Tables 5 and 6), suggesting hooded skunks occur slightly more frequently at sites with elevated human disturbance (including cattle) than less disturbed sites. The coefficient in the model equation for percent canopy cover was very small, indicating that variable had a negligible effect on hooded skunk presence. The variable was removed from the equation as it appears in Table 6.

Interactions between Hooded and Hog-nosed skunks: Hooded and hog-nosed skunks are of similar size and with similar diets and activity periods (Hass 2003; Ceballos 2014), thus there is a potential for interspecific competition. Twelve of 18 hooded skunk camera sites also registered hog-nosed skunks, and 12 of 21 hog-nosed skunk camera sites also registered hooded skunks. Thus they show at least a moderate level of overlap on the landscape. However, there is a stark difference in abundance at site types. Relative abundance of hooded skunks was greatest on ridgelines and upland sites and lowest along the Río Cocóspera. Hog-nosed skunks were most abundant along the Río Cocóspera and uncommon at upland sites. Hooded skunks were moderately abundant at cattle waters, whereas a hog-nosed skunk was only recorded once at that site type. There is strong daily temporal overlap - both species are highly nocturnal, although their activity peaks differ somewhat (Figures 42 and 45). As discussed, based on frequency of use of log crossings over the Río Cocóspera, the hog-nosed skunk is probably a better climber and more arboreal than the hooded skunk. Hooded skunks are more tolerant of human disturbance than hog-nosed skunks, based on the logistic regression analyses. If numbers of hooded skunks affected numbers of hog-nosed skunks, or vice versa, events per camera day of these two species might be inversely correlated over time. However, numbers of events per camera day for these two skunk species varied similarly across the four years of the study (Figure 46). Those numbers are correlated ($r = 0.736$) and the correlation is significant ($p = 0.041$). Consequently, if hooded and hog-nosed skunks are competing for resources at Rancho El Aribabi, the effects on their populations are negligible. As presented above, the two species may be avoiding resource competition by segregating out spatially and perhaps to a lesser degree, temporally. The extreme fluctuations in relative abundance of both species across the four and a half years of our camera trap study is interesting and again underscores the importance of long-term studies in properly assessing abundance.

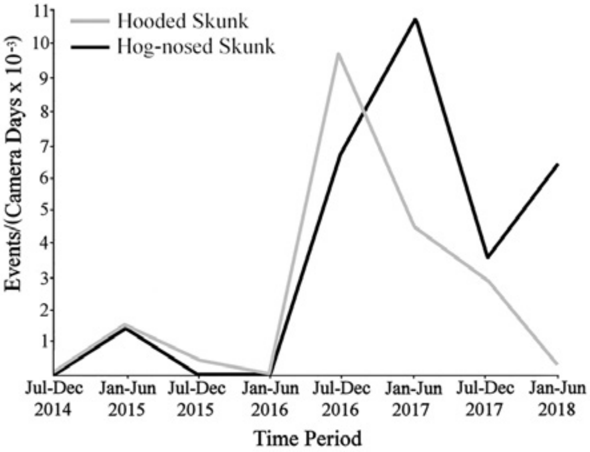

Figure 46. Hog-nosed and hooded skunk events per camera days (x10^{-3}) plotted over the course of the study. We omitted data from July to Dec 2018 because few cameras were operated in that period.

Spilogale gracilis, Western Spotted Skunk (Zorillo Manchado Occidental)

This small skunk is distributed from southern Canada and the USA south to Querétaro, Mexico. Caire (2019) lists seven localities for Sonora, including one near Ímuris west of Rancho El Aribabi, and suggests it occurs throughout the state. The distribution map in Alvarez-Castañeda and Patton (2000) shows it absent from western portions of Sonora outside of the northwestern deserts. Records listed by Hoffmeister (1986) show it to be widespread in Arizona. The MDE database includes 36 records for Sonora, all from the northeast at elevations of 463 to 2254 m. The database includes no western spotted skunk records for the Municipio of Ímuris, which includes Rancho El Aribabi.

Local Distribution: The western spotted skunk was our least photographed medium to large mammal. There were only three events at three camera sites, including two along the Río Cocóspera – one in a velvet mesquite bosque (site R20) and one in a Fremont cottonwood-Goodding willow riparian forest (site R1). The third was at a concrete cattle trough (site CW1) in a velvet mesquite grassland (Figure 47). Elevations of detections were 989, 995, and 1098 m. All three were of solitary animals and all were at night (2100-0100 hrs). Photos were obtained in May, June, and November. We detected this species only by camera trap. The western spotted skunk is an adept climber (Patton 1974), but our cameras were aimed at the ground; hence, we may have underestimated the naïve occupancy and relative abundance of this species. Also, as a relatively small animal, it would be less likely to be detected and photographed, particularly at greater distances from the cameras.

Figure 47. Western spotted skunk drinking from a cattle trough. Site CW1, 27 November 2016, 0106 hrs.

Interaction with Cattle and Important Habitat Variables: Due to the limited number of sites where western spotted skunks were photographed (three) and absence of events at Las Palomas, we neither evaluated effects of cattle on western spotted skunk occurrence, nor conducted binary logistic regression to identify important habitat variables.

PROCYONIDAE

Bassariscus astutus, Ringtail (Cacomixtle Norteño)

The ringtail occurs from the western and southwestern USA south through most of Mexico to the state of Oaxaca. In Sonora, it likely occurs throughout most of the state (Ceballos 2014; Caire 2019), although only seven localities are listed by Caire (2019). One of those seven is "9 mi NNE of Ímuris" near Rancho El Aribabi. The MDE database contains 142 ringtail records for Sonora, mostly from the northeast at elevations of 296 to 2470 m. The database includes eight localities for Rancho El Aribabi, including Arroyo Los Amorosos, Las Palomas and vicinity, Agua Fría, and Arroyo Guerigo, a tributary to the Río Cocóspera, at elevations of 1022 to 1327 m. Vegetation communities of those localities include Fremont cottonwood-Goodding willow riparian forest, oak woodland, and Sonoran desertscrub-foothills thornscrub ecotone.

Local Distribution: We obtained 150 ringtail events at 19 camera sites in the following vegetation communities: Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, montane arroyo, velvet mesquite-netleaf hackberry woodland, and Sonoran desertscrub-foothills thornscrub ecotone (Figures 48 and 49). Ringtails were photographed on the Río Cocóspera corridor, the bajada, and in montane arroyos at elevations of 968 to 1406 m. This species is often associated with rocky areas (Hoffmeister 1986), although they can also den in hollow trees (Ceballos 2014). Only one of our ringtail localities lacked nearby rock outcrops – an upland site that was a south-facing slope in a velvet mesquite bosque (site U2).

Figure 48. Ringtail, site R17, 26 February 2017, 0400 hrs.

Figure 49. Ringtail, site R18, 28 November 2016, 2258 hrs.

Relative Abundance: We calculated the mean number of camera days per ringtail event for each of the camera site types as follows: cattle waters = 685.5, riverine = 196.2, upland = 134.3, Las Palomas = 88.6, and tributaries to Las Palomas = 70.3. No ringtails were photographed on ridgelines. Relative abundance of the ringtail was greatest at Las Palomas and its tributaries and lowest at cattle waters and riverine sites along the Río Cocóspera.

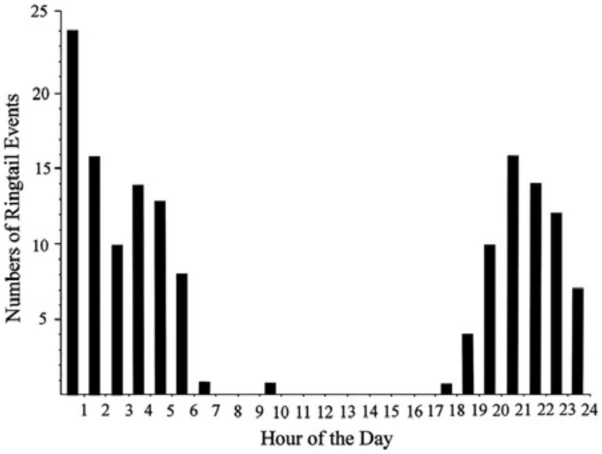

Figure 50. Ringtail 24-hr activity pattern.

Behavior: Ringtails were strongly nocturnal and were photographed only twice during the day (Figure 50). Activity peaked from 2000 to 2200 and 0000 to 0100 hrs. Detectability varied by month. The highest monthly adjusted events occurred in December (1.35) and January (1.44), while only a total 0.45 monthly adjusted events occurred from July through October. Other months had adjusted event totals ranging from 1.31 (March) to 0.58 (November). We can think of no reason for this monthly variation in events. We detected ringtails only via camera traps.

Seventeen (11%) of the events showed a ringtail crossing fallen logs over the Río Cocóspera. They are described as being good climbers (Hoffmeister 1986). If ringtails frequent trees or rock outcrops we may have underestimated their naïve occupancy and relative abundance, because our cameras were aimed at the ground and rarely included outcrops in the frame. Also, our cameras may not have always triggered when this relatively small animal was in the field of view, particularly if it was far from the camera. All events pictured solitary animals and we never photographed ringtails we could identify (by size) as juveniles. One event featured a ringtail drinking from the stream at Las Palomas. Another showed a ringtail standing on its hind legs, peering at something above the surrounding grasses. A ringtail was photographed with the dead white-tailed deer killed by the puma at Las Palomas (site ALP6, Figure 30), but our pictures do not show the ringtail coming close to or investigating the carcass. A ringtail was photographed with a hooded skunk in one event and a white-nosed coati in another.

Interaction with Cattle and Important Habitat Variables: We recorded 82 ringtail events during 202 camera months without cattle and 11 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a ringtail event is equal in any given month, regardless of cattle presence (null hypothesis: cattle have no effect on ringtail events, or the difference between the two ratios equals zero), we would expect 74 events during months without cattle and 19 with cattle. The calculated z statistic is 3.03, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on ringtail events.

Ringtails were photographed at 19 camera sites and not photographed at 24 sites where the camera was operated for at least 66.3 days (the mean number of camera days necessary to photograph a ringtail event at the 19 sites where they were photographed). The logistic regression model was a reasonably good fit with the data. It predicted presence reasonably well, but absence with less accuracy (Table 6). None of the variables rose to the level of significance. Distance to an unpaved road came close to significance and had the largest coefficient of any variable in the model equation. Sites where ringtails were photographed were, on average, 0.34 km from an unpaved road versus 0.14 km at sites where it was not photographed (Table 5), suggesting a negative response to unpaved roads. However, no ringtail events were recorded on ridgeline camera sites, which were either unpaved roads or adjacent to unpaved roads. No variables dropped out of the model equation due to small coefficients, but percent canopy cover, shrub layer percent cover, and the anthropogenic influences variable all had coefficients of less than 0.1, indicating they contributed very little to the model's ability to predict ringtail presence or absence. As described earlier, ringtails are often found in rocky areas and they frequently den in rock outcrops (Ackerson and Harveson 2006). None of our model variables measured or could be considered an index to the presence of rock outcrops, and as a result, we likely missed a key habitat feature that perhaps could have improved the binary logistic regression model.

Nasua narica, White-nosed Coati (Coatí Norteño)

The white-nosed coati is a neotropical omnivore at the northern edge of its distribution in northern Sonora and adjacent Arizona. It occurs from Arizona, New Mexico, and Texas south to Panama (Gompper 1995). Caire (2019) portrays the distribution of the white-nosed coati in Sonora as mostly east of the Sonoran Desert. The record closest to Rancho El Aribabi in Caire

(2019) is "ca. 21 miles E of Ímuris (by road) Hwy 2". The MDE database lists 263 records for the white-nosed coati in Sonora, the vast majority of which are from the northeast. Elevational range of the MDE records is 418 to 2326 m. The MDE database contains 12 white-nosed coati records for Rancho El Aribabi, two of which are from this study. Nine others come from the work of Avila-Villegas and Lamberton-Moreno (2013). MDE localities for this species on Rancho El Aribabi include the Río Cocóspera corridor; Arroyo Guerigo, which is a tributary to the Río Cocóspera; Agua Fría; Arroyo Los Amorosas; Las Palomas; and the Sierra Azul in the vicinity of Las Palomas at elevations of about 985 to 1442 m. Vegetation communities at those localities were Fremont cottonwood-Goodding willow riparian forest, Sonoran desertscrub-foothills thornscrub ecotone, and oak woodland.

Local Distribution: The white-nosed coati was the third-most photographed species in our project. We tallied 781 events at 33 camera sites (Figure 51). We photographed it in the ciénega, Fremont cottonwood-Goodding willow riparian forest, velvet mesquite bosque, velvet mesquite grassland, velvet mesquite-netleaf hackberry woodland, velvet mesquite-oak savanna, and montane arroyos. It was photographed at elevations of 968 to 1406 m.

Relative Abundance: We calculated the mean number of camera days per white-nosed coati event for each of the camera site types as follows: ridgelines = 306.3, cattle waters = 110.1, tributaries to Las Palomas = 72.7, Las Palomas = 44.0, and riverine = 15.4. No white-nosed coatis were photographed in upland camera sites. Relative abundance of the white-nosed coati was greatest at riverine sites along the Río Cocóspera and lowest on ridgelines, cattle waters, and upland sites. Most (76%) white-nosed coati events were along the Río Cocóspera (Figure 52); while 20% and 4% of events were in Las Palomas and its tributaries and other sites (cattle waters, ridgelines), respectively.

Figure 51. White-nosed coatis – 20 of the 22 animals in this group. Site R3, 11 September 2018, 1025 hrs.

Figure 52. White-nosed coati near site R8, 14 May 2016, 1118 hrs.

Behavior: In addition to documenting this species with camera traps, we frequently observed white-nosed coatis along the Río Cocóspera during the day in group sizes from one to more than 20; although, larger group sizes were difficult to quantify as individuals typically were running away from us through an understory of vegetation. This species was sometimes observed high in trees, although when it fled from us, it would typically descend from the trees and run off on the ground. Individuals sometimes fled up into rock outcrops on the edge of the floodplain where they would stop and gaze at us. Some of these individuals uttered chuffing noises. On 11 February 2018 at 1014 hrs, we observed two adult or large juvenile white-nosed coatis about 17 m up in a Fremont cottonwood in a nest of sticks similar to a raptor nest (Figure 53). After a few minutes, those coatis descended from the tree and joined at least 14 other white-nosed coatis atop a large boulder on the edge of the floodplain (Figure 54). Females will build stick nests in trees where they give birth to and nurture their young (Kaufmann 1962; Gompper 1995); although in the Huachuca Mountains of southeastern Arizona, Hass (1997) found natal areas or dens only in rock outcrops. We are unaware of documentation of white-nosed coatis using stick tree nests for other than reproductive purposes.

Figure 53. Two white-nosed coatis in a stick nest about 17 m high in a Fremont cottonwood tree, Río Cocóspera near site R8, 11 February 2018, 1014 hrs.

Figure 54. Twelve of 14 white-nosed coatis in this group near site R8, 11 February 2018, 1024 hrs.

Mean group size throughout the year was 2.0 (range of 1-22). Fifty-one percent of events were of solitary animals. Group size varied by site type, as well. Mean group size and range were 2.2 (1-22) along the Río Cocóspera, 1.7 (1-7) in the Las Palomas area, and 1.0 (all animals were solitary) at other sites. We interpret our event and group size data to mean that population density was likely greatest along the Río Cocóspera, less in the Las Palomas area, and other sites only supported transient animals that were likely solitary males. As discussed earlier, data from our images almost certainly underestimated group size, but the bias is probably similar and therefore comparable in a relative sense among camera sites.

White-nosed coatis are social animals, with adult females and juveniles forming troops of 40 or more (Gompper 1995; Hass 1997). Males leave the troop at about age 24 months, after which they are solitary except for a short time each year during the breeding season, which in the Huachuca Mountains, Arizona, runs from mid-March until the end of April (Hass 1997). In the Huachuca Mountains, pregnant females leave the troops beginning in June. During July they are in dens where they birth their young and take care of them for five weeks, and then females and young rejoin their troops. As a result, troops lose cohesiveness during late gestation and denning, then reform again in August (Hass 1997). Given this chronology of group dynamics, we would expect to see mean group size vary throughout the year, with smaller troops in June and especially July, with a rebound in August, and perhaps reaching the highest levels soon thereafter with the addition of young-of-the-year.

Figure 55 plots mean group size, range, and events by month at camera sites along the Río Cocóspera and in the Las Palomas area. From that figure, we see that mean group size declined in May, dropped to 1.0 in June, and then rebounded in July and August. The greatest mean group size (2.9) and largest group (22; Figure 51) were recorded in September. This suggests a breeding chronology similar to what was found in the Huachuca Mountains, although pregnant females may start leaving their troops earlier (May) and group size does not recover until September. This is corroborated by images showing very young coatis beginning on 25 July. On that date, seven very small white-nosed coatis were accompanied by at least one adult at camera site R3 along the Río Cocóspera. The first young-of-the-year observed by Hass (1997) in the Huachuca Mountains was 27 July. We also photographed somewhat larger young-of-the-year on 26 and 31 August, and two juveniles that were about two-thirds grown on 25 November, all of which were on the Río Cocóspera.

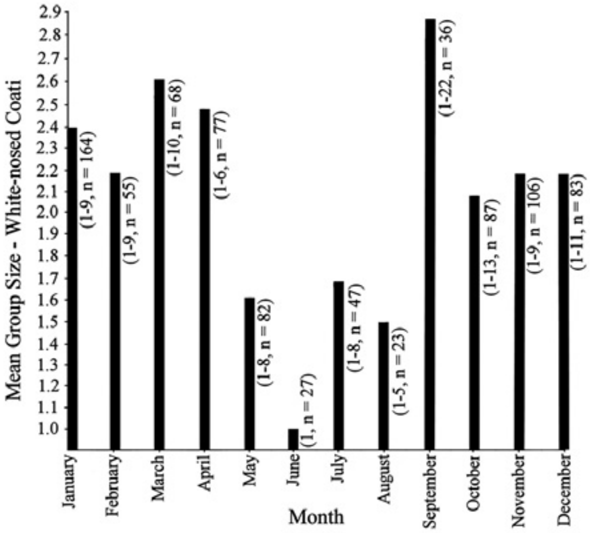

Figure 55. White-nosed coati group size by month. Range and sample size or events (n) shown in parentheses.

Also seen in Figure 55, events varied monthly, with the smallest numbers (21-43) and adjusted numbers (1.30 to 2.39) during June-August when we surmise that females were birthing and caring for their young in dens or tree nests. The greatest number of events, corresponding to greatest activity by white-nosed coatis, was in the October to January period (76-150 events and 3.42-7.45 adjusted events per month), which is also when populations were likely greatest due to addition of young-of-the-year. White-nosed coatis were largely diurnal with an activity peak from 1000 to 1700 hrs (Figure 56). However, peak activity differed in the hottest summer months (June-August) as compared to the cooler, winter months (December-February). Figure 57 shows that activity was low from 1200 to 1300 hrs during the summer, but that period supported the greatest activity during the winter, suggesting white-nosed coatis were avoiding the summer heat and or taking advantage of warm periods of the day during winter. No nocturnal activity was recorded during the summer, but white-nosed coatis were occasionally photographed through the night in winter (Figure 57).

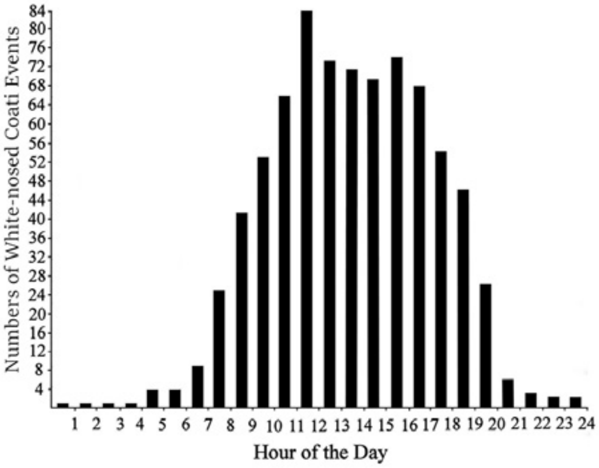

Figure 56. White-nosed coati 24-hr activity pattern.

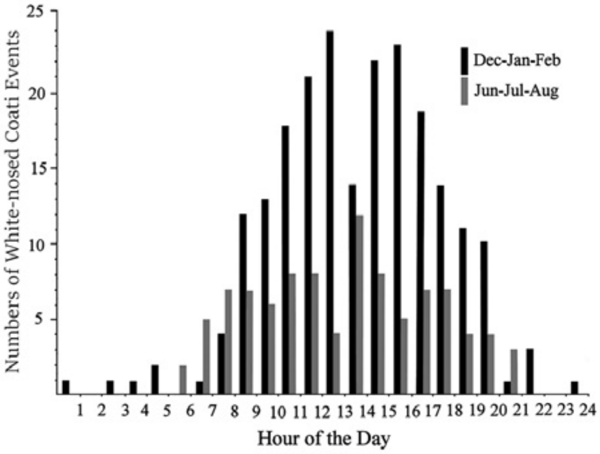

Figure 57. White-nosed coati 24-hr activity patterns in winter and summer.

We never photographed or observed coatis feeding, however, on several occasions along the Río Cocóspera we observed areas, sometimes as much as 100 m^2 in size, where animals had dug up the ground, turned over small logs, and churned the leaf litter. These areas were accompanied by the distinctive tracks of white-nosed coatis and we surmise the disturbance was made by a troop foraging for insects and other small animals.

Interaction with Cattle and Important Habitat Variables: We recorded 138 white-nosed coati events during 202 camera months without cattle and 21 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a white-nosed coati event is equal in any given month, regardless of cattle presence (null hypothesis: cattle have no effect on white-nosed coati events, or the difference between the two ratios equals zero), we would expect 126 events during months without cattle and 33 with cattle. The calculated z statistic is 2.52, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on white-nosed coati events.

White-nosed coati were photographed at 33 camera sites and not photographed at 12 sites where the camera was operated for at least 25.3 days (the mean number of camera days necessary to photograph a white-nosed coati event at the 33 sites where they were photographed). The logistic regression model predicted presence excellently, but absence poorly (Table 6). None of the variables rose to the level of significance. Percent canopy cover had a very small coefficient, indicating it contributed very little to explaining the presence or absence of white-nosed coati. As a result, it was dropped from the model as presented in Table 6. Although not achieving statistical significance, mean values for distance to water (0.31 km [present], 0.61 km [absent]) and distance to a vegetation community with riparian trees (0.15 km [present], 0.86 km [absent]) support our analyses of relative abundance, above, that white-nosed coatis were most abundant along the riparian corridor of the Río Cocóspera. Distance to a vegetation community that included riparian trees also had the largest coefficient of any variable in the logistic regression model, underlining its importance in predicting white-nosed coati presence.

Procyon lotor, Common Raccoon (Mapache)

The common raccoon occurs from southern Canada south through most of the USA and

Mexico to Panama. It has been successfully introduced to portions of Europe and Asia, and islands off Alaska (Lotze and Anderson 1979). Caire (2019) mapped the distribution in Sonora as including the entire state except for the hyper-arid Gran Desierto region. The closest records to Rancho El Aribabi given by Caire (2019) are from the Ríos Bambuto and Magdalena Valley west of the ranch. The MDE database contains 96 records for Sonora, mostly from the northeastern quarter of the state at elevations ranging from 95 to 1570 m. Included are five records for Rancho El Aribabi, however, two plot to the north of the ranch. The three valid records are from the Río Cocóspera, Las Palomas, and a locality in the Sierra Azul at elevations of 968 to 1442 m, which were in Fremont cottonwood-Goodding willow riparian forest, velvet mesquite-oak savanna, and oak woodland.

Local Distribution: We photographed 67 common raccoon events at 16 camera sites, including eight sites on the Río Cocóspera, one cattle water, and Las Palomas and a tributary thereof at elevations of 968 to 1346 m (Figure 58). Sixteen of the 67 events were recorded at a camera site aimed at the Río Cocóspera and located 0.07 km ENE of La Casona (site R6). We also observed this species once in the ciénega near La Casona at dusk. Vegetation communities where the species was photographed or observed include Fremont cottonwood-Goodding willow riparian forest, ciénega, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland (at a cattle tank), and montane arroyos.

Figure 58. Common raccoon, site R2, 21 March 2018, 0348 hrs.

Relative Abundance: We calculated the mean number of camera days per common raccoon event for each of the camera site types as follows: cattle waters = 1376.0, tributaries to Las Palomas = 1054.5, Las Palomas = 279.2, and riverine = 214.4. No common raccoons were photographed in upland camera sites or on ridgelines. Relative abundance of the common raccoon was greatest at riverine sites along the Río Cocóspera and at Las Palomas, both of which have permanent water. It was photographed only twice at an ephemeral cattle tank (sites CW2 and CW3), and twice at a tributary of Las Palomas (site T2LP2) where flows were ephemeral.

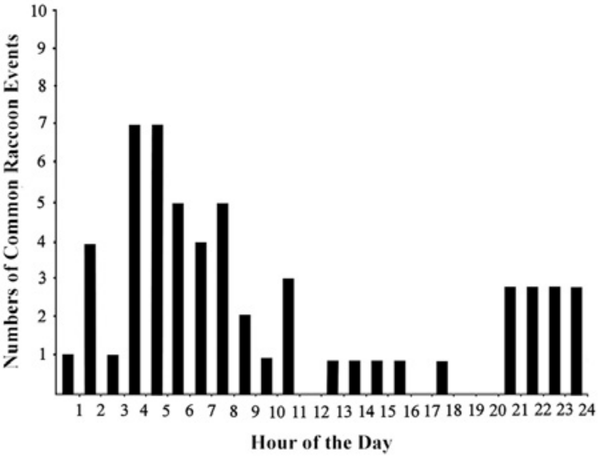

Figure 59. Common raccoon 24-hr activity pattern.

Behavior: Fifty-five (82%) of the events showed solitary animals. Seven, two, two, and one events showed two, three, four, and five raccoons, respectively, in a group. Females and their young can be found together until the offspring are about nine months of age (Sharp and Sharp 1956), and both adult males and females may form single-sex associations (Hohmann et al. 2001). Adult males and females probably do not associate except during the breeding season (Lotze and Anderson 1979). We were not able to discern any size differences (e.g. juveniles vs. adults) among common raccoons photographed in groups.

Common raccoons were photographed throughout the day and night, but their activity peaked from 0300 to 0800 hrs. Common raccoon events were relatively rare from 1100 to 2000 hrs (Figure 59). We photographed this species every month of the year except for May and June. Peak numbers of monthly adjusted events occurred in August (0.68), November (0.81), and December (0.58). Four events (6%) showed common raccoons crossing logs over the Río Cocóspera (Figure 60), although this species is a strong swimmer, capable of swimming across rivers up to 300 m in width (Kaufmann 1987).

Interaction with Cattle and Important Habitat Variables: We recorded 20 raccoon events during 202 camera months without cattle and one event during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a raccoon event is equal in any given month, regardless of cattle presence (null hypothesis: cattle have no effect on raccoon events, or the difference between the two ratios equals zero), we would expect 17 events during months without cattle and four with cattle. The calculated z statistic is 5.95, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on raccoon events. Both raccoons and cattle are likely to be found near water, and this is especially true for cattle in the dry period from about April until the start of the summer rains in late June or July.

Figure 60. Common raccoon crossing a log over the Río Cocóspera, site R17, 7 August 2017, 0846 hrs.

Common raccoons were photographed at 16 camera sites and not photographed at 20 sites where the camera was operated for at least 135.7 days (the mean number of camera days necessary to photograph a common raccoon event at the 16 sites where they were photographed). The logistic regression model was a reasonably good fit with the data. It predicted absence excellently, but presence less accurately (Table 6). Among the model variables, only distance to an unpaved road rose to the level significance. Sites where common raccoons were photographed were, on average, 0.35 km from an unpaved road versus 0.17 km for sites where they were not photographed. This could suggest an avoidance of unpaved roads by common raccoons, or the explanation may be more nuanced than that.

Common raccoons were not photographed on ridgelines, which were unpaved roads (sites RG1 and 2) or immediately adjacent to unpaved roads (sites RG3 and 4). Neither were they photographed at upland sites, which were close (0.02-0.2 km) to unpaved roads. As a result, occurrence of common raccoons could be influenced by the presence of ridgelines and or uplands as well as unpaved roads. Hoffmeister (1986) stated "In Arizona, as elsewhere, raccoons are never far from water." Yet distance to permanent water was not an important variable in the logistic regression model. Sites where common raccoons were photographed were actually farther from permanent water, on average (0.40 km), than sites at which the species was not photographed (0.34 km). That said, our photographs of common raccoons were almost always in association with water. That water, though, was not always permanent. For instance, the species was photographed along ephemeral reaches of Las Palomas and one of its tributaries, and at an ephemeral cattle tank (Represso Tascalito) when water was present at those sites. That cattle water is 2.1 km from perennial flow on the Río Cocóspera. Apparently, common raccoons will disperse along ephemeral drainages and even travel overland through arid terrain (necessary to reach Represso Tascalito from the Río Cocóspera or other sites with permanent water) to seek out ephemeral water sources when water is available. The coefficient for percent canopy cover in the logistic regression model was less than 0.01 (0.006), indicating it had very little effect on the model's ability to predict presence or absence of the common raccoon, so we removed it from the equation as shown in Table 6. Percent cover in the shrub layer and the anthropogenic influences variable also had small coefficients (0.03 and 0.09, respectively), indicating they were not very important for predicting presence or absence of common raccoons.

TAYASSUIDAE

Pecari tajacu, Javelina (Pecarí de Collar)

We elect to use the common name of javelina rather than collared peccary, because the former is the commonly-used name for this species in the southwestern USA and (for English speakers) adjacent portions of Mexico. The javelina occurs from Arizona, New Mexico, and Texas south through Mexico (absent from the Mexican plateau) and Central America to northern Argentina (Taber et al. 2011). Caire (2019) portrays this species as occurring throughout mainland Sonora except for the driest portions of the Gran Desierto-Pinacate region and the Río Colorado Valley. The nearest record to Rancho El Aribabi provided by Caire (2019) is from Santa Cruz about 43 km NNE of the ranch. The MDE database contains 263 records for Sonora, mostly from the northeastern portion of the state and at elevations of 9 to 2193 m. The database contains 13 records for Rancho El Aribabi, two of which are from this study. Two of the 13 localities plot to the north of the ranch. Eight others are from the work of Avila-Villegas and Lamberton-Moreno (2013). The 11 valid localities are from the Río Cocóspera and one of its tributaries, Las Palomas and vicinity, Arroyo Los Amorosos, and the Sierra Azul at elevations of 990 to 1442 m. Vegetation communities at those localities include Fremont cottonwood-Goodding willow riparian forest, montane arroyo, and oak woodland.

Local Distribution: The javelina was the second most photographed wildlife species (2020 events) in our study, it had the second lowest camera days/event (10.2) as measured over all 50 camera sites, and we photographed it at 43 of 50 camera sites (Table 2, Figure 61). We photographed it in Fremont cottonwood-Goodding willow riparian forest, the ciénega, velvet mesquite bosque, velvet mesquite-netleaf hackberry woodland, velvet mesquite grassland, a netleaf hackberry arroyo in velvet mesquite grassland, mesquite-oak woodland, montane arroyo, and Sonoran desertscrub-foothills thornscrub ecotone at elevations of 968 to 1406 m. We also occasionally visually observed this species during daylight hours on the Río Cocóspera and adjacent velvet mesquite grassland areas (Figure 62).

Figure 61. Javelina, site R1, 14 December 2016, 1856 hrs.

Figure 62. Javelina in mesquite grassland about 0.5 km SE La Casona, 27 April 2007, 1603 hrs.

Relative Abundance: We calculated the mean number of camera days per javelina event for each of the camera site types as follows: cattle waters = 18.7, upland = 17.4, tributaries to Las Palomas = 13.9, Las Palomas = 13.2, ridgelines = 12.4, and riverine = 7.9. Compared to other species, relative abundance of the javelina was similar across site types, but the species was most abundant at sites along the Río Cocóspera and least abundant at cattle waters. A total of only two javelina events were captured at the two camera sites closest to La Casona: a compost pile 30 m south of La Casona (site U5) and a dirt road 20 m east of La Casona (site R21), suggesting possible avoidance of human habitations. However, in Arizona, javelinas are sometimes found in close proximity to houses in urban and suburban settings where they can become a nuisance (Ticer et al. 1998).

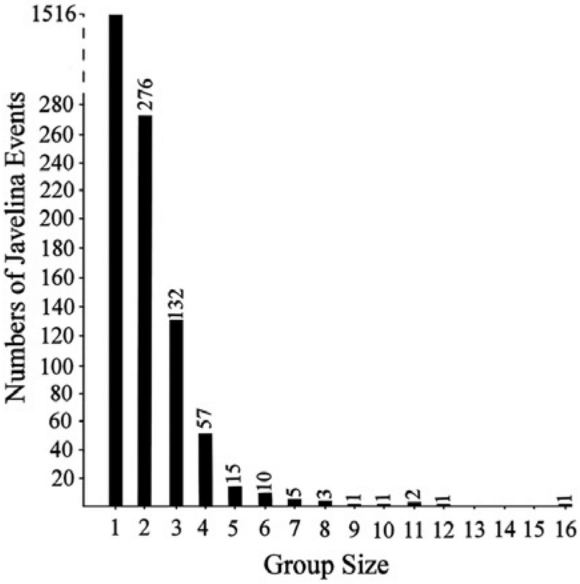

Figure 63. Javelina group size.

Behavior: Javelinas are social mammals, traveling in groups of 30 or more (Taber et al. 2011). Figure 63 illustrates group size based on our camera trap data, which varied from one to 16. A group size of one accounted for 75% of our events. However, as discussed earlier, camera trap data probably underestimate group size and at least some of the apparently solitary animals were no doubt accompanied by other javelina that eluded photo capture.

Young javelinas were often photographed in the groups, providing some insight into breeding chronology. Very small javelinas were photographed nine times, all from 16 July to 17 August at Río Cocóspera camera sites. Group configurations that included very small individuals ranged from one adult and one very young individual to three adults and two very young individuals. Other adults with older, larger juveniles were photographed numerous times from August into early January. Groups never included more than three young-of-the-year javelina. A male and female in copulation was photographed 10 February 2018 at 0051 hrs at a Río Cocóspera camera site (site R6; Figure 64). Another mating or attempted mating was photographed on 23 February 2017 at Las Palomas. Gestation lasts about 145 days (Ockenfels et al. 1985), which would put any birthings from these matings in July. Javelina can produce young throughout most of the year, although births probably peak during periods of high food abundance (Taber et al. 2011). In southern Arizona, "piglets" were observed by Day (1977) in every month except March, although most were born from May through August. At Rancho El Aribabi, births appear to be timed to the peak of the summer rains when vegetation production is at its greatest.

Figure 64. Javelina mating, site R6, 10 February 2018, 0051 hrs.

Javelinas were active at all hours, but activity peaked from 1800 to 2200 hrs and was at a low from 0300 to 0500 hrs (Figure 65). However, activity varied seasonally. Javelinas were least active from 1200 to 1700 hrs in the summer months, a period of moderate activity during the winter (Figure 66). This is consistent with the findings of Day (1977) in southern Arizona, and likely represents javelina avoiding activity during the hottest parts of summer days. Monthly adjusted events varied from 6.62 in July to 14.13 in November. The October to December period showed the greatest activity of any three-month period, with adjusted totals from 13.09 to 14.13. That was preceded by a period of least activity, from July to September when monthly adjusted events ranged from 6.62 to 8.18.

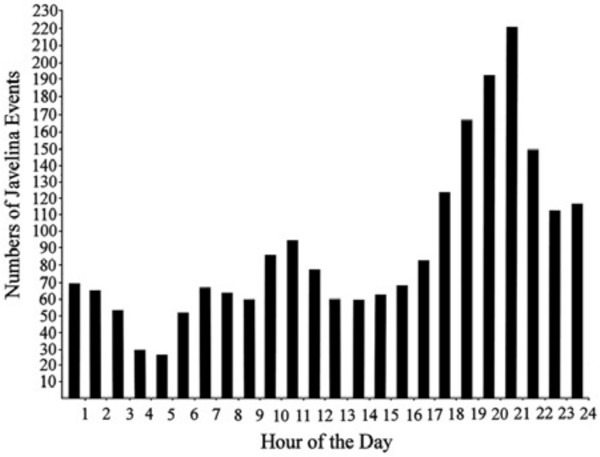

Figure 65. Javelina 24-hr activity pattern.

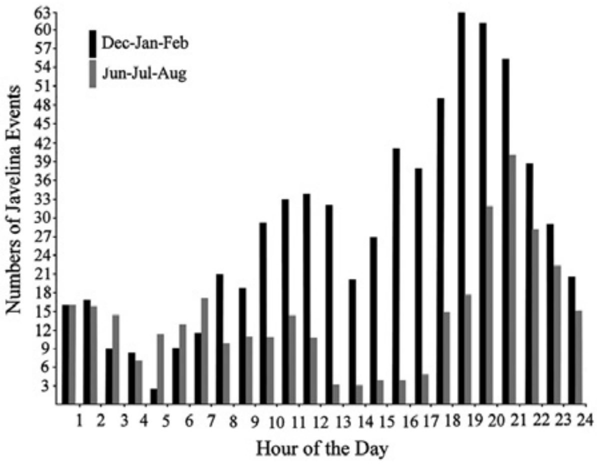

Figure 66. Javelina 24-hr activity patterns in winter and summer.

Groups of one to eight javelinas sniffed at and investigated the white-tailed deer kill site pictured in Figure 30. These javelina events continued through 27 April 2018, 99 days after the kill occurred. Throughout our study, javelina events were usually short, but some animals lingered, and on 27 November 2016, two javelinas bedded down in front of a camera from 0847 to 1442 hrs. One of the bajada cameras (site CW1) was pointed at an elevated concrete watering trough. On 5 December 2016 at 1918 hrs, a javelina fell into the trough and could not escape. It was photographed swimming around the edge, trying to gain purchase with its hooves. The animal drowned and the next day a coyote observed the carcass but made no attempt to retrieve it. On 13 April 2017 at 2016 hrs, two javelinas at Las Palomas appeared to be in a wrestling match. The two animals juxtaposed, head to rump, and laterally pushed with their body and head at the other animal. This behavior matches that described by Byers and Bekoff (1981) as "mutual rub and related acts", including "move parallel" and "mutual rub". Javelinas were never photographed crossing logs over the Río Cocóspera, but we documented javelinas crossing the river where the water was shallow (~15 cm or less).

Interaction with Cattle and Important Habitat Variables: We recorded 540 javelina events during 202 camera months without cattle and 60 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a javelina event is equal in any given month, regardless of cattle presence (null hypothesis: cattle have no effect on javelina events, or the difference between the two ratios equals zero), we would expect 475 events during months without cattle and 125 with cattle. The calculated z statistic is 3.72, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on javelina events.

Javelina were photographed at 43 camera sites and not photographed at seven sites. Because we had only seven of the latter sites, we did not conduct a binary logistic regression to determine important habitat variables for the javelina.

CERVIDAE

Odocoileus virginianus, White-tailed Deer (Venado Cola Blanca)

White-tailed deer occur from southern Canada through most of the USA and south through mainland Mexico and Central America to Peru, Bolivia, and Venezuela (Smith 1991; Gallina and Lopez-Arevalo 2016). In Sonora, Alvarez-Castañeda and Patton (2000) and Caire (2019) show the species as occurring statewide; however, they provide no records for the hyper-arid Gran Desierto region, and based on its distribution in Arizona (Hoffmeister 1986), it is unlikely to occur there. White-tailed deer in the study area are referable to *O. v. couesi*, a small-bodied, long-eared subspecies of the southwestern USA and northwestern Mexico. Adult males in the Chiricahua Mountains, Arizona, averaged 37.6 kg (Hoffmeister 1986). The MDE database contains 552 Sonora records for white-tailed deer, primarily from the northeastern portion of the state, but with a few from southeastern Sonora and near the coast. Elevational range of those records is near sea level to 2422 m. The MDE database includes 12 records for Rancho El Aribabi, although one of those plots north of the ranch. The valid localities are from Las Palomas, lower and moderate elevations in the Sierra Azul, Arroyo Los Amorosos, and Arroyo Guerigo, a tributary to the Río Cocóspera, at elevations of 1022 to 1422 m. Vegetation communities of the valid localities include Fremont cottonwood-Goodding willow riparian forest, velvet mesquite grassland, and oak woodland.

Local Distribution: The white-tailed deer was the most frequently photographed wild mammal in this study: 3841 events at 45 of 50 camera sites. It also had the lowest camera days/event (5.5) of any photographed species as calculated over all 50 camera sites (Table 2, Figures 67-69). We photographed white-tailed deer in all the vegetation types, terrain types, and site types represented by our cameras. Elevations of records ranged from 968 to 1406 m. In addition to the camera trap images, we occasionally visually observed white-tailed deer along the Río Cocóspera and in the Sierra Azul.

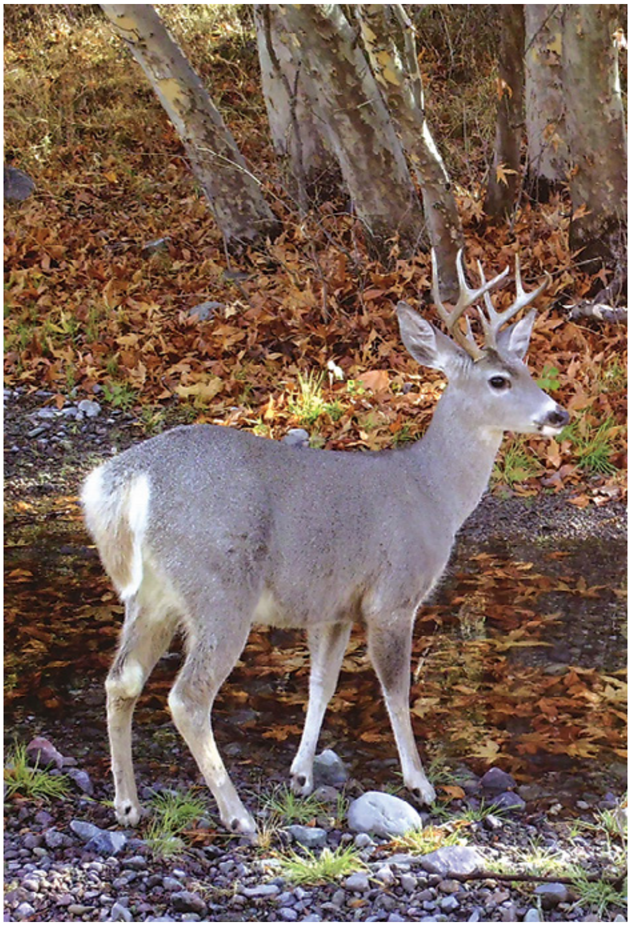

Figure 67. White-tailed deer buck, site ALP2, 15 December 2015, 1007 hrs.

Relative Abundance: We calculated the mean number of camera days per white-tailed deer event for each of the camera site types as follows: tributaries to Las Palomas = 22.2, upland = 11.2, cattle waters = 7.9, ridgeline = 5.8, Las Palomas = 5.6, and riverine = 4.3. The large number for tributaries to Las Palomas (22.2) is interesting. These sites were in relatively narrow drainages that may have been perceived as a predation threat by white-tailed deer. The camera site in the Las Palomas narrows where we documented predation of a white-tailed deer buck by a puma (site ALP6) also had a high camera days/event ratio (28.9). No white-tailed deer events were captured at the two camera sites closest to La Casona: a compost pile 30 m south of La Casona (site U5) and a dirt road 20 m east of La Casona (site R21), possibly indicating avoidance of human habitations.

Figure 68. Two sparring white-tailed deer bucks, site ALP4, 19 Feb 2018, 2157 hrs.

Figure 69. White-tailed deer on the Río Cocóspera, camera site R6, 22 March 2018, 1019 hrs.

Six white-tailed deer, all bucks, are taken by hunters each year in the study area, mostly in January. No deer hunting occurs at Las Palomas or along the Río Cocóspera. Some additional hunting of white-tailed deer occurs on adjacent parcels of Rancho El Aribabi. The MDE database contains a 2008 record for a mule deer (*Odocoileus* *hemionus*) at Las Palomas. Although the record does not include a photograph, it is from the work of Avila-Villegas and Lamberton-Moreno (2013). It is the only mule deer record in the database for the Municipio of Ímuris. The nearest record of a mule deer to Rancho El Aribabi in Caire (2019) is "near Magdalena" or Magdalena de Kino, which is about 38 km SW of La Casona in a velvet mesquite grassland-Sonoran desert-scrub transition. Sergio Avila-Villegas does not recall the Las Palomas record and believes it to be an incorrect data entry (S. Avilla-Villegas, pers. comm. 2020). The Robles family is keenly aware of deer populations at Rancho El Aribabi because the guided hunts are a source of income, and they say they have never seen mule deer on the ranch. Our images frequently did not show key diagnostic characters, so we cannot rule out the possibility that some of our images are of mule deer. However, if present, mule deer are certainly quite rare.

Behavior: The majority (2933, 76%) of our events showed solitary white-tailed deer. Group sizes of 2, 3, 4, and 5 accounted for 726 (19%), 159 (4%), 21 (1%), and 2 (< 1%) of white-tailed deer events, respectively. As discussed earlier, our camera trap events likely underestimated group size.

In southeastern Arizona, breeding typically occurs in January (Bristow 1997), but may extend from mid-December to as late as March (Hoffmeister 1986). Birthing typically occurs in July and August, but dates as early as June and as late as October have been reported (Smith 1984, Bristow 1997). Our camera trap images allow estimates of breeding chronology at Rancho El Aribabi. Sparring bucks, pushing at each other with their antlers, were photographed on 2 December 2016 on the bajada (site RG2; Figure 68), and 6 January and 15 February 2017 at Las Palomas (site ALP4), which corresponds to the rutting season for this species of deer. Fawns have a reddish-brown coat with white spots that disappear at 3-4 months of age (Hesselton and Hesselton 1982), allowing an estimate of birthing dates. Does with spotted fawns were photographed 30 times from 18 August to 3 October. Does with fawns that were no longer spotted were photographed 37 times from 1 September to 25 January. Those photographs suggest a birthing period that begins in early June or perhaps late May and extends into early July. This would be somewhat earlier, on average, than the birthing season in southeastern Arizona. Bucks in velvet were photographed numerous times from 13 July to 23 September. Antler velvet is shed from September to early November in Arizona (Hoffmeister 1986).

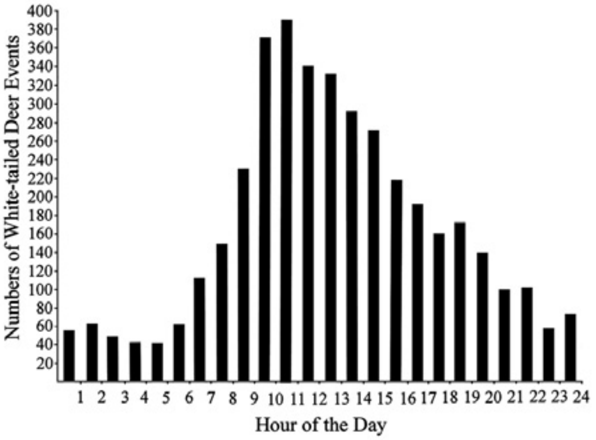

Figure 70. White-tailed deer 24-hr activity pattern.

White-tailed deer were photographed drinking from the stream in Las Palomas, gnawing on a mammalian bone along the Río Cocóspera, and consuming long stringers of green algae from a drying pool in Las Palomas. As discussed in the puma account (also see Figure 30), we photographed predation of a white-tailed deer buck by a puma on 13 January 2018 at site ALP6. Coyotes carrying pieces of white-tailed deer carcasses were photographed five times, but as discussed in the account for that species, we are unable to determine if that represented predation or scavenging. At Rancho El Aribabi, white-tailed deer were active by day and at night, but activity peaked from 0900 to 1300 hrs (Figure 70). However, activity varied seasonally. Activity was greater in the summer from 0600 to 0900 hrs and mid-day peaks were lower than in winter, possibly suggesting an avoidance of mid-day heat. Interestingly, nocturnal activity, from about 2000 to 0400 hrs, was greater in the winter months as compared to summer (Figure 71). Monthly adjusted events varied from 114 in March to 271 in August. The mean was 194.

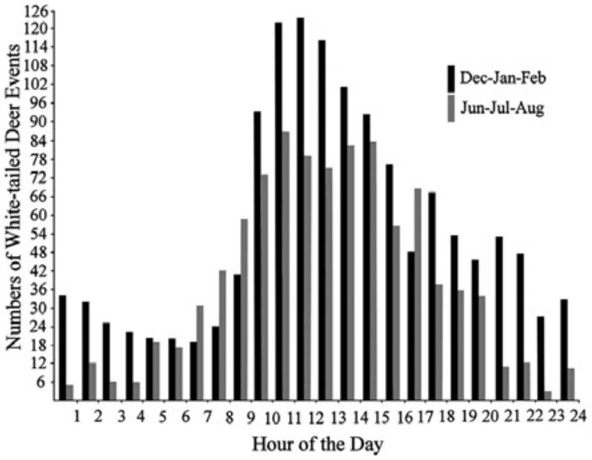

Figure 71. White-tailed deer 24-hr activity patterns in winter and summer.

Interaction with Cattle and Important Habitat Variables: We recorded 978 white-tailed deer events during 202 camera months without cattle and 114 events during 53 camera months with cattle at the Las Palomas and vicinity camera sites. Assuming the likelihood of a white-tailed deer event is equal in any given month, regardless of cattle presence (null hypothesis: cattle have no effect on white-tailed deer events, or the difference between the two ratios equals zero), we would expect 865 events during months without cattle and 227 with cattle. The calculated z statistic is 3.55, thus we reject the null hypothesis. These data provide evidence that cattle presence has a negative effect on white-tailed deer events.

White-tailed deer were photographed at 45 camera sites and not photographed at five sites. Because we only had five of the latter sites, we did not conduct a binary logistic regression to determine important habitat variables for the white-tailed deer.

PHYLLOSTOMIIDAE

Macrotus californicus, California Leaf-nosed Bat (Murciélago Orejón Californiano)

The California leaf-nosed bat occurs from southern Nevada, Arizona, and southern California south through the entirety of the Baja California peninsula, Sonora, and southwestern Chihuahua into northern Sinaloa (Barbour and Davis 1969; Ceballos 2014). Caire (2019) shows this species occurring throughout most of Sonora, with the closest record to Rancho El Aribabi in the Río Bambuto Valley northwest of the ranch. Alvarez-Castañeda and Patton (1999) list 45 records for Sonora, which are statewide, but none are very close to Rancho El Aribabi. The MDE database lists 66 Sonoran records of this species, mostly from the western half of the state. Elevations of those records range from near sea level to 1422 m. The records include no entries for Rancho El Aribabi or the Municipio of Ímuris. The California leaf-nosed bat occurs with the closely related and similar Waterhouse's leaf-nosed bat (*Macrotus waterhousii*) in southern Sonora.

Local Distribution: We captured a single California leaf-nosed bat in a mist net across the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest approximately 0.3 km SE of La Casona on 19 June 2007 at 1930 hrs. It escaped before it could be sexed or otherwise examined. Another individual was observed flying above the net on 20 June 2007 at 1938 hrs. Our surveys for bats were few and limited to areas near La Casona. They should be considered preliminary.

MOLOSSIDAE

Tadarida brasiliensis, Mexican Free-tailed Bat (Murciélago Cola Suelta)

The Mexican free-tailed bat occurs from 40 degrees north in the middle of the USA to 40 degrees south in Argentina and Chile. It is widely distributed in Mexico (Ceballos 2014), but is migratory or seasonal throughout most of its range (Cockrum 1969; Ceballos 2014). In Sonora, Caire (2019) portrays the species as occurring throughout Sonora, probably from about March to October (Villa and Cockrum 1962). Caire (2019) found a roost of several thousand of these bats in June in a tunnel near Ímuris. Most of the bats he examined were pregnant females. The MDE database contains 249 Mexican free-tailed bat records for Sonora, mostly from the western half of the state at elevations of 14 to 1530 m. The database contains many collection records for "Cueva del Tigre" about 18 km SSE of Carbó. We did not find any records for Rancho El Aribabi.

Local Distribution: We captured a single, non-lactating female Mexican free-tailed bat in a mist net over the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest on 21 September 2006 at approximately 1950 hrs (Figure 72). The elevation was 983 m. A colony of these bats day roosted in the attic of La Casona and we often saw them exiting from the rafters of the building in summer at dusk.

Figure 72. Mexican free-tailed bat, Fremont cottonwood-Goodding willow riparian forest, Río Cocóspera, 21 September 2006, ~1950 hrs.

VESPERTILONIDAE

***Eptesicus fuscus*, Big Brown Bat (Murciélago Moreno Norteamericano)**

The big brown bat is found over an extensive distribution from Canada south to Colombia and Venezuela (Ceballos 2014). In Mexico, it occurs throughout most of the country except for the Yucatan Peninsula (Davis 1965; Hall 1981). Caire (2019) and Alvarez-Castañeda and Patton (1999) map its distribution in Sonora as statewide, although no records for the hyper-arid northwestern deserts are listed in those publications. Included among Caire's (2019) records are three close to Rancho El Aribabi, including specimens from "9 mi NE Imuris", "11 mi E Imuris, Hwy 2", and "12 mi ENE Imuris". The MDE database contains seven records for this species, which are scattered across the state from near sea level to 1910 m elevation. The database includes no records for Rancho El Aribabi.

Local Distribution: We captured five individuals of this species, 19–20 June 2007, in mist nets set over the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest. The elevation was 983 m. Captures included one of unknown sex that escaped before it could be examined, two females, one lactating the other not, and two males. Captures occurred from 2048 to 2130 hrs. One of the males had two bed bugs (*Cimex* sp.) attached to its forearms.

***Myotis velifer*, Cave Myotis**
(Murciélago Mexicano)

The cave myotis occurs mostly at lower elevations from Kansas, Oklahoma, and Texas west to southeastern California and southward through most of Mexico to Honduras (Barbour and Davis 1969; Ceballos 2014). In Sonora, the species occurs in lower mountains and foothills in the eastern half of the state wherever suitable roosts (caves, mines, abandoned tunnels and houses) are found. A record from Caire (2019) at "11 mi E Imuris, Hwy 2" is close to Rancho El Aribabi. The MDE database includes 78 records for Sonora, mostly in the foothill region in the middle of the state at elevations of 43 to 1669 m. There are many collections from Mina del Durazo "12 mi S, 5 mi W Santa Ana" and the Álamos region in southeastern Sonora. We found no records for Rancho El Aribabi.

Local Distribution: Four female cave myotis were captured in mist nets over the the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest approximately 0.25 km SE of La Casona during 19-20 June 2007. The elevation was 983 m. Captures occurred from 2050 to 2145 hrs. Two of the bats were lactating, one was pregnant, and the fourth was non-lactating and not pregnant. One of the lactating females had two bed bugs (*Cimex* sp.) attached to her body and her stomach was distended and full.

Lasiurus blossevillii, Western Red Bat (Murciélago Cola Peluda Blosevil)

The western red bat occurs from the western USA south through Mexico outside of the Mexican Plateau and into Central America (Barbour and Davis 1969; Ceballos 2014). In Sonora, Caire (2019) mapped its distribution across the eastern portion of the state, but that map was based on only seven records. Using the same records, Alvarez-Castañeda and Patton (1999) mapped its distribution in the east but also in northwestern Sonora. Medellín et al. (2008) shows its distribution across the state. Caire (2019) suggested the species is limited to riparian situations where large trees are available as roosting sites. One of Caire's (2019) localities – "9 mi NNE Imuris", is close to Rancho El Aribabi. The MDE database contains six Sonoran records, all from east-central to southeastern Sonora at elevations of about 400 to 1954 m. We found no records for Rancho El Aribabi.

Local Distribution: On 20 June 2007 at 2049 hrs, we captured one pregnant female western red bat in a mist net over the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest approximately 0.25 km SE of La Casona. The elevation was 983 m.

Lasiurus cinereus, Hoary Bat (Murciélago Cola Peluda Canoso)

The hoary bat occurs from Canada south through nearly all of the USA and Mexico to Chile and Argentina (Burt and Grossenheider 1980; Ceballos 2014). This is a species of wooded areas; it roosts in trees. Montane woodlands as well as deciduous riparian forests serve as its habitat in Sonora, where it occurs primarily in the eastern portion of the state (Caire 2019). Seven Sonora localities are listed by Caire (2019) and Alvarez-Castañeda and Patton (1999), including one close to Rancho El Aribabi ("9 mi NNE Imuris"). The MDE database contains eight records for this species, all in areas mapped by Caire (2019) as within the distribution. Elevations range from about 183 to 1945 m. We found no records for Rancho El Aribabi.

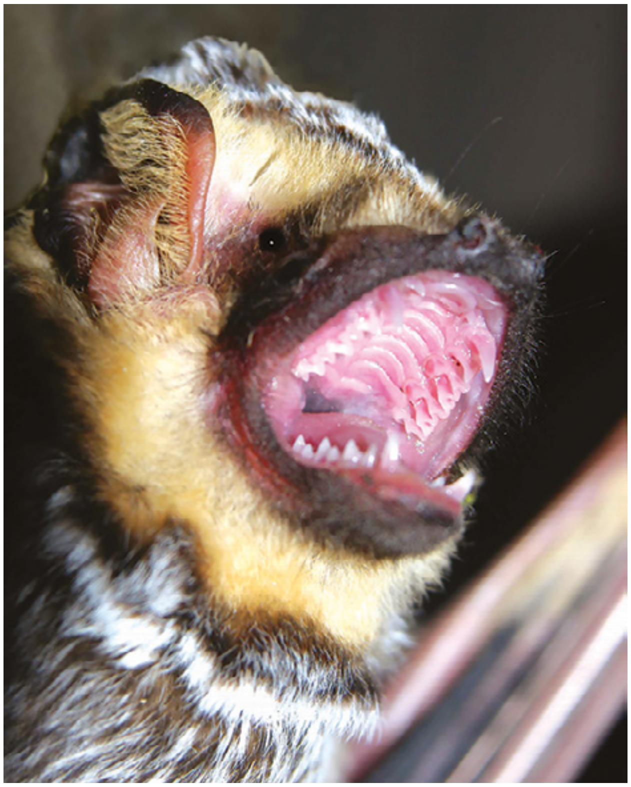

Figure 73. Hoary bat. Fremont cottonwood-Goodding willow riparian forest, Río Cocóspera, 21 September 2006, 1855 hrs.

Local Distribution: We captured two of these bats on 21 September 2006 in mist nets suspended over the Río Cocóspera in a Fremont cottonwood-Goodding willow riparian forest approximately 0.25 km SE of La Casona. The elevation was 983 m. Included were one non-lactating female, netted at approximately 1910 hrs, and one male, netted at approximately 1855 hrs (Figure 73).

***Parastrellus hesperus*, Canyon Bat (Pipistrello de Oeste Americano)**

This bat was, until recently, known as *Pipistrellus hesperus* (Hoofer et al. 2006). Its distribution ranges from the western USA south through all of the Baja California peninsula and mainland Mexico to Puebla and Guerrero (Burt and Grossenheider 1980; Ceballos 2014). This is a species of rocky areas; it typically roosts in rock crevices (Barbour and Davis 1969). In Sonora, it occurs statewide, although Caire (2019) suggests it avoids high elevations in the Sierra Madre Occidental. Caire (2019) lists three localities close to Rancho El Aribabi ("Imuris area", "10 mi N Imuris", and "9 mi NNE Imuris"). The MDE database includes 24 Sonoran records (as *Pipistrellus hesperus*), many from coastal areas, but several from the Álamos area, near Yécora, and one from the Sierra El Tigre at elevations of near sea level to 1246 m. We found no records for Rancho El Aribabi.

Local Distribution: We mist-netted one lactating female canyon bat at 2005 hrs, 19 June 2007, at the Río Cocóspera approximately 0.25 km SE of La Casona in a Fremont cottonwood-Goodding willow forest. A second individual was seen flying over the river at the same location on 20 June 2007 at 1938 hrs. The elevation was 983 m.

ANTROZOIDAE

***Antrozous pallidus*, Pallid Bat (Murciélago Desértico Norteño)**

The pallid bat occurs from southern British Columbia south through the western USA, all of the Baja California peninsula, and the Mexico mainland to Hidalgo and Jalisco (Burt and Grossenheider 1980; Ceballos 2014). In Sonora, Caire (2019) mapped its distribution as nearly statewide, but suggests it is less abundant at higher elevations and in southern Sonora than elsewhere in the state. The nearest record to Rancho El Aribabi listed by Caire (2019) is from the Río Bambuto Valley to the west of the ranch. The MDE database lists 12 records for Sonora, mostly from the western half of the state and ranging in elevation from near sea level to about 1500 m. We found no records for Rancho El Aribabi.

Local Distribution: Six pallid bats were found roosting in the eaves of the patio roof of La Casona on 8 August 2007. We observed the species in clusters of up to 31 individuals (Figure 74) in the La Casona rafters on several occasions during the summer in subsequent trips. The elevation was 996 m.

Figure 74. Pallid bats on the La Casona patio, 29 August 2014, 2249 hrs.

Other Mammals Likely to Occur at Rancho El Aribabi and Extirpated Species

Table 7 lists 39 mammal species that may occur at Rancho El Aribabi but were not documented by us or others. We used shaded distribution and dot maps in Alvarez-Castañeda and Patton (1999, 2000), Medellín et al. (2008), Ceballos (2014), and Caire (2019) as our primary sources for compiling this list. Most species on the list are rodents and bats, which we did not thoroughly survey, and all of our small mammal trapping and mist-netting occurred on the Río Cocóspera or in scrub habitats near La Casona. In particular, those activities need to be expanded to the higher elevations of the Sierra Azul and into velvet mesquite grasslands on the bajada to compile a better list of these smaller mammals.

Table 7. Hypothetical mammals that may occur at Rancho El Aribabi, supporting literature sources, and where on Rancho El Aribabi each is most likely to occur.

Species	Source	Most Likely to Occur
Lepus californicus, Black-tailed jackrabbit	Ceballos (2014), Caire (2019)	Low elevation, Sonoran desertscrub-foothills thornscrub ecotone
Sylvilagus floridanus, Eastern cottontail	Ceballos (2014), Coronel-Arellano (2016), Caire (2019)	Oak woodland or savanna, pine-oak woodland in the Sierra Azul
Ammospermophilus harrisii, Harris's antelope squirrel	Ceballos (2014), Caire (2019)	Low elevation, Sonoran desertscrub-foothills thornscrub ecotone
Dipodomys ordii, Ord's kangaroo rat	Ceballos (2014), Caire (2019)	Velvet mesquite grassland
Liomys pictus, Painted pocket mouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Shrublands, montane woodlands
Chaetodipus baileyi, Bailey's pocket mouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Low elevation, Sonoran desertscrub-foothills thornscrub ecotone
Neotoma mexicana, Mexican woodrat	Ceballos (2014), Caire (2019)	Sierra Azul
Onychomys torridus, Southern grasshopper mouse	Ceballos (2014), Caire (2019)	Low elevation, Sonoran desertscrub-foothills thornscrub ecotone
Peromyscus boylii, Brush deermouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Throughout
Peromyscus eremicus, Cactus deermouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Throughout
Peromyscus leucopus, White-footed deermouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Throughout
Peromyscus merriami, Merriam's deermouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Moderate to low elevations, especially with velvet mesquite
Reithrodontomys fulvescens, Fulvous harvest mouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Oak woodlands and mesquite grasslands
Reithrodontomys megalotis, Western harvest mouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Grasslands within oak woodlands in the Sierra Azul
Reithrodontomys montanus, Plains harvest mouse	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Grasslands in and adjacent to oak woodlands in the Sierra Azul
Sigmodon arizonae, Arizona cotton rat	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Low elevation, Sonoran desertscrub-foothills thornscrub ecotone and the Río Cocóspera
Sigmodon fulviventer, Tawny-bellied cotton rat	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Velvet mesquite bosque and mesquite grasslands

Table 7. (continued) Hypothetical mammals that may occur at Rancho El Aribabi, supporting literature sources, and where on Rancho El Aribabi each is most likely to occur.

Sigmodon ochrognathus, Yellow-nosed cotton rat	Ceballos (2014), Caire (2019)	Velvet mesquite bosque and mesquite grassland
Notiosorex sp.[1], Shrew	Alvarez-Castañeda and Patton (1999), Ceballos (2014), Caire (2019)	Throughout
Mephitis mephitis, striped skunk	Ceballos (2014)	Throughout
Odocoileus hemionus, Mule deer	Ceballos (2014), Culver (2016), Coronel-Arellano et al. (2016)	Lower elevations that are not rugged in terrain
Choeronycteris mexicana, Mexican long-tongued bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout, particularly where there are shallow caves. Expected at La Casona hummingbird feeders.
Leptonycteris yebabuenae, Lesser long-nosed bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout, particularly where there are caves and mine shafts or tunnels. Expected at La Casona hummingbird feeders.
Mormoops megalophylla, Ghost-faced bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in caves and forage over water.
Eumops perotis, Western mastiff bat	Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in high rock crevices, hollow trees, and tunnels.
Eumops underwoodi, Underwood's mastiff bat	Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in high rock crevices, hollow trees, and building roofs.
Nyctinomops femorasaccus, Pocketed free-tailed bat	Medellín et al. (2008), Ceballos (2014), Caire (2019)	Lower elevations, may roost in rocky cliffs, small caves, and buildings.
Nyctinomops macrotis, Big free-tailed bat	Medellín et al. (2008), Ceballos (2014), Caire (2019)	Mainly at moderate to low elevations. May roost in rocky cliffs, caves, tree cavities, and buildings.
Myotis auriculus, Southwestern myotis	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in rock crevices, tree cavities, and buildings.
Myotis californicus, California myotis	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Near water throughout. May roost in mines, tree cavities, loose rocks, and buildings.
Myotis fortidens, Cinnamon myotis	Medellín et al. (2008), Ceballos (2014), Caire (2019)	Lower elevations of Sonoran desertscrub foothills thornscrub ecotone. May roost in rock crevices, caves, under tree bark, and buildings.
Myotis ciliolabrum, Western small-footed myotis	Ceballos (2014), Caire (2019)	Throughout. May roost in rock crevices and caves.
Myotis thysanodes, Fringed myotis	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in caves or mine tunnels and shafts.
Myotis volans, Long-legged myotis	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in caves, mine tunnels and shafts, tree cavities, and buildings.
Myotis yumanensis, Yuma myotis	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in caves and buildings.

Table 7. (continued) Hypothetical mammals that may occur at Rancho El Aribabi, supporting literature sources, and where on Rancho El Aribabi each is most likely to occur.

Corynorhinus townsendii, Townsend's big-eared bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in caves, mines, and buildings.
Euderma maculatum, Spotted bat	Villa-Ramirez (1967), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Probably at moderate and lower elevations. May roost in rock crevices.
Idionycteris phyllotis, Allen's big-eared bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Throughout. May roost in rock crevices.
Lasiurus xanthinus, Western yellow bat	Alvarez-Castañeda and Patton (1999), Medellín et al. (2008), Ceballos (2014), Caire (2019)	Moderate to lower elevations. May roost under branches of trees.

[1]A *Notiosorex* was observed by us (see the species account), but we are unsure if it was *N. crawfordi*, Crawford's gray shrew, or *N. cockrumi*, Cockrum's shrew. Both could occur at Rancho El Aribabi.

Few medium to large mammals are listed in Table 7 and most of those are discussed in the species accounts above. Eastern cottontail, black-tailed jackrabbit, striped skunk, and mule deer could have been photographed by our cameras but the resulting images failed to show enough detail to discriminate them from other similar species. It is possible we observed nests built by Mexican woodrats, but those are indistinguishable from the nests of white-throated woodrats, which we documented via Sherman live traps.

In Table 7, we have not listed two medium-sized mammals that are shown as occurring in the Rancho El Aribabi area by Ceballos (2014), including the kit fox (*Vulpes macrotis*) and jaguarundi (*Puma yagouaroundi*). The kit fox is a small canid of desertscrub and grasslands, including in northeastern Sonora. Caire (2019) shows one record about 39 km SW of La Casona "near Magdalena" (see Bailey 1932). The MDE has only two records for Sonora, one in the Pinacate region and another near Álamos in southeastern Sonora. Hoffmeister (1986) lists only three records for Cochise County and no records for Santa Cruz County, Arizona, to the north of Rancho El Aribabi. The species was not captured via camera traps by Culver (2016) in Arizona or in any of the camera trap projects we have cited for Sonora. We suspect that in our area, this is a species of grassland and desertscrub valleys and plains, neither of which occur at Rancho El Aribabi.

Although included among the mammalian fauna of Sonora by Alvarez-Castañeda and Patton (2000), Ceballos (2014), and other workers, including Caire (2019) and Castillo-Gámez et al. (2010), we are unaware of any verifiable records of the jaguarundi in Sonora. There have been many sightings of jaguarundi in both Sonora and southern Arizona; however, the species has not been documented via photographs or specimens. Castillo-Gámez et al. (2010) note that many of the sightings in Sonora have been at dusk and the animal was moving, making it difficult to formulate a good identification. Brown and López-González (1999) make the case that the jaguarundi does not occur north of Sinaloa.

Three species that probably once occurred at Rancho El Aribabi historically are now almost certainly extirpated. These include Mexican gray wolf (*Canis lupus*), beaver (*Castor canadensis*), and grizzly bear (*Ursus arctos*). Historical distribution maps in Ceballos (2014) for all these species include Rancho El Aribabi. A wolf was collected long ago at "Santa Cruz" about 43 km NNE of the ranch (Caire 2019), but with the possible exception of wolves reintroduced to the Sierra Madre Occidental of northeastern Chihuahua that may have spread to adjacent sierras of Sonora (López-González and Lara-Díaz 2016), probably

Figure 75. Human-made impressions of bear tracks and various symbols in what would have been wet travertine but is now rock, Rancho El Aribabi.

no wolves have occurred in Sonora in the last two decades (Ceballos 2014).

The perennial reach of the Río Cocóspera downstream of La Casona was once probably excellent habitat for beaver. Construction of dams and cutting down of trees by these animals would have created more complex hydrology along the river and large, deep pools, varied surface water elevations and channel morphology, decreased flow velocities, and likely altered stream temperature regimes compared to the current situation (Majerova et al. 2015). Beaver activity is often associated with an increase in riparian plant diversity (Russell et al. 1999; Cunningham et al. 2007) and decreases in riparian tree canopy cover (Kay 1994).

Grizzly bears likely inhabited most of Rancho El Aribabi before they were extirpated from Mexico in the late 20th century. Alvarez-Castañeda and Patton (2000) note an old record for the mountains near Nogales. A juvenile grizzly bear was shot in the Sierra de la Madera about 20 km SSW of La Casona in 1976, which

Figure 76. Carlos Robles Elías pointing out human-made impressions of bear tracks and various other symbols inside a shallow cave at Rancho El Aribabi.

is the most recent record of a grizzly in Mexico (Gallo-Reynoso et al. 2008). On Rancho El Aribabi in a shallow cave formed from boulders, we found facsimiles of bear footprints made by human hands pushed into what would have been at the time soft, wet travertine (Figures 75 and 76). These human-made footprints were up to 40 cm in length and may have been inspired by grizzly bears living in the area. The impressions are probably quite old, as there is no spring that could form travertine in that area now.

Incidental Camera Trap Wildlife Species

Our camera traps captured 66 wildlife species other than medium to large mammals, including three invertebrates, one amphibian, five reptiles, 54 birds, and four small mammals (Table 4, Figures 77-79). In some cases, identification to species is tentative due to small size and lack of details in the camera trap images. Three invertebrates is certainly a very small fraction of what occurs at Rancho El Aribabi, which clearly illustrates how poorly conventional camera traps work to inventory these animals. Numbers of amphibian and reptile species documented via camera trap was 17% of the known herpetofauna of Rancho El Aribabi (Rorabaugh et al. 2013), but camera traps are good at documenting predation of reptiles by mammals and birds (Rorabaugh and Van Devender 2020). Birds were photographed not uncommonly, often in flight, but most images were not clear enough to identify the bird to species. Nonetheless, we still identified 54 species of birds from our images, which is impressive given that the known avifauna of the ranch consists of 192 species (www.elaribabi.com). Bats in flight were photographed fairly frequently, but it was impossible to identify them to species. Small mammals such as rodents were infrequently captured in our images and usually not identifiable to species. However, those images added Merriam's kangaroo rat to the ranch's mammalian species list, as it was not detected by other means; but see the note on identification in the species account.

Figure 77. Red-tailed hawk (incidental species), site R12, 10 February 17, 1604 hrs.

Figure 78. Wild turkey (incidental species), site R1, 28 May 2017, 0932 hrs.

Figure 79. Male elegant trogon (incidental species), site ALP4, 21 May 2017, 1148 hrs.

Livestock, Dogs, Introduced Species, Vehicles, and Humans

Our camera traps documented 6704 notable events other than wildlife and incidental species, including cattle (5557), horse (*Equus caballus*) with rider (337), vehicle (278), human (215), dog (178, *Canis lupus familiaris*), horse (135), and wild burro (4, *Equus africanus*) (Table 3). The number of cattle events far exceeded that of the most frequently photographed wild mammal (white-tailed deer, 3841 events), reflecting the predominant land use on the ranch – cattle grazing and production. From 2012 to 2015 in southeastern Arizona mountain ranges, numbers of cattle detections were relatively lower and detections of humans were relatively higher than in our study area. Cattle were the second-most detected species and humans were number four in Arizona and adjacent New Mexico, although numbers varied considerably across mountain ranges (Culver 2016). In our project, humans (not associated with horses or vehicles) were tied for the 12th most animal events.

Comparisons to Inventories in Other Sky Island Regions

Culver (2016) inventoried medium to large mammals in most of the sky island mountain ranges in southeastern Arizona and southwestern New Mexico south of Interstate 10 from 2012 to 2015. Coronel-Arellano et al. (2016) inventoried medium to large mammals in the Sierras San Luis, El Tigre, Los Ajos, and La Madera of Sonora to the east and southeast of Rancho El Aribabi. Both studies used camera traps to document mammals. Our results are similar to those studies in terms of species richness of wild mammals. We documented 20 medium to large species via camera traps, compared to 20 (Culver 2016) and 25 (Coronel-Arellano et al. 2016), although Culver (2016) did not attempt to distinguish between skunk or squirrel species. Except for the squirrels and skunks, we did not detect any species via camera trapping that Culver (2016) did not detect, but she reported pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), jaguar, and mule deer, which we did not photograph. Coronel-Arellano et al. (2016) documented Mexican fox squirrel (*Sciurus nayaritensis*), eastern cottontail, jaguar, striped skunk, and mule deer in their study areas, which we did not photograph. We did not document any medium to large mammals that Coronel-Arellano et al. (2016) did not find in their study areas.

In the foothills of the Sierra Madre Occidental, Sonora, Lorenzana-Piña et al. (2004) documented 18 species of medium to large mammals via camera trapping. They photographed jaguar and eastern cottontail, which we did not find at Rancho El Aribabi, but we documented Arizona gray squirrel, hooded skunk, desert cottontail, and American black bear, which they did not detect.

In four Sonora sky islands studied by Coronel-Arellano et al. (2016), the three species with the most photographic events were, from greatest to fewest, white-tailed deer, rock squirrel, and gray fox. In the foothills of the Sierra Madre Occidental, the five species with the greatest number of events were (from greatest to fewest) gray fox, white-tailed deer, coyote, eastern cottontail, and puma (Lorenzana-Piña et al. 2004). In the Arizona and New Mexico sky islands, the most commonly photographed wild mammals were white-tailed deer, javelina, black bear, and "squirrels" (Culver 2016). Our top five were white-tailed deer, javelina, white-nosed coati, coyote, and gray fox, in that order (Table 2).

Threats to Species Conservation

Table 2 lists the conservation status of mammalian species we documented at Rancho El Aribabi. That status derives from Mexico's list of species at risk (SEMARNAT 2019) and version 2020-2 of the IUCN's (International Union for Conservation of Nature) Red List of threatened species. Seven species found at Rancho El Aribabi are on the Mexican list, one of which is also on the Red List above the "least concern" category: Arizona gray squirrel (A/DD), desert shrew (A/LC), North American porcupine (P/LC), ocelot (P/LC), jaguar (P/NT), black bear (Pr/LC), and California leaf-nosed bat (P/LC). See Table 2 for definitions of these categories.

Nowak (1991) surmised that in Mexico the Arizona gray squirrel is threatened by habitat loss caused by logging, clearing of forests for agriculture, and fires. We found the Arizona gray squirrel to be limited to the riparian forests of the Río Cocóspera where it was moderately abundant in our camera trap images. The MDE database included one record from an oak woodland (Arroyo Los Amorosas), suggesting it occurs elsewhere on the ranch in montane woodlands. The Río Cocóspera is a free-flowing river that experiences high flows that periodically topple trees. In 2014, we witnessed the aftermath of a damaging flood in which many young Fremont cottonwoods (up to ~0.3 m in diameter) had been uprooted and deposited in massive log jams along the river. Most of the Fremont cottonwoods on the river are relatively young. High flows after heavy winter rains in 1993 scoured out most of the trees from the floodplain, and the young trees seen now began growing soon thereafter (C. Robles Eliás, pers. comm. 2018). These catastrophic flooding events likely adversely affect Arizona gray squirrels that forage and nest in tall riparian trees. Flooding is likely more severe than would occur naturally due to watershed degradation upstream of Rancho El Aribabi. Wildfire is also a threat to the riparian forest and montane woodlands where Arizona gray squirrels occur. Wildfire ignitions occur naturally from lightning strikes but also from various human activities. Climate change is expected to increase the likelihood of fires in habitats of the Arizona gray squirrel (Garfin et al. 2013). The hydrology of the ciénega that is the source of perennial flow in the Río Cocóspera has not been studied; however, climate change and predicted reduced precipitation and higher temperatures in the watershed (Garfin et al. 2013) could reduce flow from the ciénega and in the river, affecting riparian forests.

A proposal to reroute Mexico Highway 2 through the Río Cocóspera canyon was thwarted, but current plans may still have the new highway pass through the ranch between the river and Las Palomas (the precise route is yet to be determined), adversely affecting velvet mesquite grasslands and movement of wildlife through the ranch. Wildlife underpasses are likely to be part of the project and are expected to mitigate, in part, adverse effects to wildlife connectivity. An underground gas pipeline runs within the river corridor and construction or repairs to that pipeline could have adverse effects to the riparian habitats of the Arizona gray squirrel. Overall, free-flowing riparian habitats are resilient to disturbance (White and Stromberg 2011) and would likely recover fairly quickly from floods, fire, and pipeline work. In 2018, pasture fences were rebuilt and improved so that cattle are now excluded from the perennial reach of the Río Cocóspera.

As discussed in the species accounts, we are not sure if the shrews we found were desert or Cockrum's shrews. However, one was found along the river corridor and another was in a velvet mesquite grassland area on the bajada. If the species is well-distributed in those habitats, it should be secure under current management. The locality on the bajada could be affected by the new highway. Possible impacts to the riparian forest were discussed above for the Arizona gray squirrel.

The North American porcupine, listed as endangered on the Mexican list, was occasionally observed at Rancho El Aribabi and adjacent areas 20–30 years ago, but none have been found since. As we discuss in the species account, the species may be in decline in the sky island region. But it is a secretive species that, to our knowledge, has only been captured once by a camera trap in Sonora (see the species account). Ceballos (2014) lists the following reasons for its endangerment in Mexico: (1) low densities, (2) poaching, and (3) loss of suitable habitat such as riparian corridors due to poor livestock management and exploitation of water resources. Livestock management at Rancho El Aribabi is consistent with sustainable use, the riparian corridor along the Río Cocóspera is in excellent condition, water is not being exploited, and North American porcupines are not hunted on the ranch. So if the species is in decline or extirpated from Rancho El Aribabi, the reasons for that declining status are unknown. This is a species that could be adversely affected by a warming and drying climate that could reduce stream flow and associated riparian forests (see discussion, above), and reduce montane woodlands through drought and fire (Garfin et al. 2013).

Conservation of the ocelot at Rancho El Aribabi was discussed by Rorabaugh et al. (2020). The species is sensitive to various forms of human disturbance. Ocelots were found at Las Palomas and its tributaries and the Río Cocóspera, with one individual in between those two areas. There was no evidence of ocelots moving between the river and the Las Palomas area. The rerouted Highway 2 would likely further isolate these two small populations of ocelots. Ocelots were also found to occur in proximity to water. Permanent water is quite limited at Las Palomas and its tributaries during the arid April to June period before the onset of the summer rains. The climate in the study area is expected to become hotter and drier as a result of anthropogenic climate change, further limiting water sources outside of the Río Cocóspera. Drought will likely place ocelots in contact more often with cattle in the Las Palomas area, and Rorabaugh et al. (2020) found that ocelots were adversely affected by concentrations of cattle there. A management recommendation we suggest is to exclude cattle from Las Palomas during the dry April-June period, before the onset of the summer rains, or develop alternate water sources for cattle in the Las Palomas pasture.

A montane corridor of oak and pine-oak woodland similar to that at Las Palomas connects the Sierra Azul with the Sierra Los Pinitos to the northwest. From the Los Pinitos, if an animal crosses the Río Santa Cruz, it can travel into the Sierra San Antonio, which is the southern end of the Patagonia Mountains in Arizona (Figure 80). Thus, a continuity of montane woodland habitat exists for movement of species such as North American porcupine, ocelot, jaguar, and American black bear. This cross-border connectivity is especially important for maintaining a presence of ocelot and jaguars in the U.S. (McCain and Childs 2008; Stoner et al. 2015; Peters et al. 2018; USFWS 2018; Rorabaugh et al. 2020), but also for maintaining populations of black bear in northwestern Mexico. Lara-Diaz et al. (2013) stated, "If black bear populations are to survive in Sky Islands of Northwest Mexico, it is essential to maintain the connectivity of sites from SSL (Sierra San Luis) and Sierra de Ajos to the United States." Although they did not mention the Sierra San Antonio-Patagonia Mountain corridor, the same is likely true there. Furthermore, the ocelot population at Rancho El Aribabi is likely a source of ocelots that are occasionally found in southeastern Arizona (Rorabaugh et al. 2020). However, U.S. Customs and Border Protection has built pedestrian barriers (10-m tall walls) along the border that will preclude the movement of medium to large mammals as well as other species (Lasky et al. 2011; Peters et al. 2018). As of this writing, a border wall that is impassable to larger mammals stretches from Nogales to about the crest of the Patagonia Mountains. The eastern portion of that wall is newly-constructed, 10-m tall fencing of the bollard design. Gates are being installed in new sections of the fence at arroyo and river crossings that will be left open during the summer rainy season. Animals may cross the border through these open gates. Some smaller mammals may be able to pass through the gaps between bollards, as well. However, lights and vehicle traffic along the fences may inhibit crossings. To the east of the Patagonia Mountains are vehicle barriers through which mammals should be able to cross. In some portions of the fence on the Arizona-Sonora border, wildlife openings, about 22 cm (width) by 28 cm (height), have been installed flush with the ground. However, none are planned as of this writing in the Patagonia Mountains or elsewhere to the north of Rancho El Aribabi. For information on border fencing see USFWS 2018 and https://www.cbp.gov/border-security/along-us-borders/border-wall-system.

California leaf-nosed bats do not hibernate and large numbers are present through the winter in the southwestern USA and Sonora (Burt 1930; Bradshaw 1962; Brown 2013), so they are highly dependent on suitable day roosts, which take the form of caves or mine tunnels or shafts, and occasionally buildings that maintain a fairly constant warm temperature and high humidity year-round (Berry and Brown 1995; Tuttle 1998). Most foraging occurs within 5–10 km of the day roost (O'Shea et al. 2018). We are not aware of

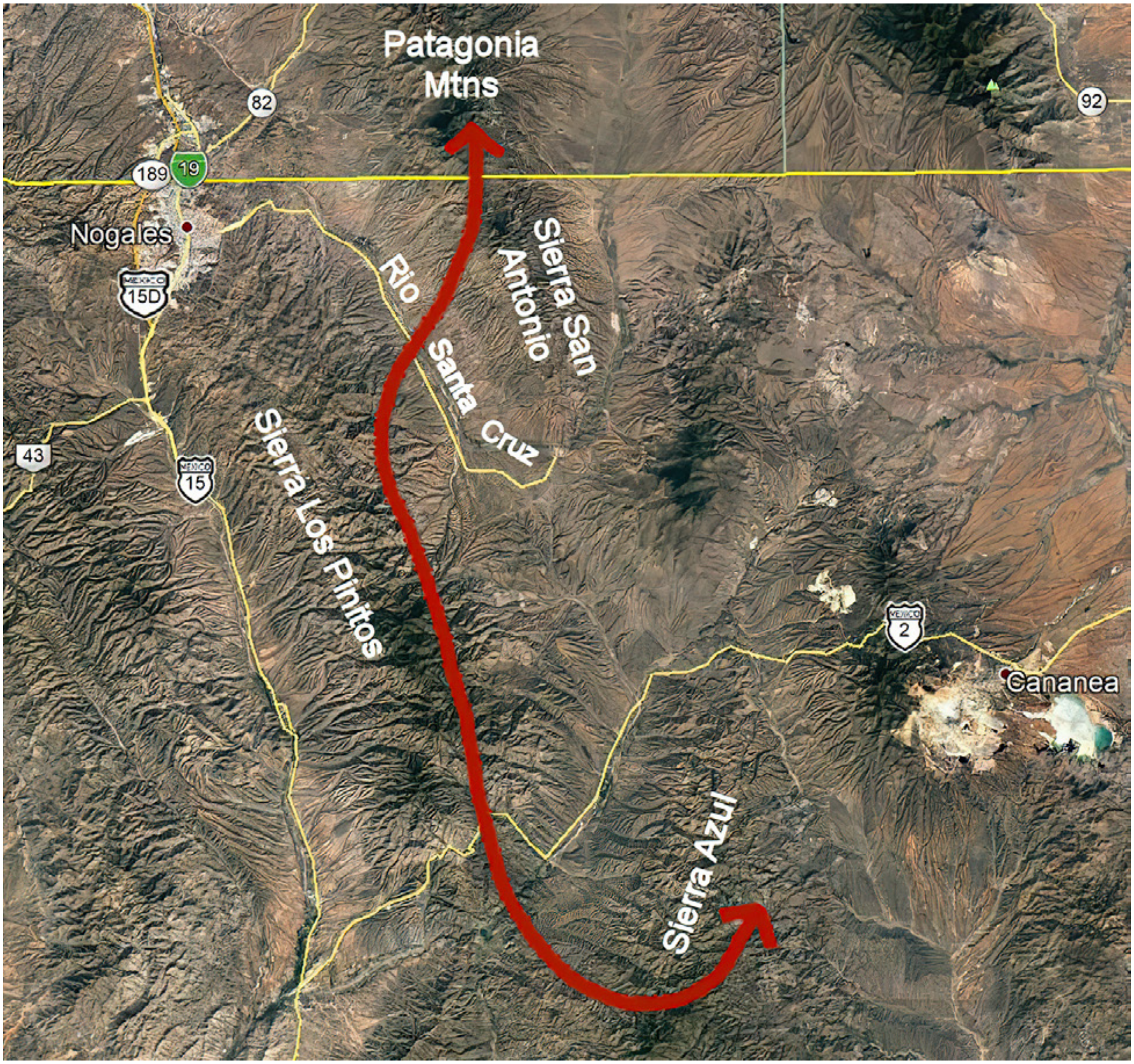

Figure 80. Montane corridor for mammals such as ocelot, jaguar, and American black bear to move from Rancho El Aribabi to Arizona, or vice versa.

any deep mines or caves on Rancho El Aribabi and we did not note this species around La Casona or other buildings in the area. A tunnel along Highway 2 (between km markers 145 and 146) in the Sierra Los Pinitos hosts day-roosting bats and is a place where locals collect guano. It could be where California leaf-nosed bats occurring at Rancho El Aribabi day roost. In any case, if day roosts of this species can be protected from alteration or other disturbance, California leaf-nosed bats will likely persist at Rancho El Aribabi into the foreseeable future. If Highway 2 is rerouted through the ranch, bridges and culverts could be designed to provide habitat for bats (Sparks et al. 2019).

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APPENDICES

Appendix 1. Camera Sites, Rancho El Aribabi.

Camera #	Type	Location	Coordinates (WGS84)/Elev.	Vegetation Community	Dates Operated	Camera Days	# Images[1]
R1	River	Río Cocóspera	30.84819 N, -110.67495 W, 989 m	Fremont cottonwood-Goodding willow riparian forest	20 Nov 2016 to 30 May 2018	483	4119
R2	Log crossing of the river	Río Cocóspera	30.850767 N, -110.674916 W, 982 m	Fremont cottonwood-Goodding willow riparian forest	9 Feb 2018 to 30 May 2018	111	643
R3	Tributary to River	Arroyo Tinaja	30.850722 N, -110.675606 W, 995 m	Velvet mesquite/netleaf hackberry woodland	14 May 2016 to 6 Nov 2018	866	41348, 317v,
R4	River	Río Cocóspera	30.849190 N, -110.674104 W, 982 m	Fremont cottonwood-Goodding willow riparian forest	7 Mar 2015 to May 28 2018	1133	9446
R5	River	Río Cocóspera	30.852976 N, -110.667872 W, 992 m	Fremont cottonwood-Goodding willow riparian forest	12 May 2017 to 30 May 2018	387	6496
R6	River	Río Cocóspera	30.856531 N, -110.664984 W, 984m	Fremont cottonwood-Goodding willow riparian forest	15 Aug 2016 to 30 May 2018	564	12891
R7	Mouth of tributary to the river	Mouth of Cañon Corallilo at the Río Cocóspera	30.844975 N, -110.681096 W, 985 m	Velvet mesquite bosque	5 Jul 2014 to 30 May 2018	947	21632
R8	Mouth of tributary to the river	Mouth of Cañon Puma at the Río Cocóspera	30.855531 N, -110.666206 W, 972 m	Fremont cottonwood-Goodding willow riparian forest	7 Mar 2015 to 6 Sep 2018	1115	6793
R9	Mouth of tributary to the river	Río Cocóspera Ciénega	30.856145 N, -110.664631 W, 983 m	Ciénega	23 Aug 2015 to 28 May 2018	804	24347
R10	Mouth of tributary to the river	Río Cocóspera	30.857324 N, -110.665707 W, 993 m	Velvet mesquite/netleaf hackberry woodland	7 Mar 2015 to 13 May 2016, 18 Nov 2016 to 9 Aug 2017	359	1125
R11	River	Río Cocóspera	30.853284 N, -110.668164 W, 996 m	Velvet mesquite bosque	10 Feb 2017 to 18 Aug 2017	151	1716
R12	River	Río Cocóspera Ciénega	30.857808 N, -110.665192 W, 983 m	Ciénega	10 Feb 2017 to 12 May 2017	92	1822

Appendix 1. (continued) Camera Sites, Rancho El Aribabi.

Camera #	Type	Location	Coordinates (WGS84)/Elev.	Vegetation Community	Dates Operated	Camera Days	# Images[1]
R13	River	Río Cocóspera	30.852114 N, -110.672520 W, 982 m	Fremont cottonwood-Goodding willow riparian forest	12-25 May 2017	14	9132
R14	River	Río Cocóspera	30.853657 N, -110.666102 W, 990 m	Velvet mesquite bosque	3 Sep 2016 to 12 Nov 2016	71	621
R15	Mouth of tributary to the river	Mouth of Cañon Coati at the Río Cocóspera	30.852273 N, -110.674680 W, 981 m	Fremont cottonwood-Goodding willow riparian forest	11 Apr 2015 to 28 May 2018	670	3291
R16	Log crossing of the river	Near mouth of Cañon Puma, Río Cocóspera	30.852836 N, -110.666568 W, ele 992 m	Fremont cottonwood-Goodding willow riparian forest	3-7 July 2017	5	3662
R17	Log crossing of the river	Río Cocóspera	30.85248 N, -110.67233 W, ele 968 m	Fremont cottonwood-Goodding willow riparian forest	19 Nov 2016 to 19 Aug 2017	274	3427
R18	Log crossing of the river	Río Cocóspera	30.851333 N, -110.675140 W ele 984 m	Fremont cottonwood-Goodding willow riparian forest	20 Nov 2016 to 19 Aug 2017	273	3724
R19	River	Río Cocóspera	30.855031 N, -110.663971 W, ele 982 m	Fremont cottonwood-Goodding willow riparian forest	7 Mar 2015 to 15 Aug 2016	335	825
R20	Mouth of tributary to the river	Río Cocóspera	30.859832 N, -110.665906 W, ele 995 m	Velvet mesquite bosque	28 Nov 2015 to 9 Feb 2018	432	1705
R21	Road on W bank of the river	Río Cocóspera	30.856109 N, -110.665457 W, ele 986 m	Fremont cottonwood-Goodding willow riparian forest	3 Oct 2015 to 28 Nov 2015	56	650
R22	River	Río Cocóspera	30.85227 N, -110.67153 W, ele 984 m	Velvet mesquite bosque	10 July 2015 to 25 Sep 2015	78	31
RG1	Ridgeline road	Ridgeline road to Agua Fría	30.834421 N, -110.593623 W, ele 1305 m	Velvet mesquite grassland	19 Nov 2016 to 12 Apr 2018	390	11833
RG2	Ridgeline road	SE of La Casona	30.84763 N, -110.65978 W, ele 1097 m	Velvet mesquite grassland	19 Nov 2016 to 19 Aug 2017	274	6554
RG3	Just off a ridgeline road	Sierra Azul bajada	30.83132 N, -110.64577 W, ele 1149 m	Velvet mesquite grassland	19 Nov 2016 to 28 Mar 2017	130	11344
RG4	Just off a ridgeline road	Sierra Azul bajada	30.83064 N, -110.64014 W, ele 1169 m	Velvet mesquite grassland	19 Nov 2016 to 23 Mar 2017	125	12409

Appendix 1. (continued) Camera Sites, Rancho El Aribabi.

Camera #	Type	Location	Coordinates (WGS84)/Elev.	Vegetation Community	Dates Operated	Camera Days	# Images[1]
CW1	Cattle water, concrete drinker	Sierra Azul bajada	30.83398 N, -110.65468 W, ele 1098	Velvet mesquite grassland	19 Nov 2016 to 20 Feb 2017	94	11679
CW2	Cattle Tank	Represso Tascalito, NE side	30.845466 N, -110.644827 W, ele 1039 m	Velvet mesquite grassland	9 Sep 2014 to 2 Oct 2015	76	11127
CW3	Cattle Tank	Represso Tascalito, W side	30.845174 N, -110.645819 W, ele 1038 m	Velvet mesquite bosque	10 Mar 2015 to 11 May 2018	304	14491
CW4	Cattle Tank	Represso at Agua Fría, E side	30.827976 N, -110.588042 W, ele 1312 m	Velvet mesquite-oak woodland	5 Jul 2014 to 7 Jul 2016, 10 Feb to 8 Dec 2018	462	17036
CW5	Cattle Tank	Represso at Agua Fría, W side	30.827962 N, -110.588534 W, ele 1310 m	Velvet mesquite-oak woodland	5 Jul 2014 to 2 Sep 2016, 12 May 2017 to 29 May 2018	1172	16253
CW6	Cattle Tank	Along trail just W of Represso at Agua Fría	30.82789 N, -110.58842 W, ele 1323 m	Velvet mesquite-oak woodland	2 Sep 2016 to 12 May 2017	634	3459
CW7	Cattle trough	Sierra Azul bajada	30.837097 N, -110.612386 W, ele 1124 m	Velvet mesquite grassland	19 to 28 Aug 2017	10	9804
U1	Uplands	Sierra Azul foothills	30.827025 N, -110.589412 W, ele 1300 m	Sonoran desertscrub/ foothills thornscrub ecotone	10 Feb 2018 to 29 May 2018	109	3330
U2	Uplands	Sierra Azul bajada	30.85118 N, -110.66171 W, ele 1037 m	Velvet mesquite bosque	19 Nov 2016 to 19 Aug 2017	274	4092
U3	Uplands	Sierra Azul bajada	30.844865 N, -110.646572 W, ele 1025 m	Velvet mesquite grassland	3 Oct 2015 to 10 Jul 2016	30	5127
U4	Uplands	Arroyo SW of Represso Tascalito	30.844696 N, -110.650693 W, ele 1023 m	Velvet mesquite-netleaf hackberry lined arroyo in velvet mesquite grassland	3 Sep 2016 to 22 May 2018	523	6726
U5	Uplands	Compost pile at La Casona	30.855723 N, -110.665995 W, ele 996 m	Velvet mesquite grassland	13-14 May 2016, 7-9 Dec 2018	4	174
T2LP1	Montane arroyo	Tributary to Las Palomas	30.81917 N, -110.55399 W, ele 1347 m	Oak savanna with scattered Fremont cottonwoods in a montane arroyo	5 Jul 2014 to 23 Jan 2018	507	10235

Appendix 1. (continued) Camera Sites, Rancho El Aribabi.

Camera #	Type	Location	Coordinates (WGS84)/Elev.	Vegetation Community	Dates Operated	Camera Days	# Images[1]
T2LP2	Montane arroyo	Tributary to Las Palomas	30.81997 N, -110.55452 W, ele 1345 m	Oak savanna with scattered Fremont cottonwoods in a montane arroyo	7 Mar 2015 to 29 May 2018	847	8482
T2LP3	Montane arroyo	Tributary to Las Palomas	30.822365 N, -110.561101 W, ele 1358 m	Oak savanna with scattered Fremont cottonwoods in a montane arroyo	7 Mar 2015 to 22 Aug 2015	43	2135
T2LP4	Montane arroyo	Tributary to Las Palomas	30.824263 N, -110.566287 W, ele 1406 m	Oak savanna with scattered Fremont cottonwoods in a montane arroyo	28 Nov 2015 to 4 Nov 2017	712	3423
ALP1	Montane arroyo	Las Palomas	30.819620 N, -110.548616 W, ele 1345 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	3 Oct 2015 to 29 May 2018	876	5360
ALP2	Montane arroyo	Las Palomas	30.82061 N, -110.54879 W, ele 1346 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	5 Jul 2014 to 23 Feb 2018	774	7916
ALP3	Montane arroyo	Las Palomas	30.82061 N, -110.54879 W, ele 1346 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	3 Oct 2015 to 13 Jun 2017	672	7930
ALP4	Montane arroyo	Las Palomas	30.821530 N, -110.549641 W, ele 1323 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	7 Mar 2015 to 22 Apr 2018	934	27306
ALP5	Montane arroyo	Upper end of narrows, Las Palomas	30.819620 N, -110.548616 W, ele 1333 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	3 Oct 2015 to 8 Dec 2018	1091	12057
ALP6	Montane arroyo	Narrows, Las Palomas	30.823499 N, -110.551544 W, ele 1333 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	3 Oct 2015 to 29 May 2018	839	4319
ALP7	Montane arroyo	Las Palomas	30.822229 N, -110.550164 W, ele 1323 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	6 Oct 2015 to 10 May 2017	387	3872, 716v

Appendix 1. (continued) Camera Sites, Rancho El Aribabi.

Camera #	Type	Location	Coordinates (WGS84)/Elev.	Vegetation Community	Dates Operated	Camera Days	# Images[1]
ALP8	Montane arroyo	Las Palomas	30.814968 N, -110.544007 W, ele 1382 m	Oak savanna with scattered Fremont cottonwoods and Arizona sycamores in a montane arroyo	13 May 2017 to 29 May 2018	11	1067

[1] A number followed by "v" indicates number of video clips.

Appendix 2. Wild mammalian species photographed at each camera site.

Camera #	Location	Wild Mammalian Species Photographed
R1	Río Cocóspera	Virginia opossum, desert cottontail, rock squirrel, Arizona gray squirrel, ocelot, bobcat, puma, coyote, gray fox, hog-nosed skunk, hooded skunk, hooded or hog-nosed skunk, western spotted skunk, ringtail, white-nosed coati, javelina, white-tailed deer
R2	Río Cocóspera	Arizona gray squirrel, bobcat, gray fox, hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
R3	Arroyo Tinaja, tributary to the Río Cocóspera	Virginia opossum, desert cottontail, rock squirrel, white-throated woodrat, ocelot, bobcat, puma, coyote, gray fox, badger, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer, bat
R4	Río Cocóspera	bobcat, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer
R5	Río Cocóspera	ocelot, bobcat, puma, coyote, gray fox, badger, white-nosed coati, common raccoon, javelina, white-tailed deer
R6	Río Cocóspera	Arizona gray squirrel, ocelot, bobcat, puma, coyote, gray fox, badger, hog-nosed skunk, hooded skunk, hooded or hog-nosed skunk, white-nosed coati, common raccoon, javelina, white-tailed deer, bat
R7	Mouth of Cañon Corallilo at the Río Cocóspera	Virginia opossum, desert cottontail, rock squirrel, white-throated woodrat, Merriam's kangaroo rat, ocelot, bobcat, puma, coyote, gray fox, badger, hog-nosed skunk, hooded skunk, ringtail, white-nosed coati, javelina, white-tailed deer
R8	Mouth of Cañon Puma at the Río Cocóspera	Arizona gray squirrel, ocelot, bobcat, puma, coyote, gray fox, badger, hog-nosed skunk, white-nosed coati, javelina, white-tailed deer, bat
R9	Río Cocóspera Ciénega	bobcat, puma, coyote, gray fox, badger, white-nosed coati, common raccoon, javelina, white-tailed deer
R10	Río Cocóspera	Arizona gray squirrel, bobcat, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer
R11	Río Cocóspera	puma, coyote, gray fox, hooded skunk, javelina, white-tailed deer
R12	Río Cocóspera Ciénega	coyote, javelina, white-tailed deer
R13	Río Cocóspera	desert cottontail, ocelot, bobcat, puma, gray fox, javelina, white-tailed deer
R14	Río Cocóspera	desert cottontail, ocelot, bobcat, coyote, gray fox, hog-nosed skunk, hooded or hog-nosed skunk, javelina, white-tailed deer

Appendix 2. (continued) Wild mammalian species photographed at each camera site.

Camera #	Location	Wild Mammalian Species Photographed
R15	Mouth of Cañon Coati at the Río Cocóspera	Virginia opossum, rock squirrel, ocelot, puma, coyote, gray fox, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, javelina, white-tailed deer
R16	Near mouth of Cañon Puma, Río Cocóspera	Incidentals only
R17	Río Cocóspera	rock squirrel, Arizona gray squirrel, ocelot, bobcat, puma, gray fox, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
R18	Río Cocóspera	rock squirrel, Arizona gray squirrel, deer mouse (*Peromyscus* sp.), bobcat, puma, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon
R19	Río Cocóspera	coyote, white-nosed coati, white-tailed deer
R20	Río Cocóspera	antelope jackrabbit, bobcat, puma, coyote, gray fox, western spotted skunk, ringtail, white-nosed coati, javelina, white-tailed deer
R21	Río Cocóspera	bobcat, puma, coyote, gray fox, javelina
R22	Río Cocóspera	white-tailed deer
RG1	Ridgeline road to Agua Fría	antelope jackrabbit, desert cottontail, bobcat, puma, coyote, gray fox, hog-nosed skunk, hooded skunk, hooded or hog-nosed skunk, white-nosed coati, javelina, white-tailed deer
RG2	SE of La Casona	antelope jackrabbit, desert cottontail, rock squirrel, Merriam's kangaroo rat, bobcat, puma, coyote, gray fox, hog-nosed skunk, hooded skunk, hooded or hog-nosed skunk, white-nosed coati, javelina, white-tailed deer
RG3	Sierra Azul bajada	antelope jackrabbit, desert cottontail, bobcat, gray fox, hog-nosed skunk, hooded skunk, javelina, white-tailed deer
RG4	Sierra Azul bajada	antelope jackrabbit, bobcat, puma, coyote, gray fox, hooded skunk, white-tailed deer, bat
CW1	Sierra Azul bajada	bobcat, coyote, gray fox, hooded skunk, western spotted skunk, ringtail, javelina, white-tailed deer
CW2	Represso Tascalito, NE side	antelope jackrabbit, coyote, hooded or hog-nosed skunk, common raccoon, javelina, white-tailed deer
CW3	Represso Tascalito, W side	antelope jackrabbit, bobcat, puma, coyote, gray fox, hooded skunk, white-nosed coati, common raccoon, javelina, white-tailed deer
CW4	Represso at Agua Fría, E side	antelope jackrabbit, desert cottontail, rock squirrel, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer, bat
CW5	Represso at Agua Fría, W side	rock squirrel, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer
CW6	Along trail just W of Represso at Agua Fría	desert cottontail, rock squirrel, bobcat, gray fox, hog-nosed skunk, hooded or hog-nosed skunk, white-nosed coati, javelina, white-tailed deer

Appendix 2. (continued) Wild mammalian species photographed at each camera site.

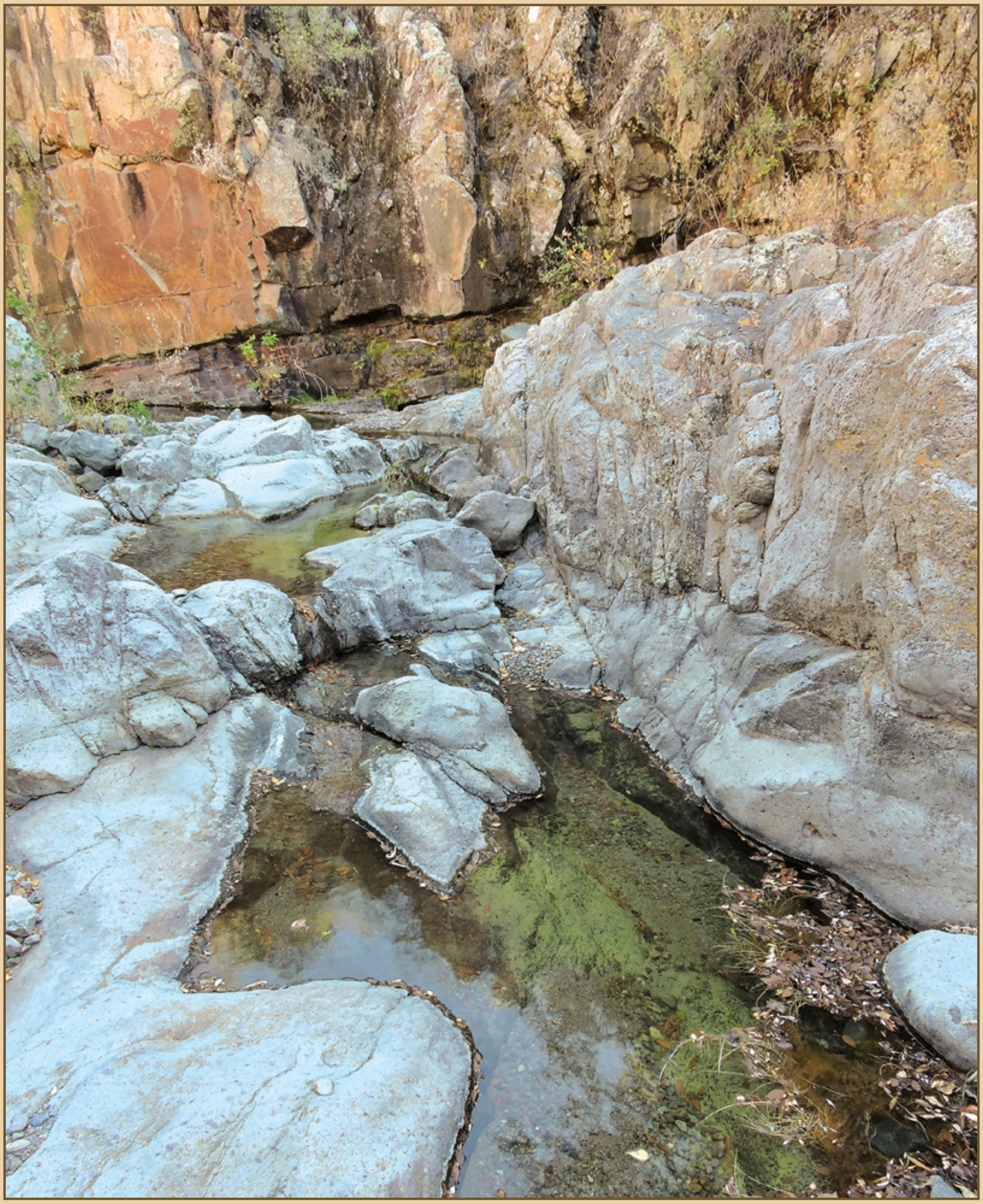
Camera #	Location	Wild Mammalian Species Photographed
CW7	Sierra Azul bajada	javelina, white-tailed deer
U1	Sierra Azul foothills	ocelot, bobcat, coyote, gray fox, hog-nosed skunk, ringtail, javelina, white-tailed deer
U2	Sierra Azul bajada	Virginia opossum, desert cottontail, bobcat, puma, coyote, gray fox, hog-nosed skunk, hooded skunk, ringtail, javelina, white-tailed deer
U3	Sierra Azul bajada	antelope jackrabbit, bobcat, gray fox, hooded skunk, javelina, white-tailed deer
U4	Arroyo SW of Represso Tascalito	antelope jackrabbit, puma, coyote, gray fox, javelina, white-tailed deer
U5	Compost pile at La Casona	coyote
T2LP1	Tributary to Las Palomas	rock squirrel, ocelot, bobcat, puma, coyote, gray fox, black bear, hooded or hog-nosed skunk, white-nosed coati, javelina, white-tailed deer
T2LP2	Tributary to Las Palomas	rock squirrel, ocelot, bobcat, puma, gray fox, black bear, hooded skunk, hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
T2LP3	Tributary to Las Palomas	rock squirrel, puma, white-nosed coati, javelina, white-tailed deer
T2LP4	Tributary to Las Palomas	desert cottontail, rock squirrel, bobcat, puma, coyote, gray fox, hooded skunk, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, javelina, white-tailed deer
ALP1	Las Palomas	rock squirrel, ocelot, puma, coyote, gray fox, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
ALP2	Las Palomas	rock squirrel, ocelot, bobcat, puma, coyote, gray fox, black bear, hooded skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
ALP3	Las Palomas	desert cottontail, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer
ALP4	Las Palomas	Virginia opossum, desert cottontail, rock squirrel, ocelot, puma, bobcat, coyote, gray fox, hooded skunk, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer
ALP5	Upper end of narrows, Las Palomas	Virginia opossum, rock squirrel, ocelot, puma, bobcat, coyote, gray fox, black bear, hooded skunk, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer, bat
ALP6	Narrows, Las Palomas	Virginia opossum, rock squirrel, ocelot, puma, coyote, gray fox, black bear, hooded skunk, hog-nosed skunk, hooded or hog-nosed skunk, ringtail, white-nosed coati, common raccoon, javelina, white-tailed deer, bat
ALP7	Las Palomas	desert cottontail, rock squirrel, puma, coyote, gray fox, white-nosed coati, javelina, white-tailed deer, bat
ALP8	Las Palomas	ocelot, ringtail

Appendix 3. Camera sites and habitat variables used in the binary logistic regression models.

Camera site	Distance to permanent water (km)	Distance to paved road (km)	Distance to unpaved road (km)	Distance to human habitation (km)	Presence (1) or absence (0) of cottonwood, willow, or sycamore (macro vegetation community)	Percent canopy cover (>1.8 m)	Percent cover in the shrub and ground layer (≤1.8m)	Anthropogenic influences index
R1	0.04	2.77	0.53	1.22	1	200	3.0	1.30
R2	0	2.53	0.64	1.02	1	117	72	0.93
R3	0.08	2.53	0.69	1.11	1	40	11	0.16
R4	0.07	2.45	0.57	1.00	1	127	39	3.36
R5	0.02	2.00	0.39	0.49	1	71	2.1	6.29
R6	0	1.45	0.04	0.07	1	108	77	0.90
R7	0.03	2.00	0.44	0.52	1	67	11	0.12
R8	0.003	1.88	0.13	0.25	1	150	9.5	1.05
R9	0.003	1.51	0.18	0.18	1	73	102	8.76
R10	0.1	1.24	0.02	0.31	1	155	31	0.84
R11	0.03	1.91	0.09	0.36	1	140	73	8.54
R12	0	1.38	0.02	0.13	1	102	133	7.18
R13	0.07	2.35	0.58	0.88	1	71	40	1.14
R14	0.03	1.79	0.23	0.22	1	41	65	0.73
R15	0.03	2.34	0.51	0.93	1	123	25	0.19
R16	0	2.07	0.46	0.56	1	118	51	0
R17	0	2.20	0.54	0.73	1	139	63	1.13
R18	0	2.42	0.57	1.00	1	119	19	0
R19	0.003	1.64	0.13	0.11	1	48	71	1.21
R20	0.18	1.18	0.01	0.38	0	141	11	0.74
R21	0.004	1.56	0	0.02	1	4.5	71	9.79
R22	0.03	2.14	0.54	0.66	1	173	14	0.17
RG1	0.86	7.01	0	6.01	0	0	35	7.29
RG2	0.83	2.29	0	0.79	0	22	51	3.43
RG3	0.91	4.25	0	1.77	0	14	14	0.81
RG4	1.45	4.51	0	2.31	0	36	40	1.45
CW1	0	3.81	0	1.10	0	0	2.7	1.10
CW2	1.65	2.80	0.45	2.04	0	10	0	12.0
CW3	1.53	2.82	0.38	2.00	0	55	51	4.0
CW4	0.003	7.86	0.09	7.23	1	27	3.3	0.47
CW5	0	7.85	0.07	7.22	1	91	18	4.02
CW6	0.01	7.85	0.07	7.22	0	15	90	1.66
CW7	2.51	5.50	0	5.00	0	0	17	375

Appendix 3. (continued) Camera sites and habitat variables used in the binary logistic regression models.

Camera site	Distance to permanent water (km)	Distance to paved road (km)	Distance to unpaved road (km)	Distance to human habitation (km)	Presence (1) or absence (0) of cottonwood, willow, or sycamore (macro vegetation community)	Percent canopy cover (>1.8 m)	Percent cover in the shrub and ground layer (≤1.8m)	Anthropogenic influences index
U1	0.14	7.86	0.20	7.16	0	9.7	42	0
U2	0.42	1.96	0.19	0.36	0	57	33	2.51
U3	1.43	2.83	0.20	1.88	0	22	56	36.2
U4	1.25	2.70	0.02	1.59	0	11	14	31.6
U5	0.09	1.64	0.02	0.03	0	37	35	2.25
T2LP1	0.58	10.94	0.02	9.70	1	94	22	10.91
T2LP2	0.53	10.94	0.02	9.69	1	120	29	0.76
T2LP3	0.68	10.13	0.02	8.99	1	40	7.6	0.07
T2LP4	1.11	9.68	0	8.59	1	58	34	3.95
ALP1	0.62	11.31	0.01	10.06	1	83	6.4	3.67
ALP2	0.70	11.16	0.17	9.89	1	70	0	2.10
ALP3	0.70	11.16	0.17	9.89	1	83	4.3	7.61
ALP4	0.55	10.97	0.29	9.79	1	74	6.0	0.66
ALP5	0.36	10.75	0.49	9.60	1	23	0	7.54
ALP6	0.31	10.74	0.50	9.59	1	0	28	1.69
ALP7	0.46	10.89	0.40	9.69	1	85	6.0	3.76
ALP8	0	11.95	0.63	10.74	1	19	4.2	43.36



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