

Richness of Mammals on the San Bernardino Ranch in the Municipality of Agua Prieta, Sonora, Mexico

Mario Erandi Bonillas-Monge and Carlos Manuel Valdez-Coronel

Departamento de Investigaciones Científicas y Tecnológicas de la Universidad de Sonora, Sonora, Mexico

Abstract—Historically, the San Bernardino Ranch has performed, as economical activities, livestock and farming, which has contributed to the deterioration of regional ecosystems. The ranch is ecologically important due to the diverse types of habitats of conservation interest such as the semi-desert grassland, the riparian vegetation, and a large *ciénega*, in which restoration efforts are being applied through water harvesting by gabions. Mammals are essential in the ecosystem. Knowing about the actual species that live on the different sites of the ranch tells us about the healthy state of the environments. We used the direct and indirect sampling methods to identify 26 species of terrestrial mammals on the Ranch. Using this information, we compared the richness and diversity of the ranch species with the species living in the San Bernardino National Wildlife Refuge located next to the border, which was a helpful comparison since the Refuge has more years of restoration experience than does the San Bernardino Ranch.

Introduction

Due to the biogeographic location, Sonora is in a transition zone between the Nearctic and Neotropical region, and is considered an arid region because its large surface is covered by desert shrubs; however, there are deciduous forests in the southern part of the state and pine-oak woodlands in the Sierra Madre Occidental, providing a diversity of ecosystems (Molina-Freaner and Van Devender 2009). This diversity is a reflection of the mammals in the state including the presence of 126 identified species and 35 as possible occurrences (Castillo and others 2010). Mammals are a fundamental part in an ecosystem covering a huge variety of niches. Some species, like carnivores, are indicators of the healthy state of the ecosystem and are key in the maintenance of an ecological balance; they also provide data for diagnosing conservation

Several areas of Sonora are considered of special interest because their resources are important to the population, as is the case of the San Bernardino Ranch, located at the Northeastern border with the United States inside the priority land region (RTP) number 45 denominated by San Luis-Janos. This area contains the headwaters of the Rio Yaqui River and is important for the diverse ecosystems of grasslands and mountains (Arriaga and others 2000) consisting of a series of tributary rivers and streams (Hudson and others 2005) with vegetation of pine-oak woodlands, low open forest, chaparral, thornless shrub, grasslands, mesquites and chollal (Rzedowski 1978).

According to the classification of provinces by Caire (1978), there are five mammal provinces in Sonora with the Mapími province covering the San Bernardino area having the highest diversity of rodents in Sonora. There was a big *ciénega* about 7000 years ago where the

San Bernardino Ranch is presently located. But with the arrival of the Europeans, the *Ciénega* became a field supporting agricultural crops and livestock grazing, causing the deterioration of the habitat. This area now is part of southeast Arizona and northeast Sonora (Minckley and others 2006).

According to Castillo and others (2010), rivers in the region function like tropical fauna corridors to the north, while the foothills of Sierra Madre Occidental function as corridors as well, allowing interchange of species between the north moist temperate and south tropical regions. Such is the case of Neotropical species of great interest like jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*) and jaguarundi (*Puma yagouaroundi*), which historically had their north limit in southern Arizona (Grigione and others 2007). Herein is the importance of conserving this area.

The main concerns for conservation on the San Bernardino Ranch is the Agua Prieta-Janos road, which is the international border with United States of America, with a history of residual degradation (CEDES 2011). The first efforts for conserving the general area were undertaken in 1982, when the U.S. Fish and Wildlife Service declared the area in Arizona as San Bernardino National Wildlife Refuge for the protection of water resources and to provide a habitat for native species. This area has a register of 315 bird species, 55 amphibians and reptiles, and 66 species of mammals and more than 490 types of plants according to the U.S. Fish and Wildlife Service (<http://www.fws.gov/refuges/profiles/index.cfm?id=22523>).

In Sonora, the conservation efforts in the area are carried out by the Association “Cuenca Los Ojos A C,” who work to restore the eroded soil, recharge groundwater aquifers, and promote original vegetation growth. However, these efforts are carried out only half of the time as those in the San Bernardino NWR so we do not know whether the health of the ecosystem is similar on both sides of the border. A listing of the small non-flying mammal species of the San Bernardino Ranch will help us to know more about the health of the ecosystem. Obtaining such a listing was the purpose of this study. One of the principal motives that led us to undertake this work was the demand for biological inventories of the fauna resources of the state and particularly about mammals. Also, whether similar mammal

In: Gottfried, Gerald J.; Ffolliott, Peter F.; Gebow, Brooke S.; Eskew, Lane G.; Collins, Loa C., comps. 2013. Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III; 2012 May 1-5; Tucson, AZ. Proceedings. RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

species occur on the San Bernardino Ranch and the San Bernardino NWR may help to determine better ways of environmental management. Therefore, determining the mammal species of this Ranch will provide interesting information about the restoration efforts that are taking place nowadays, and will help us know how these efforts are improving the state of the ecosystem in this important area for wildlife.

Methodology

The study was made on the San Bernardino Ranch, located in the northeast corner of the Sonora state in Mexico, 30 km from Agua Prieta within the coordinates of 31°19' 0.20" N y 109° 15' 59.91" W. This study was conducted as a part of our professional practices during the summer of 2011 from June 27 to July. We later came back in winter 2012 from March 15-18 to expand our database.

We used two types of methods: direct sampling and non-direct sampling. With the direct method, we captured small- and medium-sized mammals and we were able to obtain information on their weight, sex, reproductive state, body measurements, and other characteristics that helped us understand the biology of the studied species. With the non-direct method we collected information about the species without direct measurements by identifying mammals by associated tracks like pad prints, scats, body parts, and nests.

Direct Sampling Methods

To know the specific richness of small (non-flying) mammals of the San Bernardino Ranch, we established three study sites: one located near a dam (Site 1), another localized in Silver Creek (Site 2) and a third in the Cienega (Site 3). The criteria for selecting these sites were the closeness to water and being able to place the traps on a gradient from more to less humidity. The coordinates were taken at the beginning and ending of the each studied transect on each site.

The method of capture and recapture was used, which can be used for measuring the population structure (Krebs 1985). To capture small mammals, 10 Sherman traps were placed on four lines on each site and were separated by 10 m from one another, totaling a total of 40 traps for each site. Every trap was baited with a mixture of peanut butter and seeds, like oats, on 3 nights at each site. Every night the traps were baited and activated. In the morning (5 AM), the traps were checked for captures. Each collected individual was marked with purple ink and measured from total body, tail, ear, rear foot, and weight. Identification was determined through field guides. The individual was then release on the site of the capture.

For medium mammals, eight Tomahawk traps were placed around each site. These traps were baited with sardine, tuna, egg, and fresh vegetables. For each individual captured, the guides of Whitaker (1996) and Reid (2006) were consulted for their identification. All captured animals were released back into their area of capture after identification.

Non-Direct Sampling

Non-direct sampling was used to know the presence of some medium and large mammals. For this purpose we made walks on the main paths of the Ranch looking for tracks, footprints, scats, remains, and other marks. When these indicators were found, we used a scale and a camera with GPS to take pictures and obtain coordinates of each associated trace. The field guides of Aranda (2000) and Elbronch (2003) were used for identification of the traces. There were also five interviews with people of the Ranch (supported by illustrations)

between the ages of 16 and 61 years to provide an idea of the mammals that we might find.

Results and Discussion

The total registration of mammals obtained in the study was 26 species in the two sampling seasons of the year. This information was distributed in 4 orders, 11 families and 17 genera. The order with higher number of species was Rodentia with 14 (53.84% of total results) and seconded by the Carnivora order with 7 species representing 26.92%, a listing of which is presented in table 1. The 26 species register for the San Bernardino Ranch represent 20.63% of the total species of Sonora. This highlights the importance of conserving the mammals on the ranch.

Through the direct methods for small (non-flying) mammals, the total presence registered was 89 individuals, while there were 8 skunks (*Mephitis mephitis*) captured in the Tomahawk traps as summarized in table 2. The results of the non-direct methods of recoding medium-large mammals were the 43 proved observations shown in table 3, giving us a total of 140 proved data for the San Bernardino Ranch, which are included in the MABA data base.

Within the observed species, there was Desert shrew (*Notiosorex crawfordi*), the only species in the category of special protection (Pr) according to NOM-059-SEMARNAT-2010. We found in the Red List of IUCN that all registered species are under the category of least concern, but the populations of Mountain Lion (*Puma concolor*) and hog-nose skunk are under consideration for listing.

Through interviewing the people of the Ranch, we identified species such as Ringtale (*Bassariscus astutus*), Western spotted skunk (*Spilogale gracilis*), Cotton-tailed Rabbit (*Sylvilagus audubonii*), Pocket gopher (*Thomomys bottae*) and Badger (*Taxidea taxus*), but they were not included in the listing because of the lack of confirmation of their presence. We collected three skulls of dead animals that were taken to the Mammals Collection in the laboratory of terrestrial resources of the University of Sonora; further results are presented by the study sites in the following paragraphs.

Site 1

On this site we found the greatest amount of available water. This site is dominated by bulrush (*Scirpus americanus*) and was the site with more sampling success in the summer. *Sigmodon arizonae* was the species with more observations; this can be due to this species being associated with dense grasses to feed and make their burrows (Wilson and Ruff 1999). This was the only site where we found the desert shrew (*N. crawfordii*) in an area dominated by scrub. The site was relocated in the winter due to the increased amount of water. In this season we had more observations including two species, *Neotoma albigula* and *N. Mexicana*, which we did not have in the first phase of the study.

Site 2

We only had 2 individuals of *Chaetodipus penicillatus* and three skunks (*M. mephitis*) in the Tomahawk traps in the summer; this small number of captures might be because of the conditions of the site. Most of the area had bare ground, which does not provide adequate shelter for rodents. This number changed drastically in the winter, with observations of 28 individuals and 7 different species, resulting in the most captured individuals and with a major number of species at this site. This finding makes us think that the relation between the

Table 1—List of the mammals found in the San Bernardino Ranch.

Small non-flying mammals population	IUCN ^a	Medium and large mammals population	IUCN ^a
RODENTIA		LAGOMORPHA	
Familia Cricetidae		Familia Leporidae	
<i>Sigmodon arizonae</i>	Unknown	<i>Lepus californicus</i>	Stable
<i>Sigmodon hispidus</i>	Increasing	CARNIVORA	
<i>Reithrodontomys megalotis</i> ^b	Stable	Familia Canidae	
	Stable	<i>Canis latrans</i>	Increasing
<i>Reithrodontomys montanus</i> ^c	Stable	<i>Urocyon cinereoargenteus</i> ^b	Stable
<i>Peromyscus maniculatus</i>	Stable	Familia Felidae	
<i>Peromyscus leucopus</i>	Stable	<i>Lynx rufus</i> ^b	Stable
<i>Peromyscus boylii</i> ^c	Stable	<i>Puma concolor</i> ^b	Decreasing
<i>Peromyscus eremicus</i>	Stable	Familia Mephitidae	
<i>Baiomys taylori</i>	Stable	<i>Conepatus leuconotus</i> ^b	Decreasing
Familia Muridae		<i>Mephitis mephitis</i>	Stable
<i>Neotoma albigula</i> ^c	Stable	Familia Procyonidae	
<i>Neotoma mexicana</i> ^c	Stable	<i>Procyon lotor</i>	Increasing
Familia Heteromyidae		ARTIODACTYLA	
<i>Chaetodipus penicillatus</i>	Stable	Familia Tyassuidae	
<i>Chaetodipus intermedius</i>	Stable	<i>Pecari tajacu</i>	Stable
SORICOMORPHA		Familia Cervidae	
Familia Soricidae		<i>Odocoileus hemionus</i> ^b	Stable
<i>Notiosorex crawfordi</i> ^b	Stable	<i>Odocoileus virginianus</i>	Stable

^aRed list of threatened species by the International Union for Conservation of Nature.^bSpecies found only in Summer.^cSpecies found only in Winter.**Table 2**—Total records of small non-flying mammals.

Species	Records of species	
	Summer	Winter
<i>Sigmodon arizonae</i>	10	3
<i>Sigmodon hispidus</i>	3	5
<i>Reithrodontomys megalotis</i>	1	0
<i>Reithrodontomys fulvencens</i>	3	0
<i>Reithrodontomys montanus</i>	0	1
<i>Peromyscus maniculatus</i>	5	9
<i>Peromyscus leucops</i>	1	19
<i>Peromyscus boylii</i>	0	2
<i>Peromyscus eremicus</i>	0	13
<i>Notiosorex crawfordi</i>	1	0
<i>Chaetodipus penisillatus</i>	2	2
<i>Chaetodipus intermedius</i>	2	2
<i>Bayomys taylori</i>	1	1
<i>Neotoma albigula</i>	0	2
<i>Neotoma mexicana</i>	0	1
Total records	89	

presence of water and the number of individuals was due to the dates of water flow in Silver Creek and a high density of vegetation giving a good habitat for rodents.

Site 3

On this site we expected to find the species of *S. ochrognathus* that has been recorded in the San Bernardino NWR but not found on this side of the border. However, we found the only individual of the species *Baiomys taylori*. The number of species and individuals

Table 3—Total records of medium and large mammals.

Species	Record of species	
	Summer	Winter
<i>Puma concolor</i>	7	0
<i>Procyon lotor</i>	7	1
<i>Conepatus leuconotus</i>	1	0
<i>Mephitis mephitis</i>	5	5
<i>Pecari tajacu</i>	3	2
<i>Odocoileus hemionus</i>	2	0
<i>Urocyon cinereoargenteus</i>	1	0
<i>Lepus californicus</i>	2	0
<i>Canis latrans</i>	2	2
<i>Lynx rufus</i>	11	0
Total records	51	

increased in the winter and it was the only place where we found an individual of the species *Reithrodontomys montanus*.

Associated Traces

The bobcat (*Lynx rufus*), followed by the raccoon (*Procyon lotor*), were the species with more traces that had many footprints over the paths, mainly on the shores of the rivers and also it was possible to observe some latrines on fallen trees and over gabions with water, which can indicate the adoption for these places with water (Urban 1970). We also observed raccoon scats, a variety of insects, little mammals, and some molluscs.

We did not find many skunk scats (*M. mephitis*), probably due to the aleatory selection of defecation or to hidden places like rock crevices; however, the footprints were common on the paths (Elbroch 2003). The fewest tracks we observed were of gray fox (*Urocyon cinereo-*

argenteus). This may have been due to the avoidance of competing with another carnivore like coyote that has similar preys; on occasion, coyotes can depredate the gray fox (*Merlin* and *Siminski* 2000). We found a few traces of mountain lion (*Puma concolor*), which is normal due to being a top predator and less common than the rest of the animals because of their solitary and territorial nature. However, their presence tells us about the good conditions of the place correlated to the abundance of the preys (*Pacheco* and others 2004).

Conclusions

The San Bernardino Ranch is a place that is undergoing restoration, and, therefore, it is possible to observe favorable changes in the fauna composition. These changes are reflected in the individual and traces found near water, which is fundamental to the establishment of species richness. Comparing our list of species and the list of the San Bernardino NWR, we can see that many species remain to be documented, due to the fact of the differences between the time of restoration on the side of the United States and Mexico. However, we recommend that this study be continued to constantly sample mammals in the San Bernardino Ranch for several years in a major amount of points to obtain reliable results.

The San Bernardino Ranch is a great site for future research efforts centered on monitoring the fauna with trap cameras, determining the population structure of small mammals, and studying the eating habits of carnivores. This type of research can show us a broader picture about the healthy state of the ecosystem in the Ranch. The purpose of the work presented in this paper was to obtain presence data. However, the necessary preliminary data were also taken for future research on the population structures of small (non-flying) mammals.

References

- Aranda, J.M. 2000. Huellas y otros rastros de los mamíferos grandes y medianos de México. CONABIO, Instituto de Ecología, A.C. Xalapa, Veracruz. 212 pp.
- Arriaga, L., J.M. Espinoza, C. Aguilar, E. Martínez, L. Gómez y E. Loa (coordinadores). 2000. Regiones terrestres prioritarias de México. Comisión Nacional para el Conocimiento y uso de la Biodiversidad, México.
- Bojórquez-Tapia, L. A., P. Balvanera, and D.A. Cuarón. 1994. Biological inventories and computer data bases: their role in environmental assessments. *Environmental Management*, 18:775-785.
- Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy* 24: 346-352.
- Caire, William. 1978. The distribution and zoogeography of the mammals of Sonora, Mexico. The university of New México. Albuquerque, New México.
- Castillo-Gámez, R.A., J.P. Gallo-Reynoso, J. Egidio-Villarreal, and W. Caire. 2009. Los mamíferos. En: F.E. Molina-Freaner y T.R. Van Devender, eds. *Diversidad biológica de Sonora*. UNAM, México, pp. 421-436.
- Ceballos G. and G. Oliva 2005. "Los mamíferos silvestres de México" Comisión Nacional Para el Conocimiento y Uso de la Biodiversidad.
- Ceballos, Gerardo., Arroyo Cabrales, Joaquín., Medellín, Rodrigo A., Domínguez Castellanos, Yolanda. 2005. Lista actualizada de los mamíferos de México. *Revista Mexicana de Mastozoología*. 9:21-71. 2005.
- CEDES. 2011. Estudio previo justificativo para proponer la región de San Bernadino, municipio de Agua Prieta, Sonora como reserva estatal.
- Elbroch, Mark. 2003. Mammal tracks and sign: A guide to North American species. StackpoleBooks: Mechanicsburg, PA.
- Grajales-Tam, K.M., R. Rodríguez-Estrella y J. Cancino-Hernández. 2003. Dieta estacional del Coyote *Canis latrans* durante el periodo 1996-1997 en el Desierto de Vizcaíno, Baja California Sur, México *Acta Zoologica Mexicana (N.S.)* 89: 17-28.
- Grigione, M., A. Scoville, G. Senville, and K. Crooks. 2007. Neotropical cats in southeast Arizona and surrounding areas: Past and present status of jaguars, ocelots and Jaguarundis. *Mastozoología Neotropical*, 14(2): 189-199, Mendoza, 2007.
- Hudson, P.F., D.A. Hendrickson, A.C. Benke, A. Varela-Romero, A. Rodiles-Hernández y W.L. Minckley. 2005. Rivers of Mexico. En: Benke, A.C. and C.E. Cushing, (eds.), *Rivers of North America*. Elsevier Academic Press, Toronto, Canadá.
- Krebs, C.J. 1985. *Ecología. Estudio de distribución y la abundancia*. 2ª Ed. Harla. México.
- Leopold, A.S., 1977. Fauna silvestre de México. Instituto Mexicano de Recursos Naturales Renovables. Pax-México, México. 608 pp.
- Merlin P. and Siminski P. 2000. Coyote and fox. In: S.J. Phillips and P. Wentworth-Comus, eds. *A natural history of the Sonoran Desert*. The University of California Press.
- Minckley T.A. and A. Brunelle. 2006. Paleohydrology and growth of a desert ciénega. *Journal of Arid Environments* 69 (2007): 420-431.
- Molina-Freaner, Francisco and Thomas R. Van Devender. 2010. *Diversidad Biológica de Sonora*. Mora-Cantúa Editores, S. A. de C. V. México, Distrito Federal.
- Molina-Freaner, F.E. and T.R. Van Devender, eds. 2010. *Diversidad biológica de Sonora*. UNAM, México,
- Pacheco, L.F., A. Lucero, and M. Villca. 2004. Dieta del Puma (*Puma concolor*) en el parque Nacional Sajama, Bolivia y su conflicto con la ganadería. *Ecología en Bolivia*. 29: 75-83.
- Reid, Fiona and A. Peterson 2006. Field guide to mammals of North America. Fourth Edition. New York: national Audubon Society.
- Rzedowski, J. 1978. Vegetación de México. Editorial Limusa, S.A. Mexico D.F.
- Urban, D. 1970. Raccoon populations, movement patterns, and predation on a managed waterflow marsh. *Journal of Wildlife Management* 34: 372-382.
- Whitaker, John O., Jr. 1996. *National Audubon Society Field Guide to North American Mammals*. New York: Alfred A. Knopf.
- Wilson Don E. and Sue Ruff. 1999. *The Smithsonian Book of North American Mammals*. Smithsonian Institution Press.