

Wildlife Survey and Monitoring in the Sky Island Region with an Emphasis on Neotropical Felids

Sergio Avila-Villegas and Jessica Lamberton-Moreno
Sky Island Alliance, Tucson, Arizona

Abstract—The Sky Island region of southwestern United States and northwestern Mexico consists of isolated mountain ranges separated by deserts and grasslands. It mixes elements from five major ecosystems: the Rocky Mountains, Sierra Madre Occidental, the Sonoran and Chihuahuan deserts and the Neotropics. Here some Neotropical species reach their northern ranges, such as jaguars (*Panthera onca*) and ocelots (*Leopardus pardalis*). Sky Island Alliance seeks to build cooperative relationships with landowners in Sonora and public land managers in Arizona to facilitate scientific research, encourage large predator conservation, and establish corridors connecting patches of continuous habitat throughout the region. We have conducted wildlife surveys with remote cameras in northern Sonora since 2007 and in Arizona since 2009. Our photographic records cover 24 species of wild mammals, including jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), puma (*Puma concolor*) and bobcat (*Lynx rufus*). In 2009 we documented Arizona's first live ocelot, and recently we documented two individual jaguars 30 miles south of the border in Sonora. The project's results have increased our knowledge of borderland wildlife, especially the Sonoran ocelot, and supported the certification of a 10,000-acre private ranch as a wildlife preserve in northern Sonora.

Introduction

In 2005, Sky Island Alliance initiated a study on cross-border permeability in northern Sonora, Mexico, to establish corridors connecting habitat throughout the region, and create a network of conservation ranches in northern Sonora (Avila 2009).

Neotropical felids have been recorded in southern Arizona and northern Sonora (Brown and Lopez-Gonzalez 2001; Grigione and others 2007; McCain and Childs 2008; Rosas-Rosas and others 2010). Brown and Lopez-Gonzalez (2001) provide a comprehensive account of these Neotropical felids throughout the Sky Island region up until the end of the 1900s. Both Neotropical species are protected in the United States and Mexico. Currently the U.S. Fish and Wildlife Service (USFWS) leads recovery efforts for both species. Because of their low density and solitary nature, little is known about their population size, range, or habitat requirements in the United States (Grigione and others 2007).

At least six male jaguars have been recorded north of the border since 1996. There were two different sightings in 1996: one in the Baboquivari Mountains (Childs 1998), and another in the Peloncillo Mountains (Glenn 1996). McCain and Childs (2008) monitored at least two jaguars on the Atascosa, Tumacacori, and Baboquivari Mountains. No home range studies have been conducted for jaguars in southwestern United States; however McCain and Childs (2008)

used camera-traps to provide the only estimate of one northern jaguar, a minimum observed range of 525 mi².

There are two subspecies of ocelots found in the United States: the Sonoran subspecies (*L. p. sonoriensis*), described by Goldman (1943) with four specimens from southernmost Sonora, and the better-studied Texas subspecies (*L. p. albescentis*). Populations of the Sonoran ocelot are isolated from the Texas ocelot by the Sierra Madre highlands (Grigione and others 2007). The population of Texas ocelots is found almost 300 miles south in latitude of the northernmost Sonoran ocelots.

Lopez-Gonzalez and others (2003) conducted surveys throughout Sonora, collecting 36 records of ocelots from ranchers, cowboys, cattle associations, and outfitters. They plotted record localities on habitat maps finding that 75% were associated with subtropical thornscrub, tropical deciduous forest, and tropical thornscrub; 92% of records were within an elevation range of 820 to 3773 ft. The most northerly record of a breeding population was 30°30' in latitude. The authors found only one record of a kitten, in southern Sonora, and a few ocelots were recorded in oak woodlands, all males (Lopez-Gonzalez and others 2003).

Objectives

- To build cooperative relationships with private landowners in Sonora and Arizona to facilitate research and establish corridors connecting patches of continuous habitat throughout the region.
- To survey and inventory land mammal species in the Sky Island region.
- To increase the knowledge about jaguar and ocelot in the Sky Island region.

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.

Methodology

Study Area

The Sky Island region of southwestern United States and northwestern Mexico consists of isolated mountain ranges separated by deserts and grasslands. It mixes elements from five major ecosystems: the Rocky Mountains, Sierra Madre Occidental, the Sonoran and Chihuahuan deserts, and the Neotropics. Some Neotropical species, such as the jaguar, ocelot, and coati (*Nasua narica*), reach their northernmost ranges here (fig. 1).

We initiated landowner outreach and surveys in northern Sonora in 2005 to establish partnerships in the region. We used habitat models to ground-truth the predicted corridors for jaguars and ocelots (Boydston and Lopez-Gonzalez 2005; Hatten and others 2003; Menke and Hayes 2003; Menke 2004). We placed a total of 48 remote cameras in select locations in Nogales, Imuris, and Agua Prieta Municipios in Sonora, and Santa Cruz and Cochise Counties in Arizona (fig. 2).



Figure 1—Biotic influences in the Sky Islands.

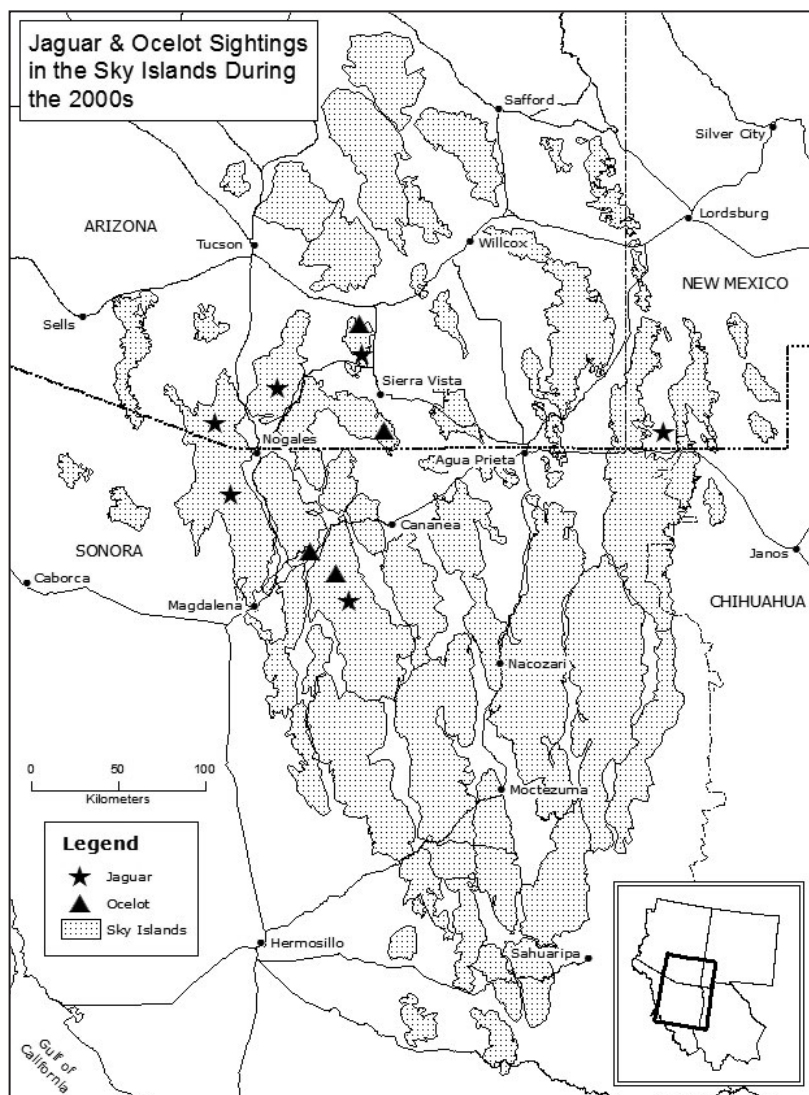


Figure 2—Sky Island Ranges. Camera locations include Sierra La Esmeralda, Cibuta and Azul mountain ranges, the Cocospera River and San Bernardino Valley in Sonora, and the Atascosa, Patagonia, Whetstone, Dagoon and Mule Mountains in Arizona (map by Alex Smith, 6/20/2012).

Table 1—Camera Locations by County or Municipio.

Municipio or County, State	Number of cameras	Landownership (Private/public)
Nogales, Sonora	10	Private
Agua Prieta, Sonora	10	Private
Imuris, Sonora	15	Private
Santa Cruz, AZ	5	Private/Public
Cochise Co., AZ	8	Public

We adopted a standardized remote camera protocol described in Chavez and Ceballos (2006). Remote cameras are non-invasive tools useful for the study of rare, protected or elusive animals (Karanth and Nichols 1998; Medellin and others 2006). We used DeerCam, Cuddeback and Covert DLC cameras that were set to display time and date on the photographs (table 1).

Given the low density of jaguars and ocelots in their northern extent (Brown and Lopez-Gonzalez 2001), camera sites were chosen to maximize the probabilities for photographing felids, instead of a randomized sampling design. We collected ocelot photographs from February 2007 to April 2011, and plotted the relative frequency of events over annual and daily cycles to estimate activity patterns.

Results

Our photographic records include 24 species of wild mammals in five orders: Marsupialia, Rodentia, Lagomorpha, Carnivora and Artiodactyla.

Sonoran Ocelot

We collected 69 records of live ocelots and four of killed ocelots. Our remote camera photographs (60 photographs, 54 events) were taken at elevation ranges between 4185 and 5330 ft. in Madrean evergreen woodland. A majority of photographs was taken in Sonora's Sierra Azul 30 miles south of the international border. Only one photograph was taken in Arizona, in the Whetstone Mountains, almost 40 miles north of the border. These records confirm the northernmost breeding population of Sonoran subspecies at 30°50' of latitude—the first reliable ocelot record in Arizona in 45 years—and an ocelot walking on fresh snow (fig. 3). Our “live” ocelot documentations include at least two males, one female, one kitten, and two of undetermined gender (table 2).

Analyses of the relative frequencies of 54 photographic events on 24-hr cycles confirm the ocelots' nocturnal activity patterns, with peaks of activity between 4:00 and 5:00 and between 20:00 and 0:00. The nocturnal activity patterns of ocelots were similar to those in Texas where activity peaked between 20:00 and 05:00 (Grigione and Mrykalo 2004; Yates 2008). Ocelots were mostly active from late winter to early foresummer (December to May; Yates 2008). Ocelot daily and annual activity patterns are shown in figs. 4 and 5.

Northern Jaguar

We found records of four jaguars in the United States in the 2000s, three confirmed with photographs. A jaguar named “Macho B” was



Figure 3—Sonoran ocelot. Sonoran ocelot walking on fresh snow in the Sierra Azul, February 2008.

Table 2—Ocelot records in the Sky Islands in the 2000s.

Number of records	Description	Municipality, State (Year)
1	Live animal in cage (photo)	Imuris/Magdalena, Sonora (2007)
2	Poached animals (carcass)	Imuris, Sonora (2007)
2	Road kill Highway 15, Sonora (photo)	Imuris, Sonora (2008)
	Road kill Highway 60, Arizona (photo)	Superior, Arizona (2010)
3	SIA tracks sets	Imuris, Sonora (2007, 08, 09)
65 photos	SIA's 53 photographic events	Imuris, Sonora (2007-2011)
	SIA's 1 photographic event	Cochise County, Arizona (2009)
	AZGFD reported sightings	Cochise County, Arizona (2011, 12)

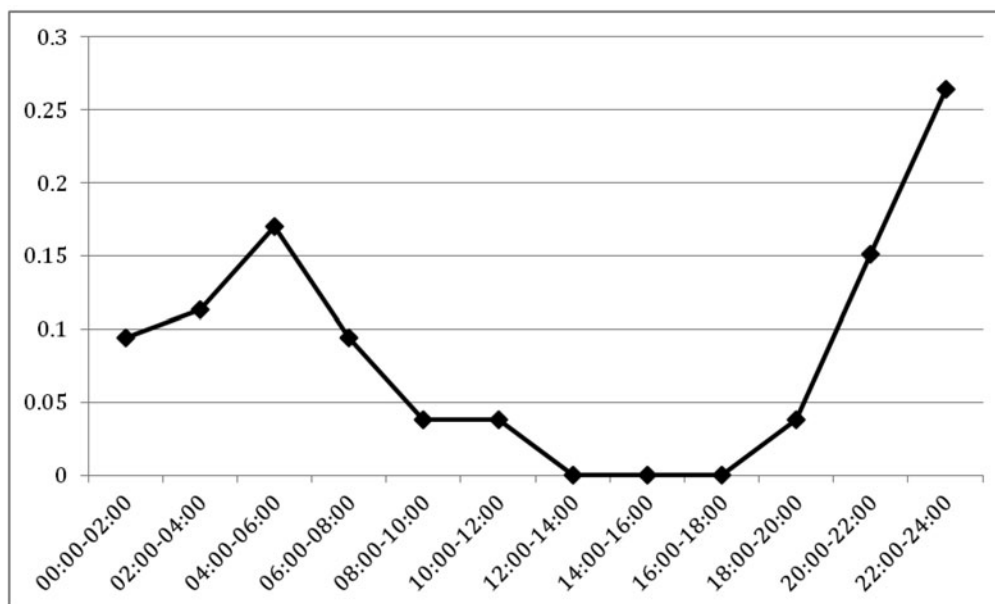


Figure 4—Ocelot daily activity patterns. Ocelot relative frequencies of 54 photographic events over 24-hr cycles.

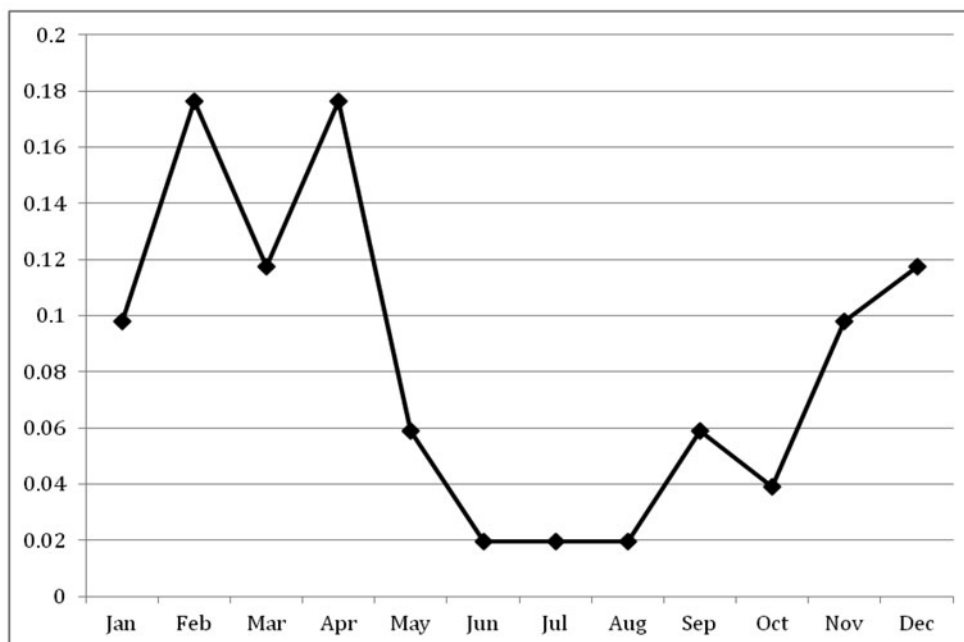


Figure 5—Ocelot annual activity patterns. Ocelot relative frequencies of 52 photographic events over 12-month period.

monitored in Arizona from 1996 (McCain and Childs 2008) until his death in 2009. Another jaguar was photographed in the Animas Valley in 2005 (Warner Glenn, personal communication). In June 2011, a U.S. Border Patrol pilot reported a jaguar in the Santa Rita Mountains approximately 40 miles north of the border. In November 2011, the Arizona Game and Fish Department (AZGFD) confirmed a jaguar sighting in the Whetstone Mountains, approximately 40 miles north of the border.

During this study we photographed two different jaguars (fig . 6) in 2010 and 2011 in the Sierra Azul, and identified two track sets in Sierra Cibuta (2005) and Sierra Azul (2009). Our photographic records were collected in Madrean evergreen woodland at elevation between 4430 and 4590 ft. All photographs were taken between 18:00 and 6:00 hrs. The small sample size of photographs might not truly indicate activity patterns of northern jaguars. Jaguar records in the Sky Islands in the 2000s are shown in table 3.

Discussion

Landowner involvement is critical for long term conservation in private lands of northern Sonora. Haines and others (2006) emphasize the importance of protecting private lands for ocelot conservation. Landowner outreach is an investment that pays off with landowner buy-in, access, local knowledge, and sharing of anecdotal information.

As a result of our outreach and research collaboration in Sonora, a 10,000-acre private ranch called El Aribabi received a Certificate of Voluntary Land Conservation by Mexican agency CONANP in 2011, thus constituting the most recent wildlife reserve in northern Mexico.

Ocelot habitat characteristics such as elevation, vegetation type, and vegetation cover found in this study contrast with those described in Lopez-Gonzalez and others (2003). The authors found ocelots associated with tropical or subtropical habitats, mostly in the southern half of Sonora. The localities where we documented ocelots in northern Sonora are typical Sky Island habitat. We confirmed the northernmost breeding population of Sonoran ocelots in the Sierra Azul Mountains in Madrean evergreen woodlands. The elevation ranges and latitude at 30°50' are above those recorded by Lopez-Gonzalez and others (2003). Additionally we found the first reliable ocelot record in Arizona in 45 years in the Whetstone Mountains at 5330 ft. of elevation (Grigione and others 2007).

The location of a breeding population 30 miles south of the international border, suggests that ocelots could travel northward and currently reside in southern Arizona. The estimated dispersal distances for Texas ocelots (3 to 20 miles; Caso 1994; Crawshaw 1995) are less than those between the breeding population in northern Sonora and sighting locations in Arizona (approximately 50 miles).

The AZGFD reported a road-killed ocelot near Superior, Arizona, and confirmed it to be of wild origin (De Young and Holbrook 2010). This animal might represent the northernmost record for the species,



Figure 6—Northern jaguar. Northern jaguar photographed in Sierra Azul, January 2010.

Table 3—Jaguar records in the Sky Islands in the 2000s.

Number of records	Description	Municipality, State (Year)
11 photos	Warner Glenn (photo)	Animas Valley, NM (2005)
	SIA's 9 photographic events (2 individuals)	Imuris, Sonora (2010-2011)
	AZGFD (photo)	Cochise Co., Arizona (2011)
Undetermined ~100 photos)	McCain and Childs (photos)	Santa Cruz and Pima County, Arizona (1996-2009)
2	SIA track set	Nogales, Sonora (2005)
	SIA track set	Imuris, Sonora (2009)
1	AZGFD/Border Patrol report	Pima County, Arizona (2011)

north of the Sky Island region. We estimate the distance between Superior to the border, to the Huachuca or to the Whetstone Mountains to be over 120 miles. It is highly probable that ocelots in northern Sonora and southern Arizona—only 70 miles apart—are connected by migration corridors and potentially represent an established trans-boundary population. However, in the case of the documentation near Superior, travel from northern Sonora seems unlikely.

Our data on jaguars is scarce; however, it includes photographs of two different males and a track set potentially expanding the known range of Macho B. We believe our data are inconclusive in terms of daily or seasonal activity patterns.

In 5 years of monitoring public and private lands along the border, we did not find any anecdotal or reliable records of jaguarondi (*Herpailurus yaguarondi*).

Conclusion

The lack of scientific information on Sonoran ocelots, other than historic localities and habitat associations, is evident in the USFWS Draft Recovery Plan. Results from this study increase the knowledge of Sonoran ocelots. The localities where we documented ocelots in Sonora are typical of Madrean Sky Islands and differ from those documented before.

Grigione and others (2007) suggest that conservation of peripheral populations, such as ocelot and the jaguar's northernmost range, plays a role in maintaining the genetic viability of a species. It is essential that source populations of jaguars and ocelots be located and travel routes be identified. Both montane corridors and riparian areas appear to be important travel routes for Neotropical felids.

The importance of trans-boundary conservation cannot be over-emphasized for felids and other species. It is critically important to consider jaguar and ocelot's recent presence in mountain ranges near the border and the connecting linkages in order to protect enough habitat for the establishment of future populations (Grigione and others 2007). The most distant portions of species' distributions are often the last refuge for their survival (Lopez Gonzalez and others 2003). The northern extent of the ocelot's range in southeastern Arizona could prove to contain enough suitable habitat, connective linkages, and prey species to support a breeding population.

The Sonoran ocelot has been given the least amount of attention in scientific research and conservation planning, plainly contrasting with information on the Texas subspecies. This lack of information could lead to inappropriate decisions for recovery, as different types of habitat, elevation, and vegetation cover are found in its northernmost distribution ranges. We believe there are clear differences between the two ocelot subspecies and their needs, with the northernmost population of Texas ocelots found in latitudes almost 300 miles south of the Sonoran ocelots. Due to unique topographic, bio-geographic and climatic features that occur in northern Sonora and southern Arizona, the Sky Island region also represents a distributional extreme with important genetic and adaptive resources that can characterize peripheral populations (Grigione and others 2007).

To support the recovery of endangered tropical felines in the Sky Island region, migration corridors that link key habitat cores in Mexico and the United States must be identified and protected. In southern Arizona, large tracts of protected public lands already exist, including National Wildlife Refuges, National Monuments, Wilderness and

National Conservation Areas. Opportunities for habitat protection south of the border exist, with Sonora being the second largest state in Mexico, and having low human population densities (Lopez-Gonzalez and others 2003). Relatively intact patches of continuous habitat make this area a stronghold for the ocelot.

Border security activities represent the greatest threat to jaguar and ocelot recovery in the United States. Habitat connectivity across the border remains highly threatened by construction of an impermeable barrier and its related infrastructure along the border. The construction of border infrastructure negatively impacts species that live in the region, endangered or otherwise. Division of otherwise continuous habitat by a physical barrier blocks the natural movements of species whose distribution in the United States is already limited, confining them to isolation and potential extinction (Córdova and De la Parra 2007).

References

- Avila, S. 2009. The Cuatro Gatos Project: wildlife research and conservation in northwestern Mexico and implications of the border fence. *Wild Felid Monitor*. Winter 2009. Vol. 2(1).
- Boydston, E. and C. Lopez-Gonzalez. 2005. Sexual differentiation in the distribution potential of the northern jaguars (*Panthera onca*). *Proc. RMRS-P-36*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Brown, D. and C. Lopez-Gonzalez. 2001. *Borderland Jaguars: tigres de la frontera*. The University of Utah Press. 170 p.
- Chavez, C., and G. Ceballos. 2006. *Memorias del Primer Simposio. El jaguar Mexicano en el Siglo XXI: Situación Actual y Manejo*. CONABIO-Alianza WWF Telcel-Universidad Nacional Autónoma de México. México, D.F.
- Childs, J. 1998. *Tracking the felids of the borderlands*. Printing Corner Press. El Paso, TX. 77 p.
- Córdova, A. and C. De la Parra. Eds. 2007. *A Barrier to our Shared Environment: The Border Fence between the United States and Mexico*. First Edition. Secretariat of Environment and Natural Resources, National Institute of Ecology, El Colegio de la Frontera Norte, Southwest Consortium for Environmental Research & Policy. Mexico.
- De Young, R. and J. Holbrook. (2010). Analysis and interpretation of ocelot material lineages from road-killed ocelots in Texas and Arizona. A report to the US Fish and Wildlife service and Texas Parks and Wildlife Department. Texas A&M University, Kingsville.
- Glenn, W. 1996. *Eyes of fire: encounter with a borderlands jaguar*. El Paso, TX: Printing Corner Press. 28 p.
- Grigione, M. and R. Mrykalo. 2004. Effects of artificial night lighting on endangered ocelots (*Leopardus pardalis*) and nocturnal prey along the United States-Mexico border: A literature review and hypotheses of potential impacts. *Urban Ecosystems*, 7: 65–77.
- Grigione, M., Scoville, A., Scoville, G., 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
- Haines, A., Janecka, J., Tewes, M., Grassman, L. and P. Morton. (2006). The importance of private lands for ocelot *Leopardus pardalis* conservation in the United States. *Oryx* Vol. 40(1).
- Hatten, J. R., Averill-Murray, A., and W. E., Van Pelt. 2003. Characterizing and mapping potential jaguar habitat in Arizona. 203, 1–28. Phoenix, AZ, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department.
- Karanth K. U. and J. D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. *Ecology*, 79:2852–2862
- Lopez-Gonzalez, C., Brown, D., and J.P. Gallo Reynoso. 2003. The ocelot *Leopardus pardalis* in north-western Mexico: ecology, distribution and conservation status. *Oryx*. Vol. 37. No.3.

- McCain, E., and J. Childs. 2008. Evidence of resident jaguar (*Panthera onca*) in the southwestern United States and the implications for conservation. *J. of Mammalogy*. 89: 1-10.
- Medellín, R., Azuara, D., Maffei, L., Zarza, H., Bárcenas, H., Cruz, E., Legaria, R., Ramos-Fernández, G., and S. Avila. (2006). *Capítulo III. Censos y Monitoreo*. In: Chavez, C., and G. Ceballos. 2006. *Memorias del Primer Simposio. El jaguar Mexicano en el Siglo XXI: Situación Actual y Manejo*. CONABIO-Alianza WWF Telcel-Universidad Nacional Autónoma de México. México, D.F.
- Menke, K. 2004. Priority Conservation Areas in the U.S.-Mexico Border Region for North American Tropical Cats: the Jaguar, Jaguarundi, and Ocelot. University of New Mexico. In: Vacariu, K., and J. Neeley. 2005. *Ecological Considerations for Border Security Operations: Outcomes and Recommendations of the Border Ecological Symposium*. Tucson, Az.
- Menke, K. A. and Hayes, C. L. 2003. Evaluation of relative suitability of potential jaguar habitat in New Mexico. 1-30. New Mexico Game and Fish Department.
- Rosas-Rosas, O., Bender, L.C., and R. Valdes. 2010. Habitat correlates of jaguar kill-sites of cattle in northeastern Sonora, Mexico. *Human-Wildlife interactions* 4(1).
- Silver, S. C., Ostro, L. E. T., Marsh, L. K., Maffei, L., Noss, A. J., Kelly, M. J., Wallace, R. B., Gomez, H., and G. Ayala. 2004. The use of camera traps for estimating jaguar *Panthera onca* abundance and density using capture/recapture analysis. *Oryx* 30(2): 148-154.
- Silver, S. C. 2004. Assessing jaguar abundance using remotely triggered cameras. 1-25. Wildlife Conservation Society, Global Carnivore Program.
- Yates, J. 2008. Using remote cameras to assess predator-prey interactions of wild felids in the Mexican sky islands. University of Georgia.