Decade of Wildlife Tracking in the Sky Islands

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Abstract— *In 2001 Sky Island Alliance developed a citizen science program that uses track and sign identification and count surveys to monitor potential wildlife corridors throughout southeastern Arizona and southwestern New Mexico. The goal of the Wildlife Linkages Program is to protect and advocate for an interconnected landscape where wildlife, based on their ecological needs, can move easily between core habitats, the Sky Island mountain ranges. Currently, we train and engage volunteers in the monitoring of fifty 1.5-mile long transects within seven priority linkage areas; the majority of these study areas are located on public lands. To date we have conducted over 1,000 track count surveys and documented over 4,100 records for more than 40 different animal species in the region. Sky Island Alliance has successfully applied the resulting species presence data to land-use policy and permanent land conservation, incorporating wildlife data and corridor priorities into the Sonoran Desert Conservation Plan, the Santa Cruz County Comprehensive Plan, the Pima County Wildlife Connectivity Assessment, and the Arizona Wildlife Linkages Assessment.*

Introduction

The ability for long-ranging species to disperse between mountain ranges and intervening valleys is paramount to species survival (Opdam 1990; Hass 2000; Bennet 2003; Arizona Wildlife Linkages Workgroup 2006). Preserving, restoring, and increasing connected ecosystems within the Sky Island region, has ever-greater urgency. Habitat fragmentation and destruction of open space caused by irresponsible off-road vehicle use and the development of new roads and highways, transmission lines, border infrastructure, and other effects of rapid human expansion are the most serious short-term threats to Sky Island species and their habitats (Avila and others *in press*). Division of otherwise continuous habitat will prevent natural movements of some species whose distribution in the U.S is already limited, confining them to isolation and potential extinction. In an elevational gradient, limiting wildlife migration movements from lower desert regions to higher elevations could be devastating (Misztal and others 2012). This would also have far-reaching effects on other, interconnected species, such as prey.

In the arid southwest, where extreme summer temperatures and long distances between water sources already affect species survival, climate change is adding another layer of difficulty. The ability of species to adapt and respond to a changing climate will depend on their ability to move freely across the landscape (Misztal and others 2012). An intact healthy landscape maintains the ability of wildlife to move between core areas where species—both plant and animal—have sufficient resources to survive, reproduce, and otherwise facilitate ecological processes (Hass 2000; Soulé and Terborgh 1999).

Tracking is an excellent tool for wildlife corridor monitoring over time. The skill of wildlife tracking is hundreds of thousands of years old and seen by some as the origin of science (Long and others 2008; CyberTracker Conservation 2012). Although somewhat forgotten except as a primitive skill and recreational practice, tracking as a technique continues to have implications for modern science and for wildlife conservation (Haynes and others 2005; CyberTracker Conservation 2012).

Tracking is a non-invasive monitoring technique that, with deliberate and careful study design, can provide presence, relative abundance, occurrence, distribution, and population density information (Long and others 2008). Wildlife tracking is also an effective tool to engage and educate the public, and attracts a wide range of people from different backgrounds as supporters and advocates for wildlife and their habitats. Track count events have become extremely valuable in bringing together activists, hunters, biologists, agency representatives, military personnel, planners, landowners, academics and volunteers in a shared interest (Linton 2003; Lamberton, Avila and Morris 2011; Sky Island Alliance 2012). Track and sign identification has some limitations in terms of its subjectivity, variable observer skills, and difficulty in distinguishing individual animals, determining gender, or estimating populations.

Tracking remains a cost-effective, easy to learn, and engaging monitoring method by which we can document trends in sign detection over time and wildlife presence in specific areas, particularly with protocols to provide data consistency based on a scientific study design (Haynes and others 2005; Beier and Cunningham 1996; Smallwood and Fitzhue 1995; Lamberton, Avila and Morris 2011). In addition, track and sign surveys can confirm the presence of rare species in new areas (Long and others 2008; Squires and others 2004). For example, Sky Island Alliance's first documentation of jaguar in the Sierra Azul range of Sonora, Mexico, came from the tracks discovered in 2009, one year before the animal triggered a nearby remote camera.

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In 2001, Sky Island Alliance (SIA) developed a citizen science program that uses track and sign identification and surveys to monitor potential wildlife corridors throughout southeastern Arizona and southwestern New Mexico. The goal of the Wildlife Linkages Program is to protect and advocate for an interconnected landscape where wildlife, based on their ecological needs, can move easily between core habitats, the Sky Island mountain ranges. We use wildlife tracking to gather data on wildlife presence in key wildlife linkage, and engage citizen scientists and advocates. Over the last decade we have monitored fifty 1.5-mile long transects within seven priority linkage areas in southern Arizona and New Mexico; the majority of these located on public lands. This article focuses on our longest monitoring effort located in the Las Ciénegas Wildlife Linkage, using Davidson Canyon transects as case study examples.

Study Area

The Sky Island region is a 70,000-square-mile world biodiversity hotspot (Mittermeier and others 2005), a biological bridge where the temperate Rocky Mountains and Colorado Plateau meet the subtropics, the Sierra Madre Occidental, and the Sonoran and the Chihuahuan Deserts.

Within this biological region, the Las Ciénegas Wildlife Linkage, which connects the Rincon Mountains to the Empire, Whetstone, and Santa Rita Mountains, has been identified as a high-priority wildlife linkage (Arizona Wildlife Linkages Workgroup 2006; Beier, Majka, and Bayless 2006). Sky Island Alliance's work in this corridor began in 2001 when we conducted a 4-month assessment on 10 transects located throughout the area. The results were included in the "Missing Link Report" (also referred to as the Ciénega Creek Corridor), presented to the Bureau of Land Management (Sonoran Institute 2003). Subsequently, Pima County recognized the ecological importance of this area and designated the linkage as a Critical Landscape Connection in the Pima County Sonoran Desert Conservation Plan (2004).

SIA continued this study and has monitored 10 transects consistently between 2002 and 2011 in the Las Ciénegas Wildlife Linkage (fig.1). Transects occur both north and south of Interstate-10; four transects occur within the Las Ciénegas National Conservation Area under Bureau of Land Management jurisdiction.

Davidson Canyon is an ephemeral stream that runs south to north, provides wildlife habitat and water recharge in the Ciénega-Rincon watershed. Its relationship to the perennial Ciénega Creek and endangered species such as the Chiricahua leopard frog (*Rana chiricahuensis)* and gila topminnow (*Poeciliopsis occidentalis occidentalis)* has led to concerns over proposed mining projects in the Santa Rita mountains (Coronado National Forest 2011; Sky Island Alliance 2011). The high and expansive bridge that spans the canyon at Interstate-10 enhances the importance of Davidson Canyon as a wildlife corridor, which is one of the few drainages in the Las Ciénegas Wildlife Linkage that facilitates safe passage of wildlife across Interstate-10. Davidson Canyon also is a direct connector for the Santa Rita Mountains across Scenic Highway 83, making it an integral piece of the Santa Rita-Rincon-Whetstone mountain linkage complex.

There are several recent confirmed sightings of jaguars and ocelots in southeast Arizona (Avila and others *In press*). It is possible that these species are moving north from the Patagonia Mountains to the Santa Rita Mountains, and across Highway 83 utilizing Davison Canyon and the Las Ciénegas Wildlife Linkage to reach large habitat blocks in locations to the east, such as the Whetstone and Dragoon Mountains. Conversely, black bear periodically use the same pathway moving south from the Rincon Mountains to the Santa Ritas (Atwood and others 2011), thereby bolstering the genetic health of a newly discovered Sonoran population, a population ironically made distinct by its isolation from northern Arizona mountain ranges (Atwood and others 2011).

Methods

The Wildlife Linkages Program track identification and data collection protocol is adapted from Keeping Track, Inc. (Hass and others 2000; Przybyl 2003) to consider regional requirements, like dry tracking conditions in sand and dirt rather than snow. Transects were established in areas most likely to provide evidence of wildlife activity, primarily in sandy washes, dirt roadways, or riparian edges, where there is suitable substrate for tracking. We established strategic 1.5-mile long by 60-feet wide transects in potential linkages, surveyed every 6 weeks by teams of trained volunteers. In aggregate, teams conduct nine surveys per year: two surveys occurring each season, with three surveys occurring in summer to capture data during pre-summer and monsoon conditions.

Volunteers go through a five-day training course in track and sign identification and documentation in the field. Teams of two to four trained trackers are then permanently assigned to one transect, and are provided with datasheets, GPS units, cameras, track identification cards and tracking rulers. A minimum of two trained trackers is required for each survey. A data point is recorded when the tracking team come to consensus about the identification of a track or sign.

Tracking teams survey in early morning, when temperatures are cool, the angle of light refraction is optimal for track visibility and photo-documentation, and nocturnal species tracks are freshest. Tracking surveys conducted later in the day have a lower chance of detecting nocturnal or crepuscular species and a higher chance of detecting diurnal species (Hanson and Hanson, personal communication). In early morning, there is also a higher probability of seeing wildlife tracks that increased human and cattle activity might eliminate during the day. No surveys are conducted during rainfall, due to low visibility of tracks and field safety.

Sky Island Alliance's Wildlife Linkages Program focuses on regional animal focal species categorized as a keystone, umbrella, or indicator species, habitat specialists, or have an unknown or shifting population or distribution. Threatened or endangered species often fit many of these categories. Focal species are plants or animals whose survival needs are also requirements of a healthy ecosystem, therefore making them indicators of ecosystem health (Miller and others 1999). Eight focal species were identified for study: jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), bobcat (*Lynx rufus*), mountain lion (*Puma concolor*), Mexican gray wolf (*Canis lupus baileyi*), black bear (*Ursus americanus*), white-nosed coati (*Nasua narica*), and western ornate box turtle (*Terrapene ornata*).

Each occurrence of focal species' track or sign is documented on a data collection form, and assigned a data point and photo number. A data point is a sign or set of signs made by a single animal at a single time. Tracks and other sign identified belonging to focal species are photographed with a reference ruler, measured, and information is collected on direction of travel and location. Any non-focal species indentified on a survey are recorded with an abundance rating, defined as A (one to five occurrences of sign); B (six to 10 occurrences of sign); and C (>10 occurrences of sign). Additional comments and observations are included; the resulting field notes provide excellent anecdotal information. In addition to track and sign counts we gather baseline information to document changes in transect condition, including evidence of off-road vehicle use, erosion, presence of stock animals, and new barriers to wildlife movement.

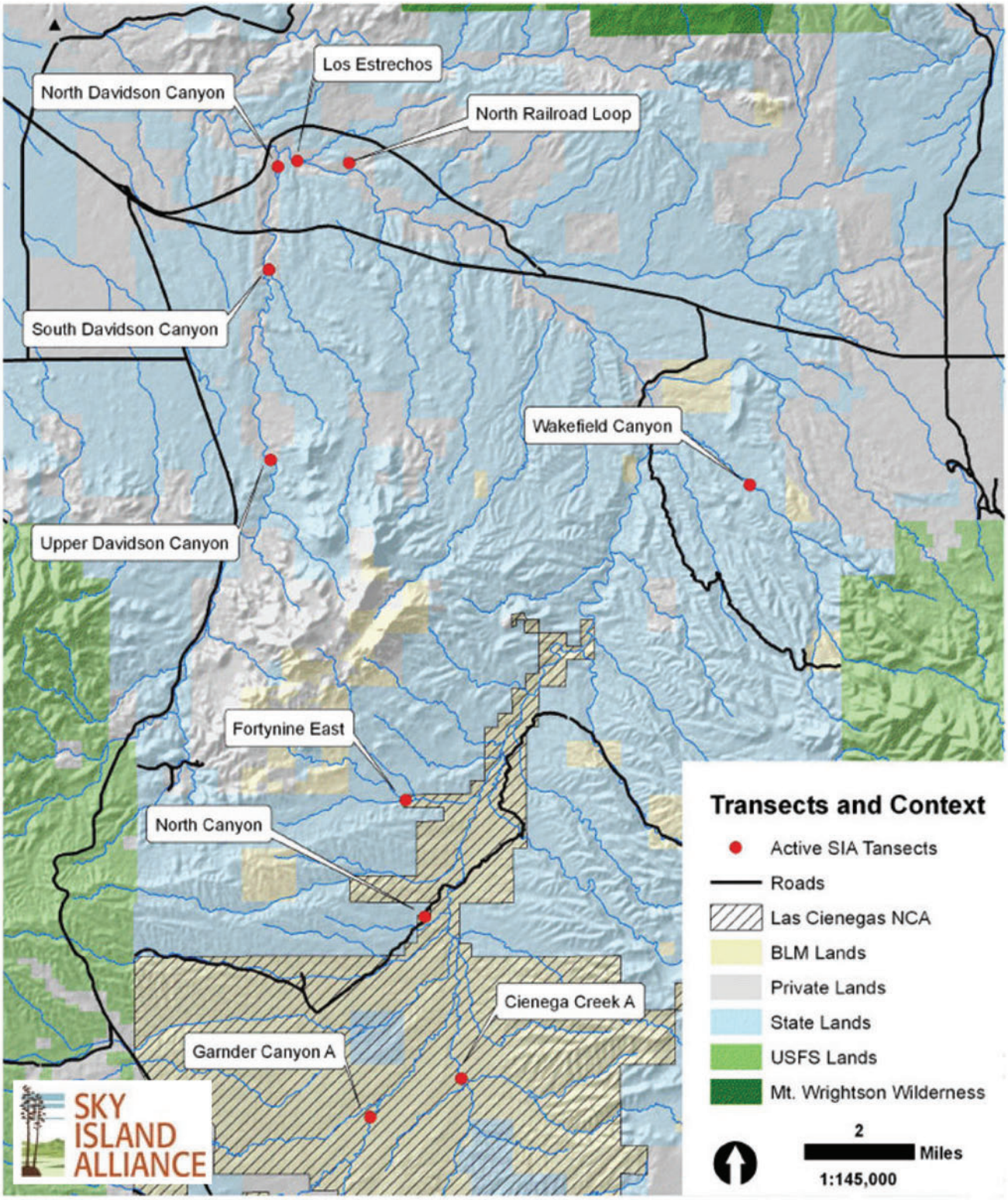

Figure 1—Study area within the Las Ceiengas Wildlife Linakge and locations of the ten tracking transects (2002-2011) (map by Nick Deyo).

Results

SIA has conducted over 1,000 track-count surveys and documented over 4,100 records for more than 40 different animal species throughout the region since 2001. In the Las Ciénegas Wildlife Linkage, we have documented 31 species with track and sign surveys throughout the 10 transect study sites between 2002 and 2011 (table 1). The majority are medium to large mammals, including both habitat specialists and generalists. We were successful in identifying tracks or sign for the majority of medium to large mammals known to be present in the area, including all four species of native skunks. We identified lagomorphs to genus, including the eastern and desert cottontail rabbit (*Sylvilagus spp*.), and the antelope and black-tailed jackrabbit (*Lepus spp.)*.

We compared transect results using the proportion of surveys with track and sign detection of similar large and medium sized mammal species (fig. 2). We categorized these by obligate carnivores: mountain lion and bobcat; omnivores: black bear and white-nosed coati; and herbivores: mule deer (*Odocoileus heminonus*), white-tail deer *(O. virginianus)* and collared peccary *(Tayassu tajacu*). Detection of ungulate track and sign in these transects appeared to be lower than in the more northern transects in the study area, possibly due to these species preferring open habitat found away from Cienega Creek.

The two transects that make up the 3-mile stretch of Davison Canyon where it flows underneath Interstate 10 have been monitored simultaneously between 2002 and 2006. We documented 24 species here during the 4-year period (table 1). We compared North and South Davidson Canyon transects for four of these species: black bear, bobcat, white-nosed coati, and mountain lion (fig. 3). There is a marked difference between the two transects for both mountain lion and white-nosed coati, although we must acknowledge that this could be a factor of observer bias or occasional track detectability changes caused by substrate or weather.

One noteworthy result from this study was that black bear track and sign increased dramatically during the months of April and September-October across all transects. Although the sample size was relatively small, all black bear tracks documented in North and South Davison Canyon transects during this period showed upstream travel (north to south). This is consistent with Atwood's finding that individuals from a northern population periodically disperse to a genetically distinct population of black bears found south of Interstate 10 (Atwood and others 2001).

Table 1—Species documented by tracks and sign on Las Cienegas Linkage transects (n = 10) between 2002-2011.

Common name	Scientific name
Badger	*Taxidea taxus*
Black bear[a]	*Ursus americanus*
Bobcat[a]	*Lynx rufus*
Collared peccary[a]	*Tayassu tajacu*
Cottontail rabbit[a]	*Sylvilagus spp.*
Coyote[a]	*Canis latrans*
Domestic cat[a]	*Felis catus*
Domestic cattle[a]	*Bos taurus*
Domestic dog[a]	*Canis lupus familiaris*
Domestic horse[a]	*Equus caballus*
Gambel's quail[a]	*Callipepla gambelii*
Gila monster[a]	*Heloderma suspectum*
Gray fox[a]	*Urocyon cinereoargenteus*
Great blue heron	*Ardea herodias*
Hooded skunk[a]	*Mephitis macroura*
Jackrabbit[a]	*Lepus spp.*
Kangaroo rat	*Dipodomys spp.*
Mountain lion[a]	*Puma concolor*
Mourning dove	*Zenaida macroura*
Mule deer[a]	*Odocoileus hemionus*
Ornate box turtle	*Terrapene ornata*
Raccoon[a]	*Procyon lotor*
Ringtail[a]	*Bassariscus astutus*
Roadrunner[a]	*Geococcyx californianus*
Sonoran desert tortoise	*Gopherus morafkai*
Striped skunk[a]	*Mephitis mephitis*
Western hognose skunk[a]	*Conepatus mesoleucus*
Western spotted skunk[a]	*Spilogale gracilis*
White-nosed coati[a]	*Nasua narica*
White-tailed deer[a]	*Odocoileus virginianus*
Wild turkey	*Meleagris gallopavo*

[a] Species documented in Davidson Canyon.

Applying Tracking to Conservation

Protected wildlife linkages are the future of sustainable wildlife conservation and rural landscape protection. Over 250 dedicated citizens have participated in our program collecting information and advocating for wildlife movement in the Sky Island region. One of the most impressive successes out of the decade of wildlife monitoring at Sky Island Alliance is the shift in perception about wildlife corridors and landscape level planning by collaborating agencies and stakeholders.

We have successfully applied the resulting species presence information to land-use policy and permanent land conservation, incorporating wildlife data and linkage priorities into the Pima County Sonoran Desert Conservation Plan (2004) and the Santa Cruz County Comprehensive Plan (2005). These results also informed the 2006 Arizona Wildlife Linkages Assessment and the 2012 Pima County Wildlife Connectivity Assessment, two comprehensive mapping projects that identify at-risk wildlife corridors and contribute recommendations for transportation planners and engineers, created through the Arizona Wildlife Linkages Workgroup (Arizona Wildlife Linkages Workgroup 2006; Arizona Game and Fish Department 2012).

Wildlife monitoring data and volunteer advocacy have been instrumental in documenting Wilderness quality lands and providing momentum to efforts to permanently protect core habitat as designated Wilderness. In addition, with wildlife tracking information we have provided strong, accurate responses to transportation infrastructure, mining and energy development projects that threaten to impact key wildlife blocks and adversely affect associated wildlife linkages. For example, we provided strong evidence to defeat a proposed amendment to the 2040 Regional Transportation Plan that called for widening Scenic Highway 83 from two to four lanes. This project would have significantly damaged the integrity of the Las Ciénegas Wildlife Linkage without extensive wildlife crossing structures in place to mitigate the loss of connectivity and allow animals to cross the highway safely.

Three wildlife crossing structures, including the second wildlife overpass to be constructed in Arizona, were recently approved as part of a needed expansion of State Route (SR) 77 in Oro Valley. Our track and sign monitoring data, the Arizona Wildlife Linkages Assessment (2006) and detailed corridor modeling (Beier, Garding and Majka 2006) in the Catalina-Tortolita mountain wildlife linkage supported this decision. Similarly, in December 2011, 10 years after tracking volunteers first put feet to the ground, a new project on SR86 near Kitt Peak proposed by the Tohono O'Odham Nation and informed by the Arizona Wildlife Linkages Assessment gained final approval

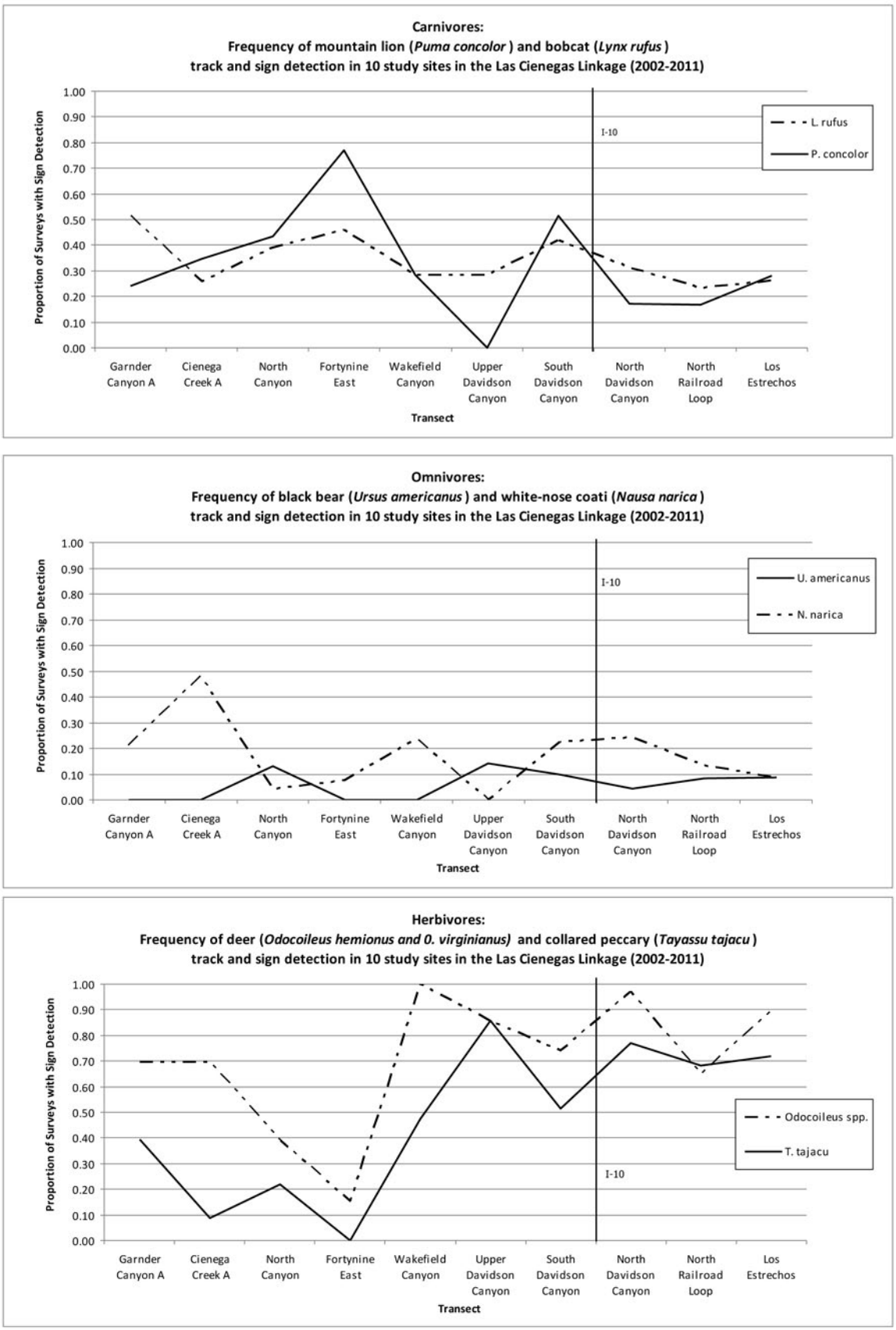

Figure 2—A comparison of the frequency of track and sign detection in 10 study sites in the Las Ceiengas Wildlife Linakge for select carnivore, omnivore, and herbivore species (2002-2011). The location of Interstate-10 is indicated on each graph, and transects are arranged left to right as south to north to provide a spatial illustration. The southernmost transects (Gardner Canyon A, Ciénega Creek A, North Canyon, and Forty-nine East) occur within the Las Ciénegas National Conservation area.

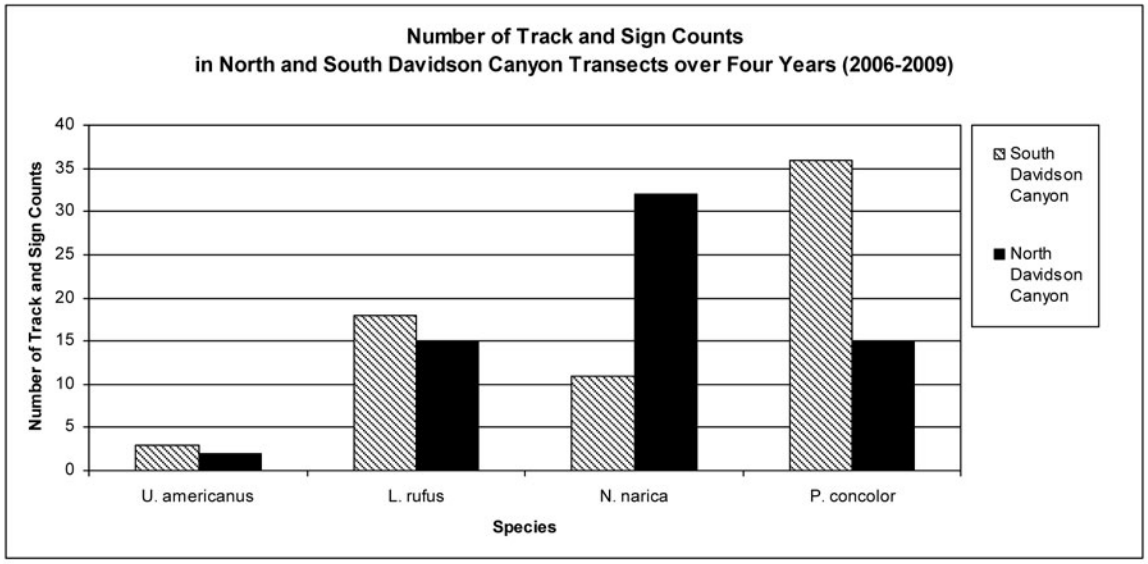

Figure 3—Number of track and sign counts documented on South and North Davidson Canyon transects over a period of 4 years (2006-2009)

for Pima County Regional Transportation Authority. This project will include two wildlife underpasses and a vegetated wildlife overpass. The SR77 wildlife-crossing project, scheduled to break ground in 2013, is serving as a model for similar projects in Pima County. As population and transportation needs increase, these critical wildlife connections will become more necessary. There is continued value for public engagement, increased public understanding of the intrinsic value of wildlife and their habitats, and the information gathered that track and sign monitoring provides.

Conclusions

Long term tracking results have provided useful information about the presence and movement of wildlife in the Las Ciénegas Wildlife Linkage and Davidson Canyon. Track and sign monitoring provides an excellent opportunity for cost-effective, publicly engaging, data collection that has strong implications for conservation. It serves as both an advocacy tool as well as a scientific method of determining wildlife presence. We recommend using track and sign identification for landscape scale wildlife monitoring efforts as a non-invasive alternative or to provide supplemental data where technicians or volunteers are conducting field investigations and the project may benefit from these additional observations.

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References

Arizona Game and Fish Department. 2012. The Pima County Wildlife Connectivity Assessment: Report on Stakeholder Input. Available: http://www.azgfd.gov/w_c/documents/PimaCountyWildlifeConnectivityAssessment.pdf.

Arizona Wildlife Linkages Workgroup. 2006. Arizona's Wildlife Linkages Assessment. Available: http://www.azdot.gov/inside_adot/OES/AZ_WildLife_Linkages/assessment.asp.

Atwood, T. C., J. K. Young, J. P. Beckmann, S.W. Breck, J. Fike, O. E. Rhodes Jr., and K. D. Bristow. 2011. Modeling connectivity of black bears in a desert sky island archipelago. Biological Conservation 144.

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).

Avila, S., Quigley, M., Hare, T., Carter, J. and M. Emerson. *In press*. Sky Island Alliance: Bi-National Efforts to Protect and Restore Native Wildlife and Habitats both Sides of the Border. In: The Border Wall between Mexico and the United States. Venues, Mechanisms and Stakeholders for a Constructive Dialogue, Cordova, A. y C. de la Parra (coords). Colegio de la Frontera Norte.

Beier, P., and S.C. Cunningham. 1996. Power of track surveys to detect changes in cougar populations. Wildlife Society bulletin 24:540-546.

Beier, P., D. Majka, and T. Bayless. 2006. Arizona Missing Linkages: Rincon-Santa Rita-Whetstone Linkage Design. Report to Arizona Game and Fish Department. School of Forestry, Northern Arizona University.

Beier, P., E. Garding, and D. Majka. 2006. Arizona Missing Linkages: Tucson – Tortolita – Santa Catalina Mountains Linkage Design. Report to Arizona Game and Fish Department. School of Forestry, Northern Arizona University.

Bennet, A. F. 2003. Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. IUCN, Gland, Switizerland and Cambridge, UK. Xiv + 254 pp.

Coronado National Forest. 2011. Draft Environmental Impact Statement for the Rosemont Copper Project: A Proposed Mining Operation. Coronado National Forest, Pima County, Arizona. Vol. 1. Available: http://www.rosemonteis.us/draft-eis.

CyberTracker Conservation. 2012. The art of tracking. Available: http://cybertracker.org/tracking/the-art-of-tracking.

Hanson, J., and R. Hanson. 2011. Tracking etiquette. Presentation at Introduction to Wildlife Tracking workshop; July 14; Tucson, AZ.

Hass, C.C. 2000. Landscape fragmentation and connectivity for carnivores in the Upper San Pedro Basin. Fort Huachuca Wildlife Office, Fort Huachuca, AZ.

Hass, C.C., S. C. Morse, and H. G. Shaw. 2000. Keeping Track Project and Data Management Protocol. Keeping Track, Inc. Vermont, USA.

Haynes, L., Z. Hackl, and M. Culver. 2005. Wild Cats of the Sky Islands: A Summary of Monitoring Efforts Using Noninvasive Techniques. In Connecting mountain islands and desert seas: biodiversity and management of the Madrean Archipelago II, compiled by Gottfried, Gerald J.; Gebow, Brooke S.; Eskew, Lane G.; and Edminster, Carleton B. Proceedings RMRS-P-36. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 631 p.

Lamberton, J. A., S. Avila and K.Morris. 2011. Where jaguar and black bear meet: tracking the pathway of temperate and tropical species in an international Sky Island corridor. In Proceedings of the 2011 International Conference on Ecology and Transportation, edited by Paul J. Wagner, Debra Nelson, and Eugene Murray. Washington State Department of Transportation, Seattle, WA.

Linton, T. 2003. Fort Huachuca Surveys Big Cats. U.S. Army Environmental Command, Fall 2003 Environmental Update.

Long, R. A., P.MacKay, J. C. Ray, W. J. Zielinski, ed. 2008. Noninvasive Survey Methods for Carnivores. Island Press. Washington, DC.

Miller, B., R. Reading, J. Strittholt, [and others]. 1999. Using focal species in the design of nature reserve networks. Wild Earth Winter 1998/1999.

Misztal, L.M, A. Score, and L. Hansen. 2012. Between a Rock and a Hot Place: Climate Change Adaptation and Resource Management for the Sky Island Region Workshop Summary Report. Sky Island Alliance and Ecoadapt. Available: http://www.skyislandalliance.org/adaptationworkshop2011.htm

Mittermeier R.A., P. Robles Gil, M. Hoffman, [and others]. 2005. Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Conservation International, Washington, DC, 392 pp.

Opdam, P. 1990. Dispersal of fragmented populations: the key to survival. pp. 3-17 In *Species Dispersal in Agricultural Habitats*, edited by R.G.H. Bunce and D.C. Howard. Belhaven Press: London.

Pima County Sonoran Desert Conservation Plan. 2004. Biological Corridors and Critical Habitat. Available: http://www.pima.gov/sdcp.

Przybyl, J.. 2003. Management Model and Training Program for Sky Island Alliance's Volunteer-based Wildlife Monitoring Program. Master's thesis. Prescott College, AZ.

Santa Cruz County Comprehensive Plan. 2005. Available: http://www.co.santa-cruz.az.us/com_development/pdf/complete-plan-2005.pdf

Sky Island Alliance. 2011. Comments re: Draft Environmental Impact Statement for the Rosemont Copper Project, A Proposed Mining Operation, Coronado National Forest, Pima County, AZ. Submitted to the U.S. Forest Service January 18, 2012. Available: https://cara.ecosystem-management.org/Public/ReadingRoom?Project=24544

Sky Island Alliance. 2012. Wildlife Linkages 10 Year Report: Celebrating a decade of citizen science and Sky Island corridor conservation. Sky Island Alliance, Tucson, AZ.

Smallwood, K. S., and E. L. Fitzhugh. 1995. A track count for estimating mountain lion *Felis concolor californica* population trend. Biological Conservation 71:251-259.

Sonoran Institute. 2003. Missing Link Assessment for Protection Measures for Certain Lands North of the Sonoita Valley Acquisition Planning District in Pima County, Arizona. Final Report for Congress, prepared for the Bureau of Land Management, U.S. Department of the Interior.

Soulé, M. E., and J. Terborgh, ed. 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press, Washington, DC.

Squires, J. R., K.S. McKelvey, and L.F. Ruggiero. 2004. A snow tracking protocol used to delineate local lynx, *Lynx Canadensis*, distributions. Canadian Field-Naturalist 118:583-589.

The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.