Irvine Spectrum Wildlife Corridor Camera Monitoring Project

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Table of Contents

List of Figures

List of Tables

INTRODUCTION

Habitat Conservation Plans (HCP) administered by the federal government and Natural Community Conservation Plans (NCCP) sponsored by the state of California have become the primary conservation tools for protecting entire landscapes, rather than focusing on species by species conservation in separate isolated preserves. One of the flagship HCP/NCCPs in California is the Central/Coastal MSCP/HCP, first signed in 1996, that protects 39 covered species across a broad swath of central Orange County. Despite the successes of this plan in protecting a number of rare species in the region, it has long been recognized that the lack of connectivity between the coastal San Joaquin Hills with protected areas to the east in the Santa Ana Mountains severely compromises the ecosystem integrity of the preserves (Figure 1). Despite the size of the roughly 22,000 acre (8,903 ha) coastal protected area, several mammal species such as mountain lion (*Felis concolor*), badger (*Taxidea taxus*), and Black-tailed Jackrabbit (*Lepus californicus*) have been extirpated from the San Joaquin Hills and are blocked from naturally recolonizing. Other species such as mule deer (*Odocoileus hemionus*), bobcat (*Felis rufus*), and Greater Roadrunner (*Geococcyx californianus*) maintain populations within the San Joaquin Hills, but continued isolation from surrounding populations will invariably lead to inbreeding depression without natural or assisted immigration into the conservation area. Long term studies of fragmented landscapes teach us that over time numerous species drop out of even the largest fragments if connectivity is not maintained, gradually degrading natural communities as biodiversity is lost (Clark 2011, Soulé et al. 1988, Haddad et al. 2015).

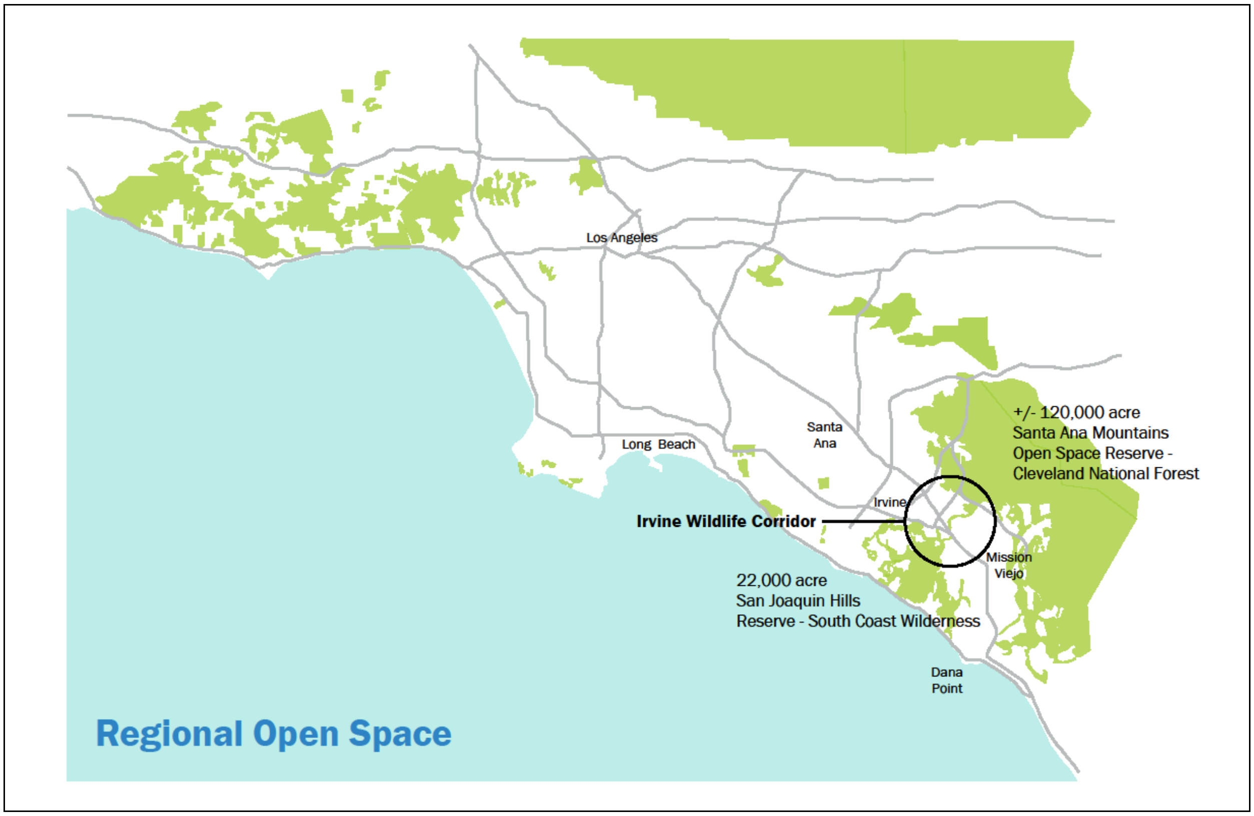

Figure 1. Irvine Spectrum Wildlife Corridor location.

The reduced biodiversity leads to weakened ecological processes such as fruit and seed dispersal, nutrient flows through the food chains, and changed herbivory patterns, all of which can profoundly restructure the natural communities into something significantly different than what was originally protected (Clark 2011, Hilty et al. 2012).

The approximate 6-mile long Irvine Spectrum Wildlife Corridor follows the paths of San Diego and Serrano Creeks from the foothills of the Santa Ana Mountains, which still maintain an intact ecological community with all of the assorted species, into the San Joaquin Hills (Figure 2).

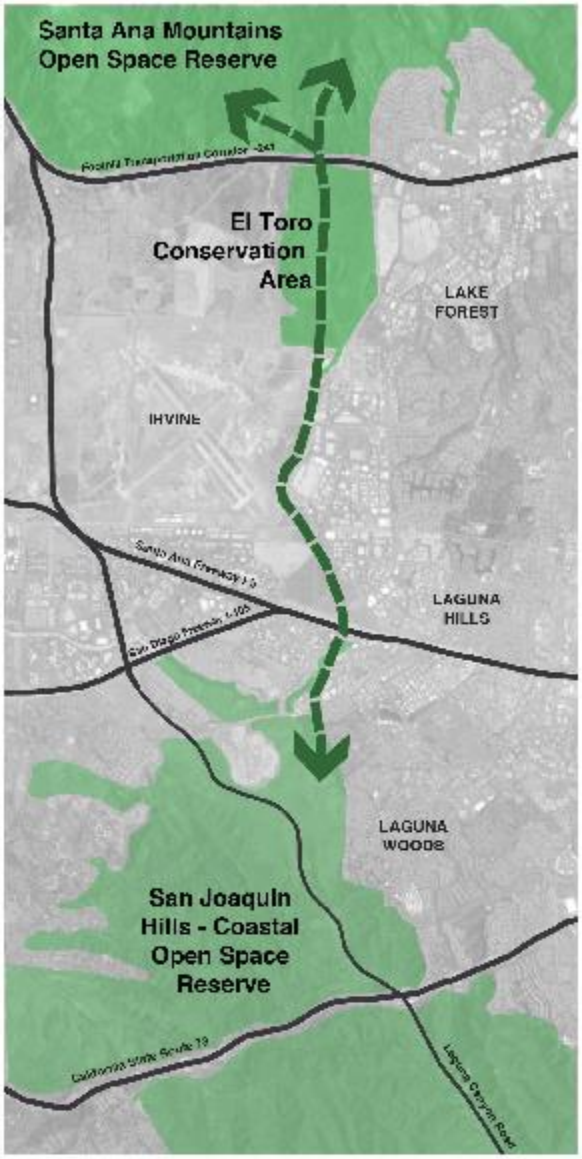

Figure 2. Orange County HCP/NCCP preserve areas and the Irvine Spectrum Wildlife Corridor. Map courtesy Laguna Greenbelt, Inc.

The first step in the corridor after it crosses the SR-241 freeway is the El Toro Conservation Area, a key component of this linkage, consisting of a 1,000-acre natural area harbouring numerous rare species (Clark 2007, Clark 2013). The remaining ~4 miles of the corridor pass through a series of habitat patches and roadways of various sizes in the Irvine Spectrum, creating a difficult path for most wildlife species to follow. Establishing a functional connection across this gap would limit or stop the biodiversity degradation of the San Joaquin Hills, allowing for natural movement and recolonization of numerous species at a fraction of the costs of individual species rescue and management efforts.

In order to assess the needed infrastructure improvements to facilitate wildlife movement through the Irvine Spectrum Wildlife Corridor, a thorough understanding of the existing functionality of the corridor is first needed (Figure 3). This has been recognized for some time, both within the original HCP documents and in later studies including a multi-year coyote (*Canis latrans*) and bobcat movement study in the area (Lyren et al. 2008). In response to this need, Laguna Greenbelt Inc. received grant funding from the City of Laguna Beach and others to implement a corridor study with the following goals:

1. Detect successful wildlife crossing of the I-5/405 using the Serrano Creek culvert.
2. Determine barriers to wildlife movement through the Irvine Spectrum V industrial park on the coastal side of the I-5.
3. Obtain a clearer picture of wildlife activity in an area traditionally rich in wildlife and centered on three creeks: Serrano, San Diego, and Needlegrass (formerly Veeh Creek). These creeks converge in SpectrumV.
4. Determine possible encroachment by humans and pets into wildlife habitat near the creeks from adjacent roads and developments built since 2007.

Figure 3. The Irvine Spectrum Wildlife Corridor study area.

The study area is managed by the Orange County Flood Control District with two primary landowners: County of Orange and The Irvine Company. The flood control channels in this area are typically soft-bottom, bordered by varied amounts of infrastructure from side walls of concrete or manufactured slopes with native habitat. Much of the corridor lacks fencing at the street level to prevent human intrusion into the culverts or wildlife from entering the roadways.

The most significant underpass, the I-5/I-405 interchange, is 1,100 ft. in length, 15 ft. in height and 25 ft. wide. It has a bend in the middle which obscures light at each end making the tunnel very dark. A diversionary tunnel meets the large tunnel at a 90-degree angle. This diversionary tunnel leads to the continuation of the wildlife corridor. This tunnel was created as mitigation for Spectrum development impacts to wildlife movement. Wildlife not using this diversionary tunnel continue through the main tunnel which ends in hardened concrete flood channels with no connection to natural habitats. Much of the underpass supports ponded water for varying amounts of time. The diversionary tunnel is about 130 ft. in length and approximately 7 ft. in height and width with a sandy bottom. The entire underpass shows extensive use by humans, with much litter and refuse scattered in the area (Figure 4).

Figure 4. The I-5/I-405 interchange underpass shows extensive human usage.

The existing corridor consists of a series of open space areas devoted to agriculture or water conveyance, and bisected by numerous roadways of various width, including the I-5/I-405 interchange, Irvine Boulevard, Research Drive, Irvine Center Drive, Bake Parkway and Lake Forest Drive. Each of these roadways contains one or more underpasses or culverts of various dimensions, facilitating the movement of some species, but discouraging others. Understanding which species are currently facilitated and which are discouraged is an important step to determining how to improve the corridor for a larger suite of species.

Issues requiring better documentation and solutions include the current human usage of the natural areas and flood control channel and underpasses. Human users including homeless populations, maintenance workers, surveyors, utility workers, planners, and taggers all make regular use of these areas at various times, and their presence can significantly affect whether and when wildlife utilize the movement corridor.

While the deployed cameras cannot capture the movement of small vertebrates, they are very successful at capturing medium and large mammals, as well as larger birds. They also provide data on daily and seasonal movement patterns of these species.

METHODS

The Laguna Greenbelt Wildlife Corridor Team started the analysis of the Study Area in late 2016 with the first camera placement in May 2017. The camera study ended with cameras removed by late November 2018. Pinch points were identified at the major under crossings. Cuddeback E2 cameras were purchased with metal cases, padlocks, security screws, u-channel poles, batteries, SD cards and readers and a placard defining the purpose.

The Cuddeback E2 cameras were programed for continuous operation for still photography and some videos. Each camera set-up was done by the Laguna Greenbelt Wildlife Corridor Team, ensuring that the timing sequence between stills and videos and the camera angles were appropriate to capture wildlife images. The Team visited the camera sites on a regular basis to exchange SD cards, clean lens and IR array, and check the batteries, camera angle, and images. They also replaced vandalized and storm damaged cameras. The Team recorded each camera visit, noting the camera and surrounding area conditions. Then each SD card was downloaded and images reviewed and labeled. At certain times of the study cameras had to be removed because of high levels of water, but were replaced when the water receded.

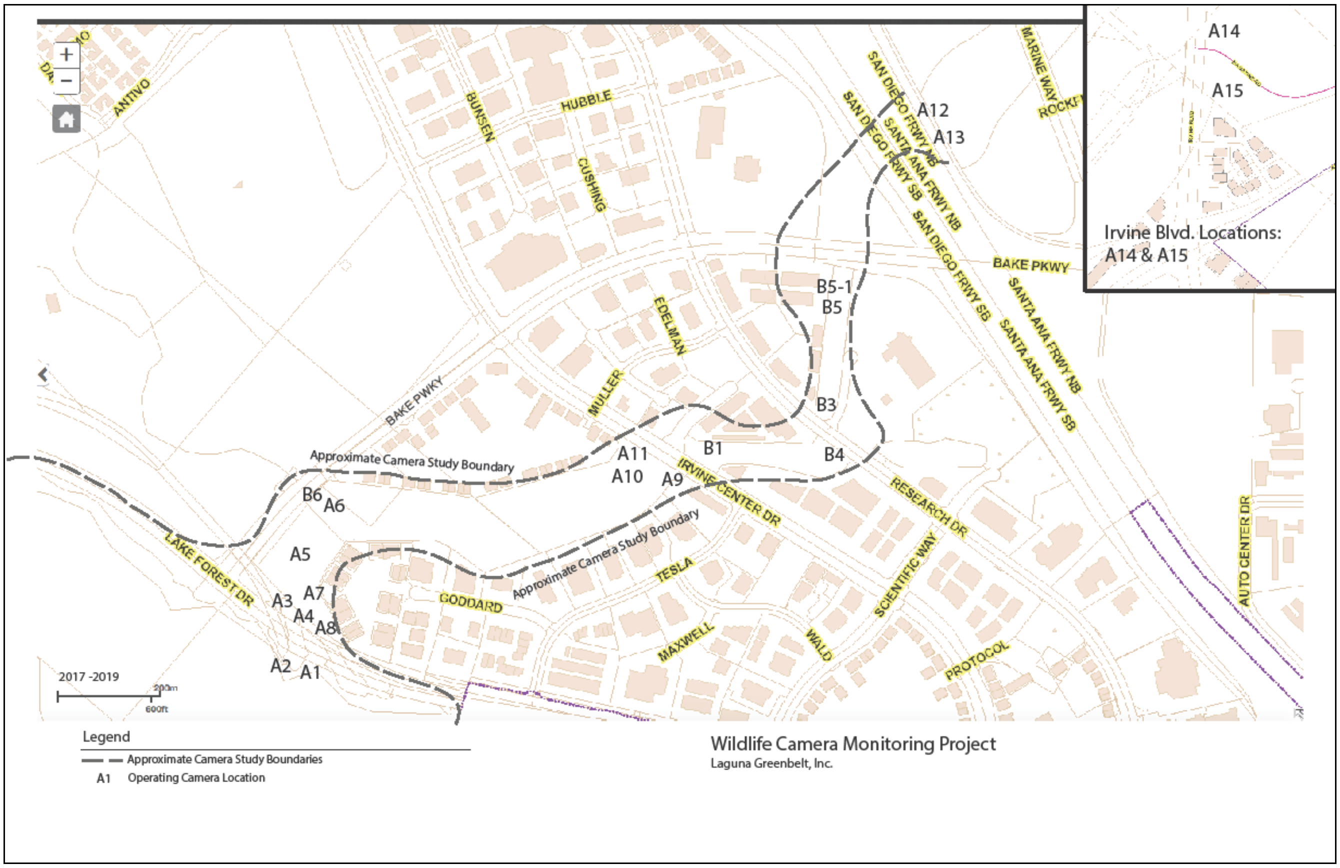

Figure 5. Camera locations within the Irvine Spectrum Wildlife Corridor study area.

Cameras were labeled to indicate the landowner, A = Orange County Flood District, B = The Irvine Company (Figure 5). Camera A10 was only in the field from June 7 – July 24, 2017. It was removed as all the images were of plants. No images were saved or used in the analysis. Camera B6 was deployed from February 24 – October 2, 2018 with no wildlife recorded.

A total of 21 wildlife cameras were established at 11 camera stations along the Irvine Spectrum Wildlife Corridor Camera Study Area (Study Area) (Table 1, Figure 6). Each camera station corresponds to one side of a pinch point, whether culvert, tunnel, or underpass. For example, camera stations 1a and 1b are located on the western and eastern side of underpass 1 (Lake Forest Drive Bridge). Camera stations had 1-4 cameras depending on the need for different camera sight lines as wildlife moved through the area. Cameras were operated between 156-552 days.

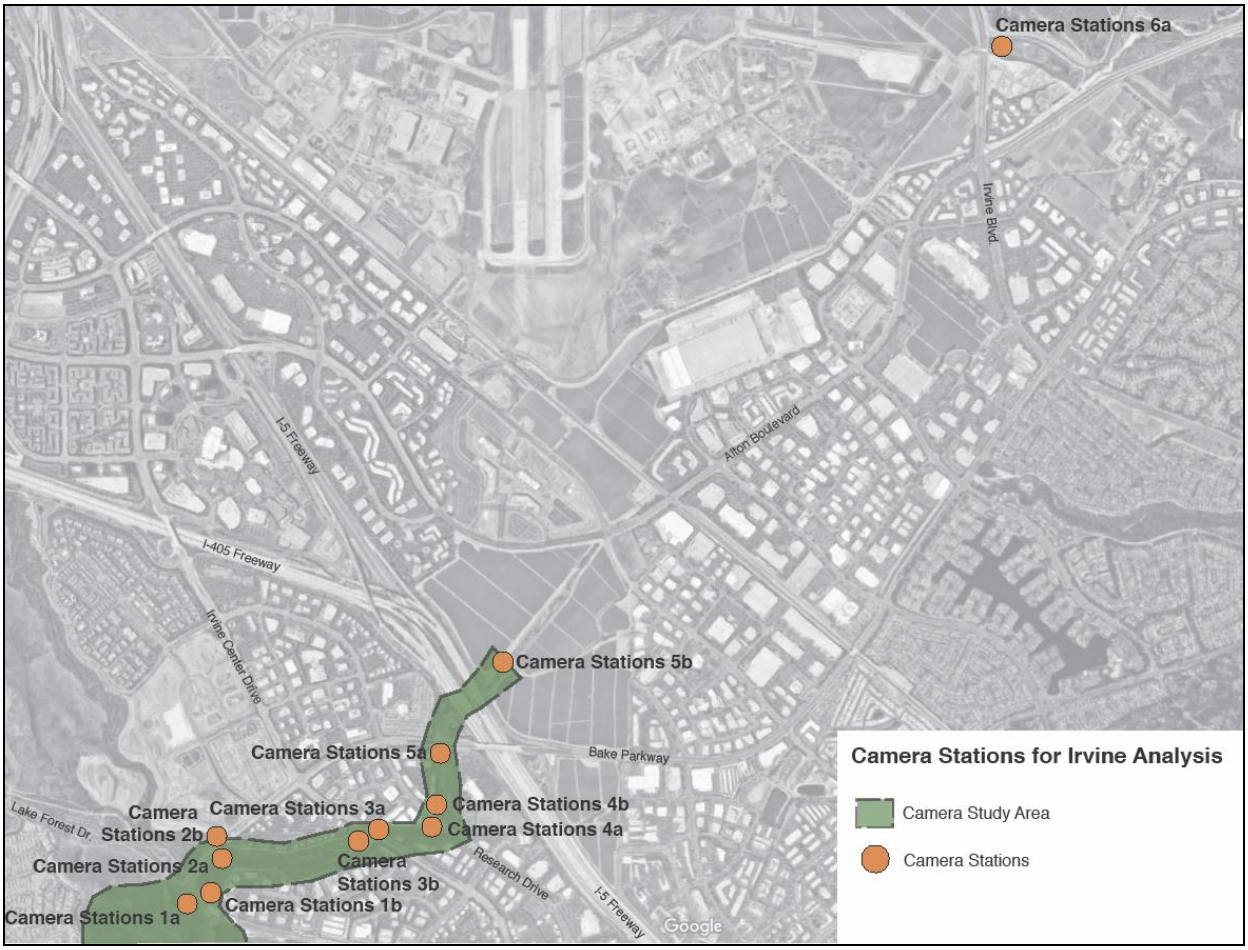

Figure 6. Camera stations used in the analysis.

Table 1. Number of days each camera was deployed at a camera station Camera stations are numbered from west to east along the corridor beginning at the underpass at Lake Forest Drive and ending at the underpass at Irvine Blvd (see Figure 6).

Station	Camera	Number of Days Deployed
1a	A-1	275
	A-2	274
1b	A-3	231
	A-4	536
	A-7	261
	A-8	261
2a	A-6	282
2b	A-5	176
3a	A-9	177
	A-11	217
3b	B-1	194
4a	B-3	495
4b	B-4	552
5a	B-5	387
	B-5-1	202
5b	A-12	440
	A-13	212
6a	A-14	411
	A-15	415

All photographs were downloaded, reviewed, and organized by Laguna Greenbelt, Inc, volunteers. Photos of wildlife were then reviewed and categorized by San Diego Natural History Museum biologists. Animal activity was defined as the number of days a species was detected at each camera. To avoid double counting, animals were counted just once per day even if there were multiple recordings of that species throughout the day. An index of relative animal activity was calculated for each camera: % animal activity = number of days active*100/number of days each camera station was active.

For analysis, we used the station as the sampling unit. Therefore, animal activity was averaged across all the cameras located at each station. We used Pearson's correlation coefficient to evaluate simple correlations between animal activity and land use and animal activity and human activity.

RESULTS

Camera Surveys

Native carnivore species that cameras detected were bobcat (*Lynx rufus*), coyote (Figure 7), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis)* (Table 2). Cameras also recorded the introduced opossum (*Didelphis virginiana*).

Figure 7. Coyote with prey at camera A-8.

Bobcats were only recorded at the most eastern and western cameras (A-8, A-15, Figure 8) located nearest to a natural open area. No bobcats were recorded in the middle sections of the corridor. Coyotes were detected at all camera stations, though their activity levels varied greatly within differing portions of the corridor (further discussed below).

Figure 8. Bobcat image from camera A-8 at the Lake Forest Drive bridge underpass. The bobcat wasn't recorded entering or emerging from the underpass or at any other camera locations. This underpass is at the western end of the corridor next to the City of Irvine Open Space which is adjacent to Laguna Coast Wilderness Park.

Other mammal species detected were desert cottontail (*Sylvilagus audubonii*), California ground squirrel (*Otospermophilus beecheyi)*, fox squirrel (*Sciurus niger*) deer mice (*Percomyscus* sp.), and woodrat (*Neotoma* sp.).

Several avian species associated with water were detected including Great Egret (*Ardea alba*), Great Blue Heron (*Ardea herodias)*, Mallard (*Anas platyrhynchos)*, Green Heron (*Butorides virescens)*, and Black-crowned Night Heron (*Nycticorax nycticorax)*. Other avian species included Greater Roadrunner (*Geococcyx californianus*, Figure 9*)*, California Quail (*Callipepla californica*), and White-crowned Sparrow (*Zonotrichia leucophrys*).

Figure 9. Greater Roadrunner and California Ground Squirrel at Camera A-8 on June 4, 2018.

Table 2. Number of days each species was observed active by station during the Irvine Spectrum Wildlife Corridor Camera Study, 2017-2018. Ranked in order from most to least observed.

Species	Station											Total Days
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	
Coyote	25	323	21	12	76	54	13	21	36	66	318	965
Human	109	143	16	10	27	10	47	28	139	68	40	637
Raccoon	4	23	0	1	2	0	1	2	6	7	12	58
California Ground Squirrel	1	52	0	0	0	0	0	0	0	0	0	53
Desert Cottontail	1	18	0	0	0	0	1	0	0	24	0	44
Great-blue Heron	0	30	2	0	0	0	0	0	0	0	0	32
Great Egret	1	11	5	0	2	0	0	0	0	7	0	26
Mallard	0	11	0	0	0	0	0	0	0	0	0	11
Opposum	0	3	0	0	0	0	0	0	0	0	0	3
Black-crowned Night Heron	0	0	1	0	0	0	0	0	0	1	0	2
Bobcat	0	1	0	0	0	0	0	0	0	0	1	2
Fox Squirrel	0	1	1	0	0	0	0	0	0	0	0	2
Greater Roadrunner	0	2	0	0	0	0	0	0	0	0	0	2
Red-tailed Hawk	0	0	1	0	0	0	0	0	0	1	0	2
Green Heron	0	1	0	0	0	0	0	0	0	0	0	1
Deer Mice	0	0	0	0	1	0	0	0	0	0	0	1
Striped Skunk	0	1	0	0	0	0	0	0	0	0	0	1
White-crowned Sparrow	0	0	0	0	0	0	0	0	0	1	0	1
California Quail	0	0	0	0	0	0	0	0	0	0	1	1
Woodrat	0	0	0	0	0	0	0	0	0	1	0	1
Total Days	141	620	47	23	108	64	62	51	181	176	372	1845

Animal Activity

Animal activity was evaluated along the corridor for coyote, raccoon, all mammals combined, and humans (Figures 10-13).

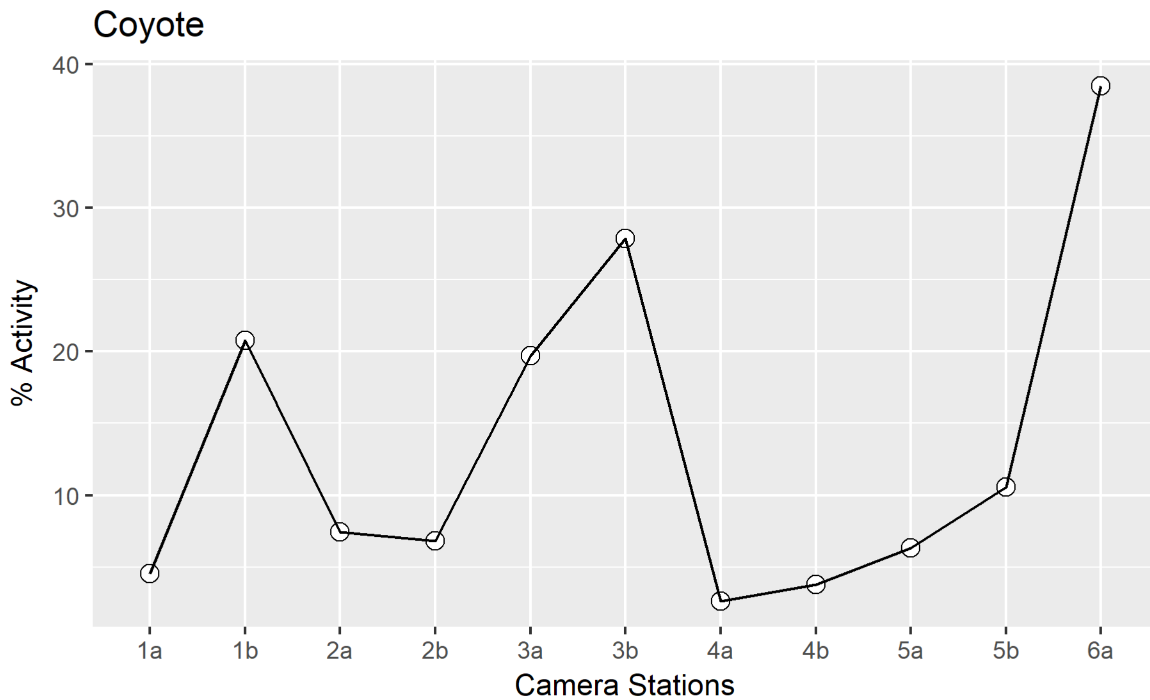

Figure 10. Coyote activity (%) observed at each camera station (6 underpasses) during the Wildlife Corridor Camera Study, 2017-2018.

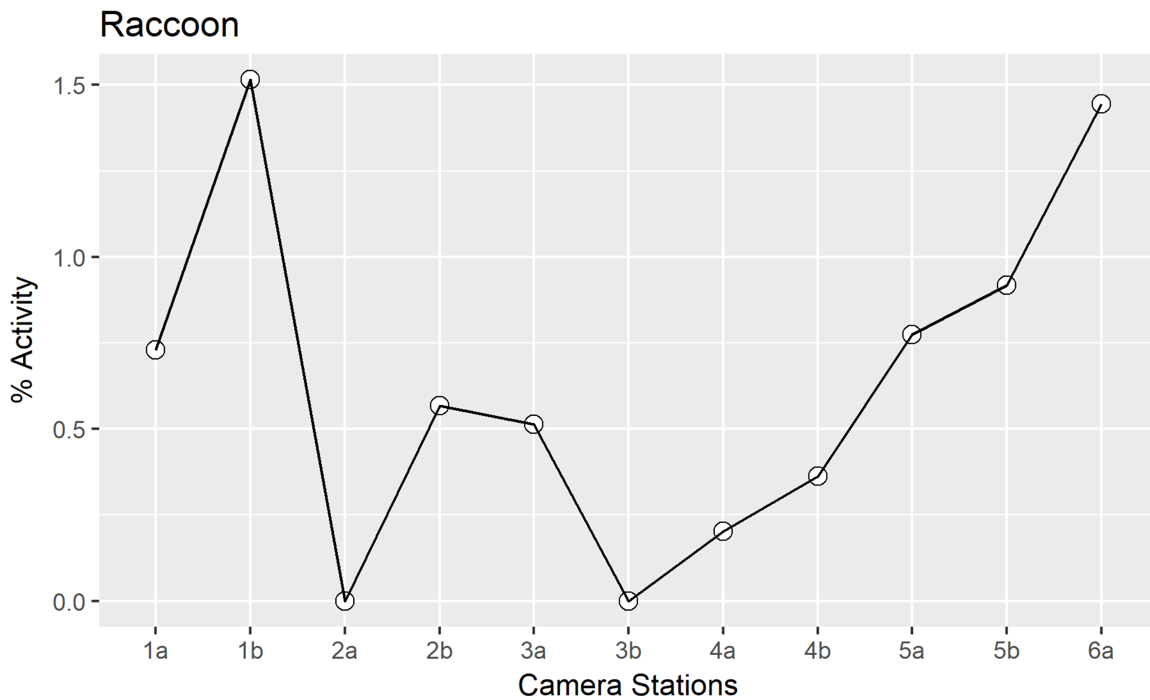

Figure 11. Raccoon activity (%) observed at each camera station (6 underpasses) during the Wildlife Corridor Camera Study, 2017-2018.

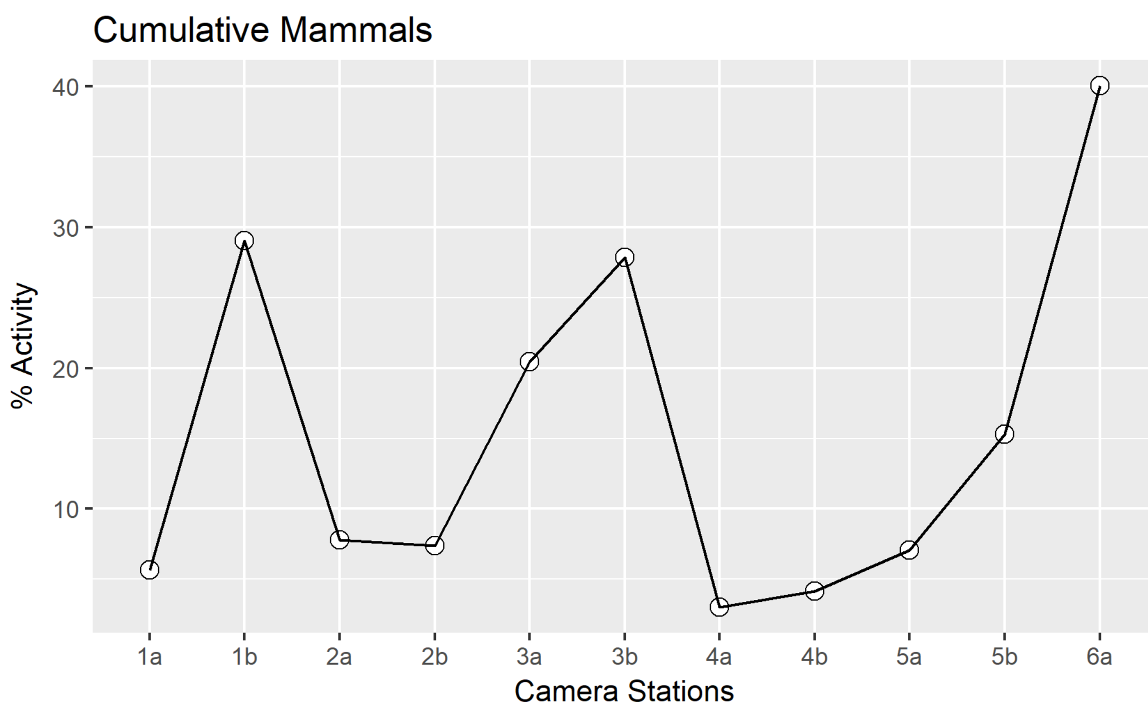

Figure 12. Cumulative mammal activity (%) observed at each camera station (6 underpasses) during the Wildlife Corridor Camera Study, 2017-2018.

The central portion of the corridor closest to Interstate 5, consisting of camera stations 4a, 4b, 5a, and 5b, had the lowest coyote activity and cumulative mammal activity along the corridor. The far ends of the corridor connected to natural areas, including stations 1a, 1b, and 6a, tended to support the highest cumulative mammal activity along the corridor.

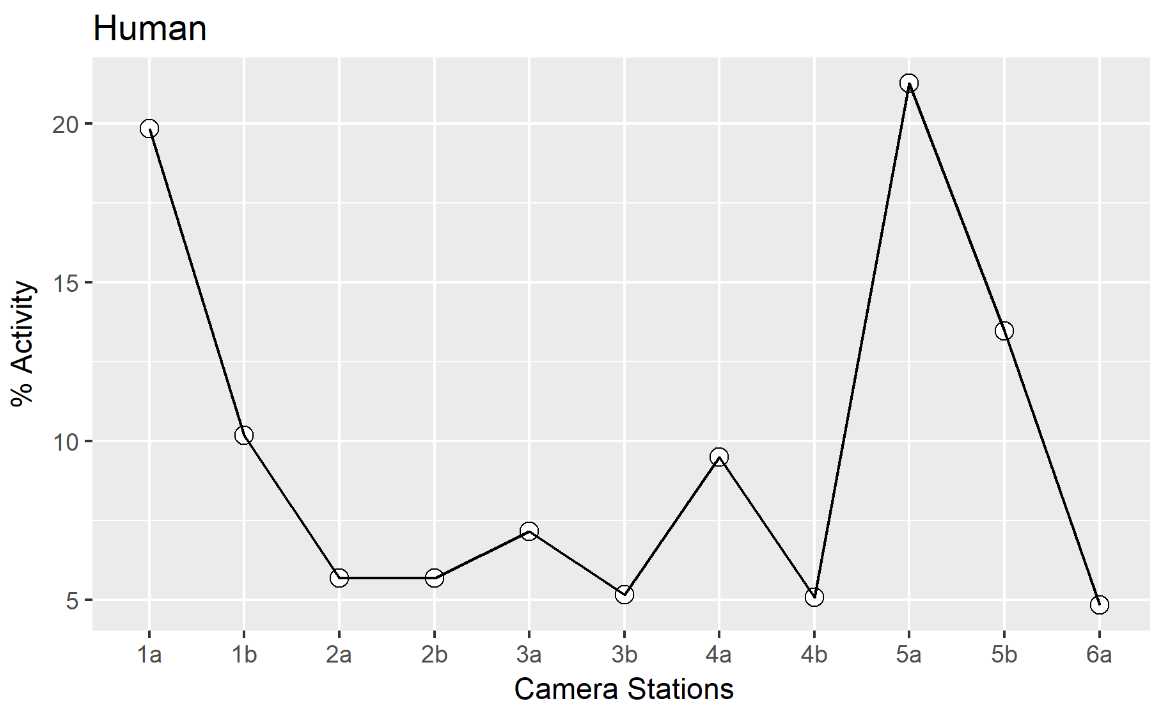

Figure 13. Human activity (%) observed at each camera station (6 underpasses) during the Wildlife Corridor Camera Study, 2017-2018.

Human activity along the corridor generally showed an inverse pattern to the mammal activity, with the central portion of the corridor near Interstate-5, especially 5a and 5b, showing significant human activity, while the end of the corridor at 6a showing very little. The west end of the corridor at 1a also showed significant human activity, and was also a station that showed low mammal activity, despite being directly adjacent to open space. The two stations with the highest human activity, 1a and 5a, were also the two stations with some of the lowest levels of both coyote and cumulative mammal activity. It's clear that there is a relationship between human activity and mammal activity at the underpasses, so we explored further whether there was statistical power to test this relationship.

Coyote and Human Activity

The two categories with the greatest sample size were coyote activity and human activity, so we tested whether these two were correlated. We found that coyote activity was negatively correlated with human activity across all camera stations (r = -0.41, Figure 14).

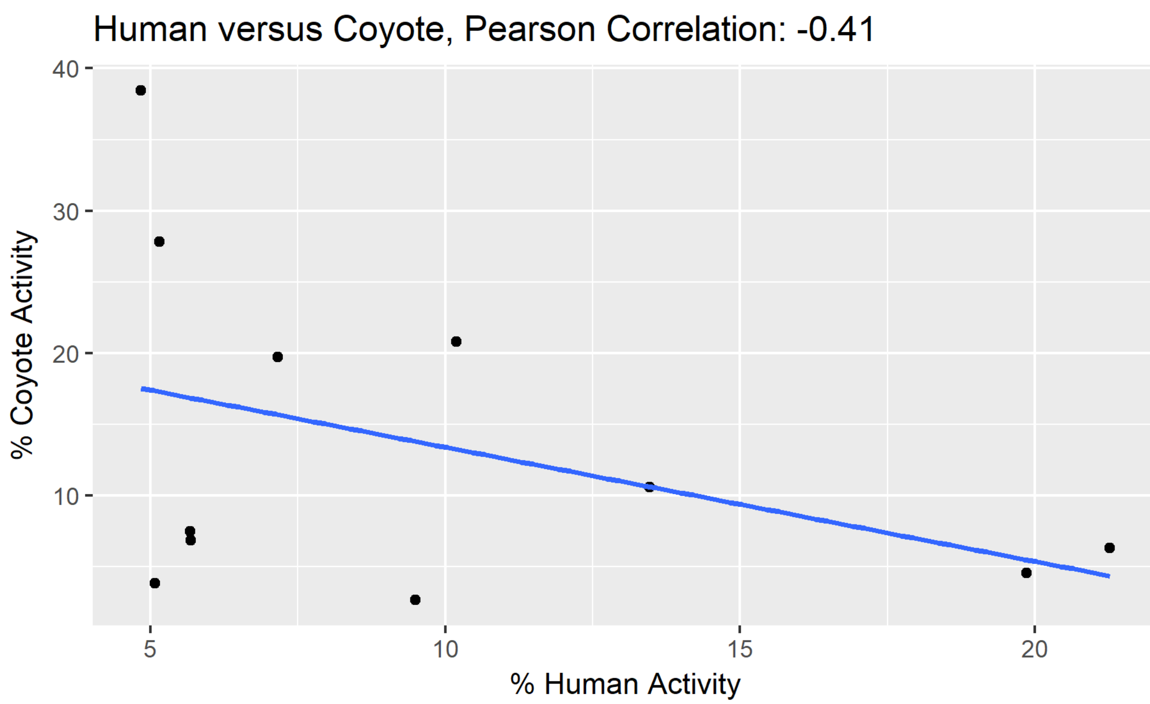

Figure 14. Correlation between coyote activity and human activity.

DISCUSSION

Wildlife Use of the Corridor

Both coyote and raccoon were found to be using the underpasses throughout the corridor. However no other medium or large-sized mammals were found to be regularly approaching the underpasses, especially in the middle sections away from the preserved areas. Human activity proved to be a negative predictor of coyote usage at underpasses throughout the study area. While only the coyote had sufficient sample sizes for this analysis, it is likely that a similar pattern would emerge for other fragmentation sensitive species such as the bobcat. Effort to discourage human usage of the corridor should be a focus of future management actions and are further discussed below.

The high coyote useage of some underpasses with limited human usage may in turn serve to deter gray foxes and bobcats from using these underpasses. Bobcats and gray foxes have been shown to avoid areas of high coyote density (Fedriani et al. 2000). No gray foxes were documented using the underpasses despite suitable habitat. Coyotes can serve as both competitors and potential predators of gray foxes and bobcats, and both of these species use higher escape terrain or climb into tall, dense vegetation to avoid coyote interactions. Possible methods to encourage corridor use by these species will be discussed below.

The lack of movement of bobcat through the corridor found in this study is consistent with other regional studies of bobcat behavior and genetics. Lee et al. (2012) found a high degree of genetic differentiation between bobcats on either side of Interstate 5 in central Orange County, with coastal bobcats in the San Joaquin Hills possessing lower genetic diversity. This same study did not find genetic differentiation in bobcat populations bisected by the SR-91 or SR-73 freeways, indicating that functional wildlife underpasses along these freeways are working in allowing bobcats to cross these barriers safely and breed. Lyren et al (2008) found a collared male bobcat made regular use of the corridor west of Interstate 5, but did not cross under the freeway. Camera stations at other locations west of Interstate 5 also detected bobcat on a few occasions in their study. Bobcat use of the corridor area west of Interstate 5 appears to have declined in the ten years since their study, with increasing urbanization of the area.

Similar to the patterns found with the bobcat, a Greater Roadrunner was photographed on two separate days at camera A-8, at the far western end of the corridor at Lake Forest Drive. No roadrunners were detected at interior portions of the corridor. Greater Roadrunner has long been recognized as a fragmentation sensitive species that disappears from small isolated fragments in southern California (Soulé et al 1988). Likewise, California Quail, another fragmentation sensitive species, were only detected at the far eastern end of the corridor adjacent to the El Toro Conservation Area.

<u>Proposed Modifications To The Corridor To Improve Movement</u>

One major finding of the camera study is that human use of the corridor encompasses all underpasses and is significant and continuous. Planting of dense or thorny vegetation including native cacti, quail bush (*Atriplex* spp.), or California boxthorn (*Lycium californicum*) near underpasses and in unauthorized trails would have the effect of both discouraging human use of the area, while also providing native habitat. One method that is used to prevent human intrusion into abandoned mines is the placement of iron or steel gates on the front of the mines, with slots large enough for wildlife to pass through. Similarly, gates could be placed on selected underpasses with significant human usage, at least seasonally in the dry seasons.

Installing fencing along the boundaries of the open space corridors would serve the dual purpose of inhibiting human use of the drainages while also discouraging wildlife from straying onto the adjacent roadways where they might be struck by vehicles. Several of the underpasses and culverts are located upslope on the sides of drainages or are obscured by vegetation, making them difficult to find and use by wildlife. Fencing would help redirect wildlife utilizing the corridor to stay within the safer habitat in the drainages, rather than risking crossing the road network at grade.

Light pollution may also negatively affect the use of the corridor by highly nocturnal animals such as bobcats. Efforts to identify night lighting spilling into the corridor and to contact landowners to install shielded lighting would encourage use by nocturnal animals.

Newly developed techniques for encouraging smaller mammals and those discouraged by standing water to use undercrossings include "critter shelves" and rodent tubes. Critter shelves consist of elevated metal grates attached to the upper sides of culverts for wildlife to use as runways through the culvert to avoid predators as well as thick mud and standing water at the base of the culvert. Both bobcat and gray fox would likely make higher use of undercrossings that were outfitted with critter shelves, as this would remove some of the vulnerability to coyote predation. Rodent tubes are long pipes, often attached to the underside of the critter shelves, which allow small mammals, mustelid (*i.e.* weasels), and reptiles to cross open areas of the culvert while feeling protected from predators. These techniques have been shown to encourage a suite of small and mid-sized animals such as rodents, cats, mustelids, and others to use undercrossings that they had previously avoided (Shea 2018, Foresman 2006).

One major challenge for the long-term function of a wildlife corridor in the study area will be making the Interstate 5 underpass and diversionary tunnel functional for multiple species to cross. The extreme length of the tunnel, lack of cover or elevated structures to hide from predators, intensive human use of the tunnel, and potentially the extreme darkness in the middle of the tunnel all pose challenges. Experimenting with various modifications and monitoring wildlife responses to these will be essential to finding effective solutions to overcoming this barrier. Further site specific recommendations to improve undercrossing usage are listed in Table 3.

Table 3. Recommendations for Improving Key Undercrossings.

Site	Recommendations
Lake Forest Drive	Extensive rip-rap likely discourages some animals from approaching underpass, should be covered with soil. Vegetation cleared around bridge likely discourages some species from crossing.
Irvine Center Drive	Fencing needed to encourage mammals to use existing underpass. Temporary dry season fencing in channel north of road would divert animals into side channel towards corridor and out of dead-end main channel.
Research Drive	Underpass entrances somewhat hidden on slopes and in dense vegetation. Fencing needed to encourage animals to use existing underpasses, and prevent roadkill. Planting of cacti and thorny shrubs would discourage human use of underpasses.
Interstate 5/Diversionary Tunnel	Plant cacti and thorny shrubs to discourage human use. Fencing needed to encourage animals to use existing underpass. Install "critter shelves" and rodent tubes for small mammals. Dry season temporary fencing in the underpass would help divert animals into side channel towards corridor. Experiment with paint colors and/or light sources to increase ambient light in tunnel

CONCLUSION

This study is the first to quantify the activity and movement of a wide assortment of wildlife species and humans across the entire breadth of the Irvine Spectrum Wildlife Corridor. Human activity was found to be a pervasive issue, and one that negatively affects the function of the corridor for wildlife movement. The Irvine Spectrum Wildlife Corridor does not currently allow for the movement of fragmentation sensitive birds and mammals between the San Joaquin Hills and the Santa Ana Mountains. However, several low cost and relatively simple modifications to the corridor network, including resurfacing the entrances to underpasses, installing fencing to guide wildlife movement, installing fencing, gates, and thorny vegetation to discourage human use, and installing critter shelves and rodent tubes for smaller wildlife species should all be experimented with to test whether they improve animal movement. After such significant investment and management to create the Central/Coastal MSCP/HCP and protect over 22,000 acres of the San Joaquin Hills, facilitating wildlife movement to and from this protected area will ensure that the biodiversity it protects is not degraded over time.

REFERENCES

Clark, K. B. 2007. Resource Management Plan, El Toro Habitat Preserve, Orange County, CA. Prepared for The Nature Reserve of Orange County, Irvine, CA. Funding provided by The California Department of Fish and Game. 71 pp. + app.

Clark, K. B. 2011. Fragmentation Effects on Vegetation and Resulting Vertebrate Species Distributions in the Sonoran Desert. Journal of the Arizona-Nevada Academy of Sciences. 42(2):84-91.

Clark, K.B. 2013. El Toro Conservation Area Post-fire Assessment. Prepared for The Nature Reserve of Orange County. Published by the San Diego Natural History Museum. 188 pp.

Fedriani, J.M., T.K. Fuller, R.M. Sauvajot, and E.C. York. 2000. Competition and intraguild predation among three sympatric carnivores Oecologia125: 258–270.

Foresman, K. 2006. How Does the Small Mammal Cross the Road? Montana Outdoors (July–August): 23-25. http://fwp.mt.gov/mtoutdoors/HTML/articles/2006/crossings.htm

Forman, R.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R.L., Heanue, K., Goldman, C.R. and Jones, J. 2003. Road Ecology: Science and Solutions. Island press.

Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D. and Cook, W.M. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science advances, 1(2), p.e1500052.

Hilty, J.A., Lidicker Jr, W.Z. and Merenlender, A., 2012. Corridor ecology: the science and practice of linking landscapes for biodiversity conservation. Island Press.

Lee, J.S., Ruell, E.W., Boydston, E.E., Lyren, L.M., Alonso, R.S., Troyer, J.L., Crooks, K.R. and Vandewoude, S. 2012. Gene flow and pathogen transmission among bobcats (*Lynx rufus*) in a fragmented urban landscape. Molecular Ecology 21(7): 1617-1631.

Lyren, L.M., Alonso, R.S., Crooks, K.R. and Boydston, E.E., 2008. Evaluation of functional connectivity for bobcats and coyotes across the former El Toro Marine Base, Orange County, California. Administrative Report. 179 pp.

Nogeire, T.M., Davis, F.W., Crooks, K.R., McRae, B.H., Lyren, L.M. and Boydston, E.E., 2015. Can orchards help connect Mediterranean ecosystems? Animal movement data Alter conservation priorities. The American Midland Naturalist, 174(1): 105-116.

Ordeñana, M.A., Crooks, K.R., Boydston, E.E., Fisher, R.N., Lyren, L.M., Siudyla, S., Haas, C.D., Harris, S., Hathaway, S.A., Turschak, G.M. and Miles, A.K.. 2010. Effects of urbanization on carnivore species distribution and richness. Journal of Mammalogy 91(6): 1322-1331.

Poessel, S.A., Burdett, C.L., Boydston, E.E., Lyren, L.M., Alonso, R.S., Fisher, R.N. and Crooks, K.R., 2014. Roads influence movement and home ranges of a fragmentation-sensitive carnivore, the bobcat, in an urban landscape. Biological Conservation 180: 224-232.

Riley, S.P., Sauvajot, R.M., Fuller, T.K., York, E.C., Kamradt, D.A., Bromley, C. and Wayne, R.K. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. Conservation Biology 17(2): 566-576.

Riley, S.P., Bromley, C., Poppenga, R.H., Uzal, F.A., Whited, L. and Sauvajot, R.M. 2007. Anticoagulant exposure and notoedric mange in bobcats and mountain lions in urban southern California. The Journal of Wildlife Management 71(6): 1874-1884.

Serieys, L.E., Lea, A.J., Epeldegui, M., Armenta, T.C., Moriarty, J., VandeWoude, S., Carver, S., Foley, J., Wayne, R.K., Riley, S.P. and Uittenbogaart, C.H. 2018. Urbanization and anticoagulant poisons promote immune dysfunction in bobcats. Proceedings of the Royal Society B: Biological Sciences 285: 20172533.

Shea, S. 2018. How did the bobcat cross the road? Natural History (November): 28-33.

Soulé, M.E., Bolger, D.T., Alberts, A.C., Wrights, J., Sorice, M. and Hill, S. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. Conservation Biology 2(1): 75-92.