Wildlife Use of the Los Piñetos Underpass Santa Clarita, California

Robert Freidin
Diane Schreck
Brooke Scruggs
Elise Shulman
Alissa Swauger
Allison Tashnek

Advisors
Dr. Travis Longcore (UCLA)
Dr. Erin Boydston (U.S. Geological Survey)

June 2011
UCLA Institute of the Environment and Sustainability
Environment 180 – Senior Practicum in Environmental Science
Client: Mountains Recreation and Conservation Authority

Table of Contents

Abstract

Corridors between fragmented habitats are critical to the maintenance of certain wildlife populations, especially those of larger, terrestrial mammalian carnivores. Commercial development is being considered in the small wedge of land between Sierra Highway and State Route (SR) 14. The Los Piñetos underpass is currently a corridor under SR 14 that provides a connection between Mountains Recreation and Conservation Authority (MRCA) and City of Santa Clarita protected land and this site. Beyond this wedge is a habitat connection to the Los Padres National Forest, which makes the Los Piñetos underpass the most likely connection between two regionally significant blocks of protected habitat. To document wildlife use of this underpass, we installed ten remotely triggered cameras, in stages, over two months around this area. We installed seven cameras near and under the underpass, and three cameras as controls up to 1 km from the underpass, in protected lands. Following 429 trap-nights, our photographs showed use of the area by coyote (*Canis latrans*), mule deer (*Odocoileus hemionus*), bobcat (*Lynx rufus*), striped skunk (*Mephitis mephitis*), Audubon's cottontail (*Sylvilagus audubonii*), California ground squirrel (*Otospermophilus beecheyi*), gray fox (*Urocyon cinereoargenteus),* and American badger (*Taxidea taxus*). The cameras along the road also captured human and vehicle activity, which we found to statistically differ temporally from that of the wildlife. We also produced data on species accumulation over time, relative activity of coyotes, and directionality of underpass use. Geographically, we found that animals traveling southeast via the underpass are veering toward an area of proposed development, and that the corridor location suggested by project proponents may not be in the area where animals are traveling, although further research on the proposed development parcel is warranted.

Introduction

Boasting high rates of endemic flora and fauna, the Mediterranean ecosystem of Southern California is a globally important center of biodiversity. Increasing development in California has had deleterious effects on wildlife endemic to this ecosystem. One serious problem that can arise from human development is roads, especially those with high traffic volumes. It is estimated that one-fifth of the U.S. land area is directly affected ecologically by the system of public roads (Forman 2000; Riitters and Wickham 2003). These roads cause animal mortality, affect the movement and dispersal of species, and threaten wildlife population stability (Grilo et al. 2008). Development also leads to habitat fragmentation, where structures such as housing developments and highways can sever an animal's contiguous home range into fragments, restrict the movement of animals from one fragment to another, and endanger a species' viability. Carnivores can be considered most affected by habitat fragmentation due to their low population densities, low fecundity, and large home range requirements (Ng et al. 2004). Possible mitigation includes creating corridors connecting fragmented habitat and modifying underpasses or culverts to provide wildlife with alternative means to cross streets and highways.

Although there are numerous patches of land protected by the National Forest Service, State conservation agencies, and other conservation organizations, singular patches of protected land do not always meet the ecological needs of all indigenous animals. Certain existing structures such as highway underpasses, however, can serve as pathways for animals seeking to move from one fragmented habitat to another; playing an important role in the conservation of species, particularly large mammals (Long et al. 2010; Tigas et al. 2002). To mitigate effects of habitat fragmentation, it is necessary to be aware of species presence and behavior in areas of interest. In this study, we monitored mammalian species using remotely triggered cameras to determine wildlife presence and behavioral patterns close to and away from human activity. We also studied wildlife use of a large underpass below a busy Southern California freeway to document use of this potentially important corridor.

The Los Piñetos Underpass of SR 14 plays a significant role in conservation based on its use by native animals. Most importantly, the underpass provides a link between the two protected wildlands in the area. The underpass should allow animals to move from the protected land owned by the Mountains Recreation and Conservation Authority (MRCA) to the nearby protected open space dedication from the Gate-King development. The area to the west of the underpass is under consideration for commercial development and a corridor may be necessary for animals to continue crossing from one protected area to another, especially if the area in between these protected lands is developed.

This project provides added insight to the relationship between development and wildlife activity, especially as it relates to use of corridors in fragmented areas. Ng et al (2004) found a significant negative relationship between use of corridors and development. Other research concludes that wildlife accessibility to habitat will only get worse in the future as landscape permeability, the ability of wildlife to make their way through the landscape, decreases (Morrison and Boyce 2009). Other effects of increased human activity include changes in temporal activity of wildlife, shifting their peak hours of activity away from their natural activity times seen away from human disturbance (Kitchen et al. 2000). The information gathered in this project could have a significant impact on determining what area is developed and where a potential wildlife corridor is established.

The general area is home to important native mammals including mountain lion (*Puma concolor*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), mule deer (*Odocoileus hemionus),* common gray fox (*Urocyon cinereoargenteus*), common raccoon (*Procyon lotor*), western spotted skunk (*Spilogale gracilis*), striped skunk (*Mephitis mephitis*), and American badger (*Taxidea taxus*) (Whitaker 1996). The availability of large swaths of land is particularly important for large mammalian carnivores to sustain their large home range requirements (Crooks 2002), thus California's large carnivores are especially at risk for habitat fragmentation. Medium-sized predators, such as bobcats and coyotes use medium-scale underpasses that are between 5 feet and 8 feet in height, which allows possible visibility through the underpass while still providing cover from predators (Spencer et al. 2010). Wildlife may not be able to cross to other habitats or may not want to exit out of their habitat, and wildlife attempting to cross to other habitats are at risk for coming into contact with humans, with potentially fatal outcomes such as road kill.

Fragmentation is not the only threat human activity poses to wildlife. Existing habitat that is not fragmented may not always be suitable and may not be in pristine condition. Although the study site consists mostly of protected land areas, it contains evidence of littering, dumping, and other degradation of habitat. As with many protected land areas, the study area has much human activity in the form of recreational use. This human activity can disturb wildlife causing them to alter their temporal, spatial, or behavioral patterns. Markovchick-Nicholls et al. (2008) conclude that the lack of other negative correlations between animal presence and human disturbances may be due to a level of "urban adaption," as smaller mammals and herbivores, such as raccoon, coyote, and deer, have adapted to moderate levels of disturbance, enabling these species to utilize greater amounts of fragmented habitats despite moderate human presence and disturbance. Nonetheless, coyotes still prefer natural and undisturbed areas when available and although they take advantage of urban and suburban areas, they still tend to avoid humans (Riley et al. 2003; Gehrt et al. 2009). The notion that bobcats are not adapted to most levels of human activity is consistent with Riley et al. (2003), who found high sensitivity of female bobcats to developed land; however, Tigas et al. (2002), also working in Southern California, found bobcats of both sexes in urban areas between fragments, suggesting a lower sensitivity to human activity. The presence of bobcats in urban areas could be due to lack of connectivity between fragments rather than a relative insensitivity to human development. Overall, researchers found that for many species, undercrossing proximity to substantial natural habitat positively affected wildlife use (Ng et al. 2004). McDonald and St. Clair (2004) also found that small mammals preferred to use corridors that were closer to home habitats.

Scientists and conservation groups in California developed the "South Coast Missing Linkages Project," which seeks to link together the most ecologically important land areas in Southern California, ensuring the viability of the native species Southern California supports (Penrod et al. 2001). One area of interest in the South Coast Missing Linkages Project is to maintain connections between the San Gabriel Mountain Range and the Castaic Range (Penrod et al. 2006). The Los Piñetos underpass of SR 14 is a potential link in the efforts to maintain connections between the aforementioned mountain ranges. Based on the findings of other wildlife corridor studies, the Los Piñetos underpass should be a suitable corridor for various species, and could provide a pathway through the wildland-urban interface between the San Gabriel Mountain Range and Castaic Range.

Our study site consists of the underpass and surrounding area at the intersection of Los Piñetos Road and SR 14 in Santa Clarita, California. This location is 53.1 km (33 miles) from

Los Angeles and is subject to development pressure from increasing urbanization. The underpass is directly between protected land area on one side and land at risk of development on the other side. This general area is of interest in a broader context to wildlife connectivity across Southern California.

For this study, we were successful in identifying species with the use of remotely triggered cameras. With this method, remotely triggered cameras observe wildlife without interrupting their lifestyle and allow researchers to examine the different habitat-use patterns of the animals (Karanth 1995; Hilty and Merenlender 2004; George and Crooks 2006). Cameras are a successful method of monitoring difficult to observe nocturnal wildlife such as carnivores because the camera is triggered by an infrared sensor (Cutler and Swann 1999; Kaufmann et al. 2007; Hilty and Merenlender 2004; George and Crooks 2006; Pettorelli et al. 2010). Remote sensor cameras are cost effective because they only need to be fixed in a specific location, and checked every few days and can be placed in various environments and climates (Cutler and Swann 1999; Pettorelli et al. 2010; Carbone et al. 2001). Our camera locations were based on the strategy of placement near trails and by vegetation food sources (Brown and Gehrt 2009). Many researchers prefer to use remotely triggered cameras because they are non-invasive, but some research suggests that wildlife can become trap-shy after repeated exposure to the camera's flash thereby decreasing the trap success rate and underestimating population size (Wegge et al. 2004, O'Connell et al. 2011).

In the sections that follow, we first discuss the research questions for this study. The methods include a detailed overview of the study site, a description of the remote camera sensors used, and a summary of the different camera locations and surveys done. We provide details on data management and methods of analysis in the methodology. We show the results of our analyses and describe what we observed occurring at the site. Lastly, the discussion section and conclusion will review the research questions and address any observations made.

Research Questions

Due its potential importance to regional conservation goals, our client, the Mountains Recreation and Conservation Authority (MRCA) needed more information on the Los Piñetos underpass. The primary goal was to discover what wildlife species were in the area and to determine what might be affected by the proposed development to the west of the underpass. The client also expressed a desire to use this study to provide information that would inform the location of a potential wildlife corridor across the proposed development, which would be used to mitigate the effects of the development and maintain connectivity for wildlife. With these goals in mind, we developed four research questions.

1. What animals are using the underpass? Based on our knowledge of species native to the site, which species are present in the area and which ones are using the underpass as a corridor?
2. Is animal activity affected by time of day, amount and time of human activity, and the amount and time of vehicle activity?
3. Does animal use of the underpass have directionality? Are animals more often heading eastward toward the MRCA protected land or westward toward the area of potential development?
4. Where do the animals go after they have crossed through the underpass and traveled into the potential development site? This information could help determine a location for a proposed wildlife corridor through the area once it is developed.

Methods

Study Site

Figure 1. A map of Los Piñetos Road and SR 14 in Santa Clarita, California.

The study site is located where Remsen Street meets Los Piñetos Road underneath SR 14 in Santa Clarita, California (Figure 1). Los Piñetos Road is a dirt road that runs through the Los Piñetos Underpass, a large open underpass measuring 56.1 m (184 ft) in length, 25 m (82 ft) in width, and a range of 6.1–7.6 m (20–25 ft) in height (Figure 2). At the beginning of the study, a closed but unlocked gate blocked vehicle entrance to Remsen Street off Sierra Highway. The gate was left unlocked and was capable of being opened by the public until March 17, 2011. Although we were not given access to open the lock until April 15, 2011, we were still able to access the underpass by foot.

Figure 2. Los Piñetos Road underpass under SR 14, 1.2 miles east of Interstate 5 in Santa Clarita, California.

MRCA protected open space lies on the northeastern side of the underpass while a protected open space newly acquired by the city of Santa Clarita lies on the southeastern side of the underpass (Figure 3). Both these areas have high levels of human recreation use including hiking, mountain biking, horseback riding, and some illegal activities such as dirt biking. Further east of the underpass is the western edge of Angeles National Forest. The area between Sierra Highway and the western side of the underpass is the site of the future Gate King development. Areas beyond Sierra Highway consist of a patchwork of MRCA property and other protected lands owned by the city of Santa Clarita and other entities.

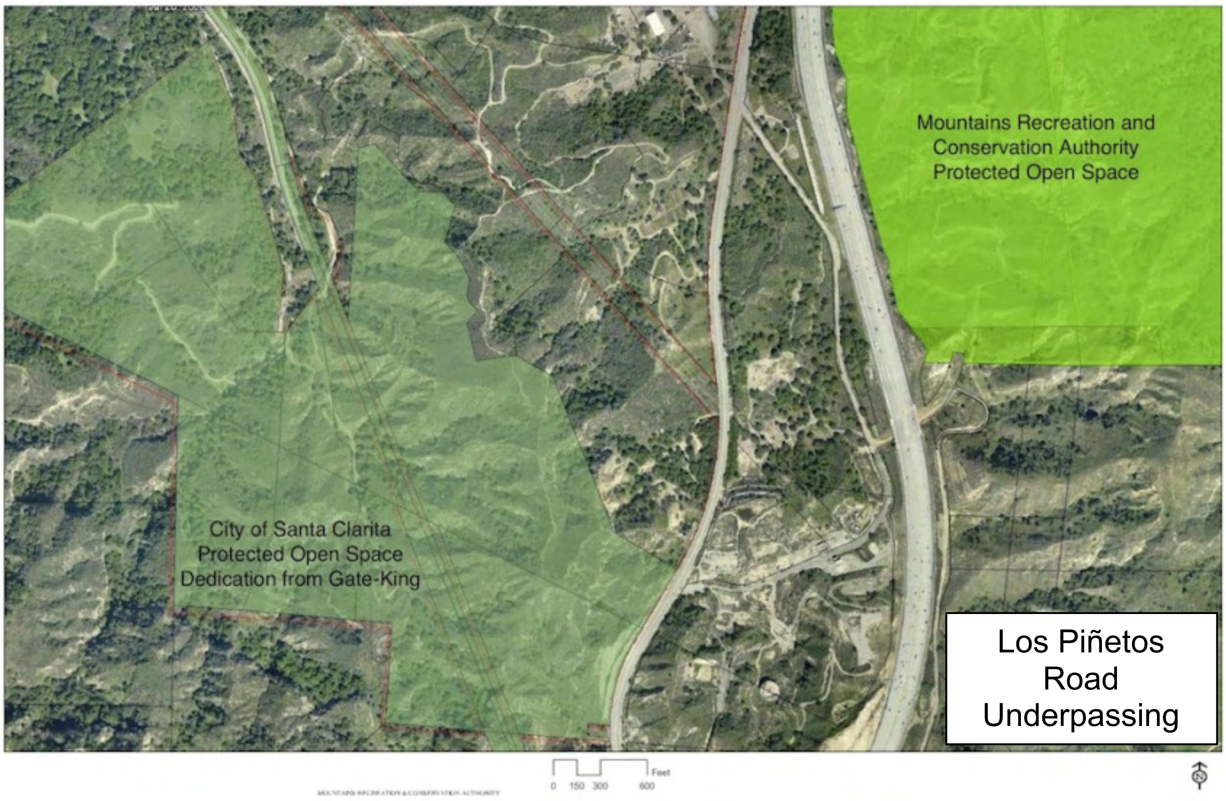


Figure 3. Protected lands (green) and potential development (in purple) surrounding the Los Piñetos underpass. Courtesy of Mountains Recreation and Conservation Authority (MRCA).

The area immediately west of the underpass is predominately covered in Coast Live Oak woodland with some grassland skirting Los Piñetos Road. The area in the underpass is mainly soft sand with sparse grasses and other low-lying vegetation. The area east of the underpass is a mix of grassland, coastal sage scrub, and chaparral with vegetation density increasing as distance from the underpass increases.

Remote Sensing Infrared Cameras

We chose to use remote sensing infrared cameras rather than using track pads because our study site was subjected to strong winds, rain, and periods of heavy construction vehicle traffic. Our research team installed ten Cuddeback Digital scouting cameras, in stages, over two months around this area. Five of the cameras were installed along Los Piñetos Road, the road that emerges from underneath the highway underpass. Two additional cameras were installed; one along Refinery Grapevine and one along Elsmere Canyon Road, the two roads that fork North and South onto the MRCA protected land. Further from the underpass, three additional cameras were placed approximately 20 meters off the road in locations we subjectively determined would be likely to be used by the local wildlife. The goal of placing the cameras further from the road was to get a baseline of animal activity in areas with less human impact.

We used the 3-megapixel Cuddeback Expert Digital Scouting Camera C3300 (Non Typical Inc., Park Falls, WI, USA). Cuddeback Expert Digital cameras have motion sensors that range from 6.09-30.48 m (20-100 ft.) depending on the surrounding air temperatures, with the motion sensor sensitivity decreasing with increasing temperature (Expert Owner's Manual). Each Cuddeback Expert Digital camera is equipped with a high performing strobe flash that illuminates up to 60 feet (Expert Owner's Manual). Date and time (Pacific Standard Time) are automatically imprinted on the bottom of every photograph and in the EXIF data on each image file.

Once our cameras were in place, identical settings were applied to each of the ten cameras. Every camera was set to "Automatic Flash", triggering the flash when necessary depending on the surrounding light intensity. All cameras were set to "All Day", allowing each camera to capture photographs twenty-four hours a day. The motion sensor was set to the highest sensitivity setting, ensuring the greatest detection distance. The cameras were set to "Live Mode," allowing the camera to capture photographs whenever activity triggered the motion sensor.

We mounted cameras on square metal posts that were placed in the ground in a north or south-facing orientation to avoid activating the remote sensor by the east-west path of the sun.

Square metal posts were three inches wide, hollow, with holes every two inches, and cut to approximately five feet. The metal posts were installed at least two feet into the ground using a fence post pounder. Protective metal camera boxes were then bolted onto the metal posts at approximately knee height. Cameras were each equipped with four D batteries and a 1 GB memory card using FAT32 format. Cameras were set to "Live Mode" then secured in metal camera boxes and padlocked to prevent theft and destruction of cameras (Figure 4). Once cameras were completely installed, GPS coordinates were taken at each camera site and used for data analysis.

Figure 4. Photograph of completed camera installation for Camera F3 (Photograph: T. Longcore).

Camera Locations

We conducted a pilot experiment to determine where animal movement was occurring in the Los Piñetos underpass. The pilot experiment included raking the underpass to remove any previous tracks of wildlife, humans or vehicles from the ground. After four days, we revisited the site and took note of the general direction and location in which wildlife tracks appeared. We found that animals traveled most frequently on the dirt road in the underpass. The soft soil type present in the underpass did not allow for many distinct prints, but we were able to identify coyote and bobcat prints. We also analyzed tracks along Los Piñetos Road to get a rough estimate of the different species that may be present.

Due to permitting issues, we installed cameras in stages in the surrounding area concluding with installation of cameras in the underpass:

Installation 1: The first installation consisted of four cameras immediately east of the underpass, with distances ranging from 60–260 m from the center of the underpass in an attempt to determine what was present around the underpass as well as the directionality of underpass usage by wildlife. Based on the expert opinion of our project consultant, Dr. Erin Boydston of the USGS, and analysis of animal prints and scat, we determined the most probable wildlife paths. We concluded that wildlife was following the most obvious, accessible paths; that is, the roads both dirt and paved, and shallow ravines or gullies.

Installation 2: Our second installation consisted of three cameras 0.75–1.82 km from the center of the underpass to get a baseline of animal activity away from human activity. These three cameras were placed at least 20 m from the dirt roads to minimize the effect human activity may have on wildlife activity.

Installation 3: The third installation placed two cameras in the underpass to capture any wildlife activity within the underpass. The third camera in this installation was placed on the west side of the underpass where Los Piñetos Road meets Remsen Road. The placement of this camera was to observe the directionality of wildlife after they exit the underpass towards the future development site. These cameras were permitted by CalTrans permit number 711-NSV-0480 to the MRCA.

Table 1. Information about installation and operation dates of remotely triggered cameras.

Installation 1				
Camera Serial	**Camera Alias**	**Camera Location**	**Capture Dates**	**Additional Notes**
X39771	C1	• East of underpass • 60.25 m from center of underpass • >1 m from dirt road • Facing southwest	3/6/11 – 5/19/11	
X38692	C2	• East of underpass • 61.61 m from center of underpass • >1 m from dirt road • Facing northeast.	3/6/11 – 4/25/11 and 5/5/11 – 5/19/11	Original memory card corrupted on 4/25/11. Replaced on 5/5/11
SX10725	C3	• East of underpass • 202.71 m from center of underpass • >1 m from dirt road • Facing southeast.	3/6/11 – 5/19/11	
X39030	C4	• East of underpass • 257.94 m from center of underpass • >1 m from dirt road • Facing southeast.	3/6/11 – 5/19/11	
Installation 2				
X13686	F1	• East of underpass • 736.65 m from center of underpass • 125.77 m from dirt	4/18/11 – 5/19/11	

		road • Facing southeast.		
X38774	F2	• East of underpass • 1.08 km from center of underpass • 56.38 m from dirt road • Facing northwest	4/9/11 – 5/19/11	
X38705	F3	• East of underpass • 1.82 km from center of underpass • 20.11 m from dirt road • Facing northeast	4/9/11 – 5/9/11	Camera not set to "Live Mode" after captures collected on 5/9/2011
Installation 3				
X38686	U1	• West of underpass • 75.61 m from center of underpass • >1 m from dirt road • Facing northwest	5/5/11 – 5/19/11	
X40944	U2	• In underpass • 25.61 meters from center of underpass • >1 m from dirt road • Facing northwest	5/5/11 – 5/19/11	
X14274	U3	• In underpass • 24.46 m from center of underpass • 14.27 m from dirt road • Facing southeast	5/5/11 – 5/19/11	

Figure 5. Location of ten remotely triggered cameras at and around the Los Piñetos underpass.

Data Collection and Management

Weekly field visits were necessary to collect photograph captures, check battery levels, check memory card status, and to remove any plant growth around the camera that could cause false triggers. Photographs were downloaded from each camera on site using a memory card reader and laptop computer.

We used the file storage and synchronizing service Dropbox to manage images. Dropbox is able to replicate a folder structure over any set number of computers with an Internet connection and is cross-platform as well. To sync the latest camera photographs, a folder for each weekly visit was created and photograph captures were organized into individual sub-folders according to each camera.

To analyze the data in any remote-sensing camera project, there needs to be a method for saving the details of each image to a database for further analysis. We used CameraBase 1.4, a program that pulls time and date information from a digital image (also referred to as EXIF data) and allows the user to add more attributes to a file such as camera location, species, sex, etc. These attributes are saved to a Microsoft Access database, which can then be manipulated through use of a pivot table or exported in a number of formats for further statistical analysis. Each camera was labeled in CameraBase by its own serial number along with a description of the location surrounding it.

Data Analysis

Once all the data were stored in CameraBase, the data were sorted by species, which involved going through each picture and labeling the picture with a species ID. As researchers, multiple pictures were taken of us whenever we visited the site to retrieve data. To control for this skewed representation of human activity, we created a method to account for repetitive pictures that would have implied a higher level of human activity than actually occurred. We disregarded human activity occurring at a single camera within ten minutes of previous human activity. By applying this methodology we removed 9.5% of our total data points and allowed for a more accurate comparison of anthropogenic activity to other wildlife in the area. We then created an updated data sheet that was used for all other activity analysis.

Results

We collected a total of 1890 images at all cameras combined (Table 2). Surveillance continued for 74 days from March 6 to May 19, 2011 with a total of 429 trap nights. The resulting photographs showed use of the area by coyote, deer, bobcat, striped skunk, rabbit, gray fox, squirrel, badger, humans, and vehicles.

Figure 6. In clockwise order from top-left: Coyote, American Badger, Bobcat Kitten, Mule Deer, Mule Deer, Bobcat

Figure 7. In clockwise order from top-left: Striped Skunk, Striped Skunk, Coyote, Gray Fox, Bobcat, Coyote

Table 2: Raw Camera Trigger Totals

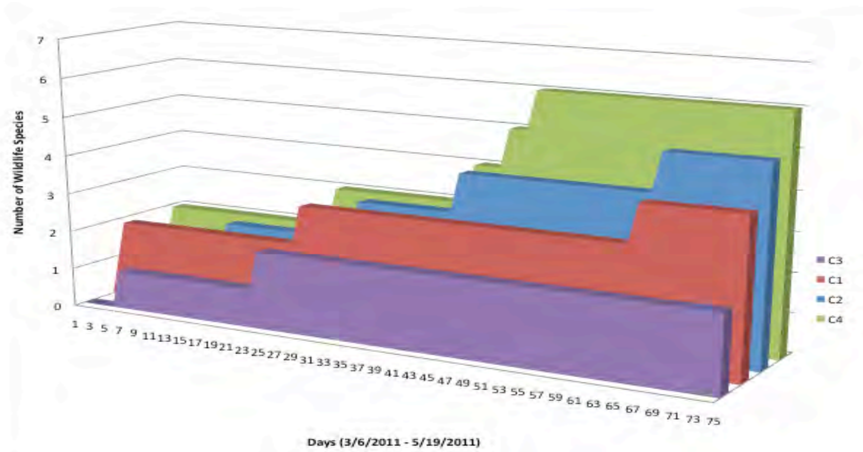
Species	**Trigger Total**
False Triggers	666
Vehicles	424
Coyote	329
Research	180
People	118
Multiple People	58
Bobcat	27
People with Bikes	20
Deer	15
Striped Skunk	12
Unknown	11
People with Dogs	7
Audubon's Cottontail	5
Dogs	4
Squirrel	3
People with Horse	3
Multiple Coyote	2
Crow	2
American Badger	2
Multiple Deer	1
Gray Fox	1
Grand Total	1890

Wildlife Activity in Surrounding Area

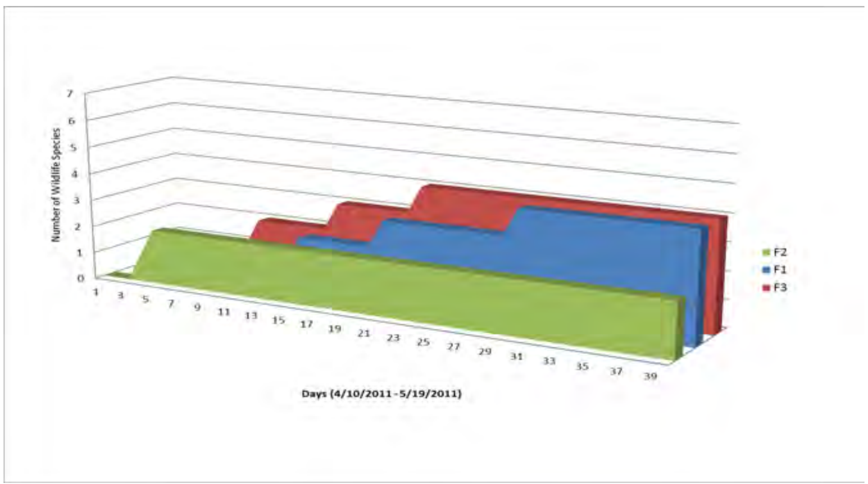
More species were caught in the Close (C) and Far (F) cameras surrounding the underpass than in the underpass itself due to the longer trap night duration of the C and F camera series. We caught various species at the C and F camera sets, but only caught coyote and American badger using the underpass (Table 3). Of all wildlife species, coyote relative activity was highest in all locations (Figure 7).

Table 3. Species photographed at cameras near (Close), distant (Far), and in the Los Piñetos underpass (Underpass) and associated number of trap nights.

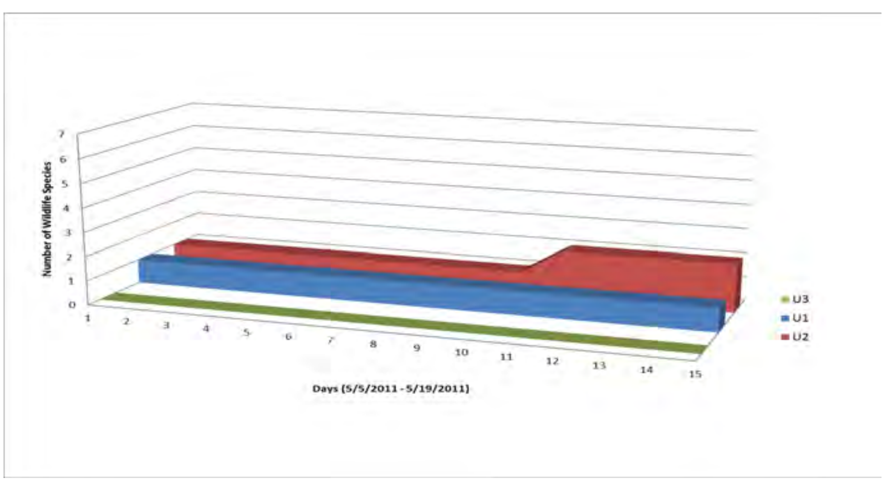
Species	**Close**	**Far**	**Underpass**
Number of Trap Nights	*286*	*101*	*42*
Coyote	X	X	X
Mule Deer	X	X	
Bobcat	X	X	
Striped Skunk	X	X	
California Ground Squirrel	X		
Audubon's Cottontail	X	X	
Gray Fox		X	
American Badger			X



a)



b)



c)

Figure 8a-c. Species Accumulation Charts. Chart shows the number of trap nights it took each camera in the Close (C) (6a), Far (F) (6b), and Underpass (U) (6c) camera series to capture new species.

The F cameras caught a maximum amount of four different species. The F camera series was active for only 101 trap nights, but F3 reached four species in 20 days and F2 reached four species in 28 days (Figure 8b). Within the C camera series, which was active for 286 trap nights, C4 reached four species in 41 days, C2 in 42 days, and C1 in 64 days (Figure 8a). The C camera series reached a maximum threshold of six species. The U camera series reached a maximum of two species (Figure 8c), but were only deployed for 15 days. Both the U and C camera series accumulated at least two species within fifteen trap nights. One camera of the F series reached three species within fifteen trap nights.

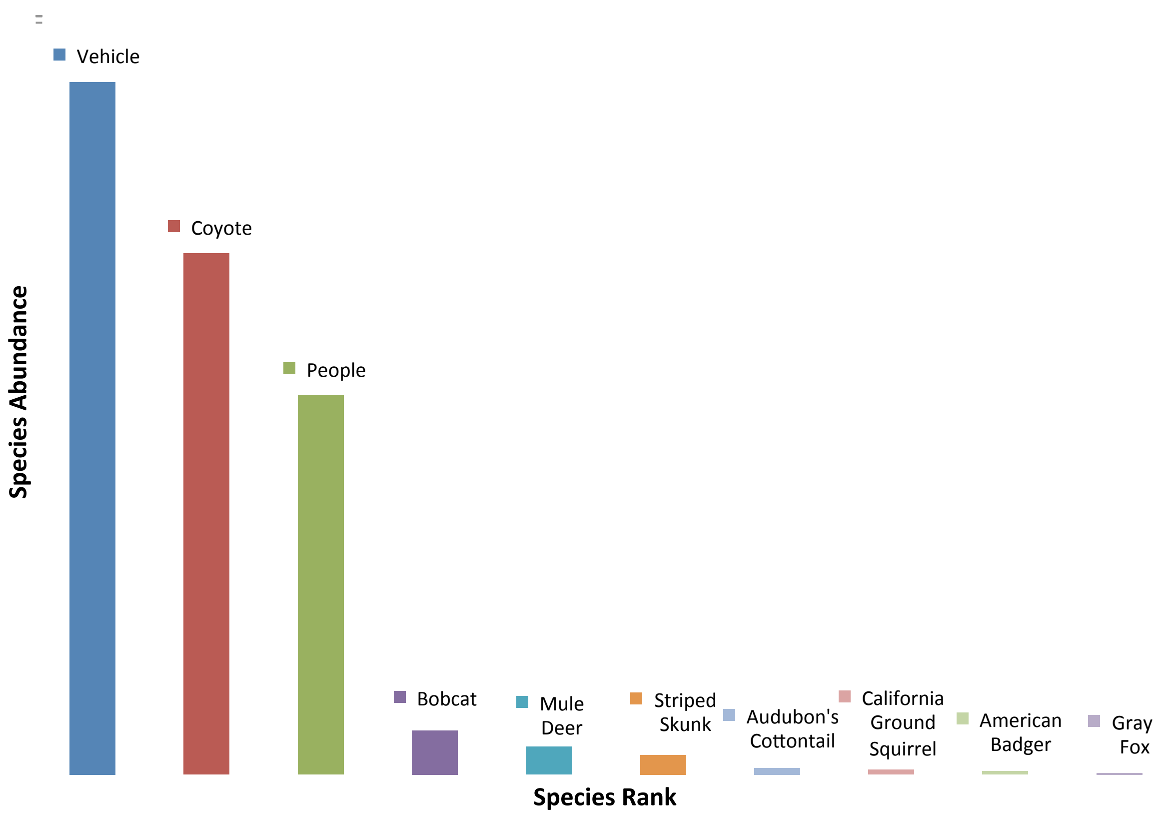


Figure 9. Species Rank Abundance. Species are ranked by prevalence then graphed according to abundance (captures of individual species/total captures of total species).

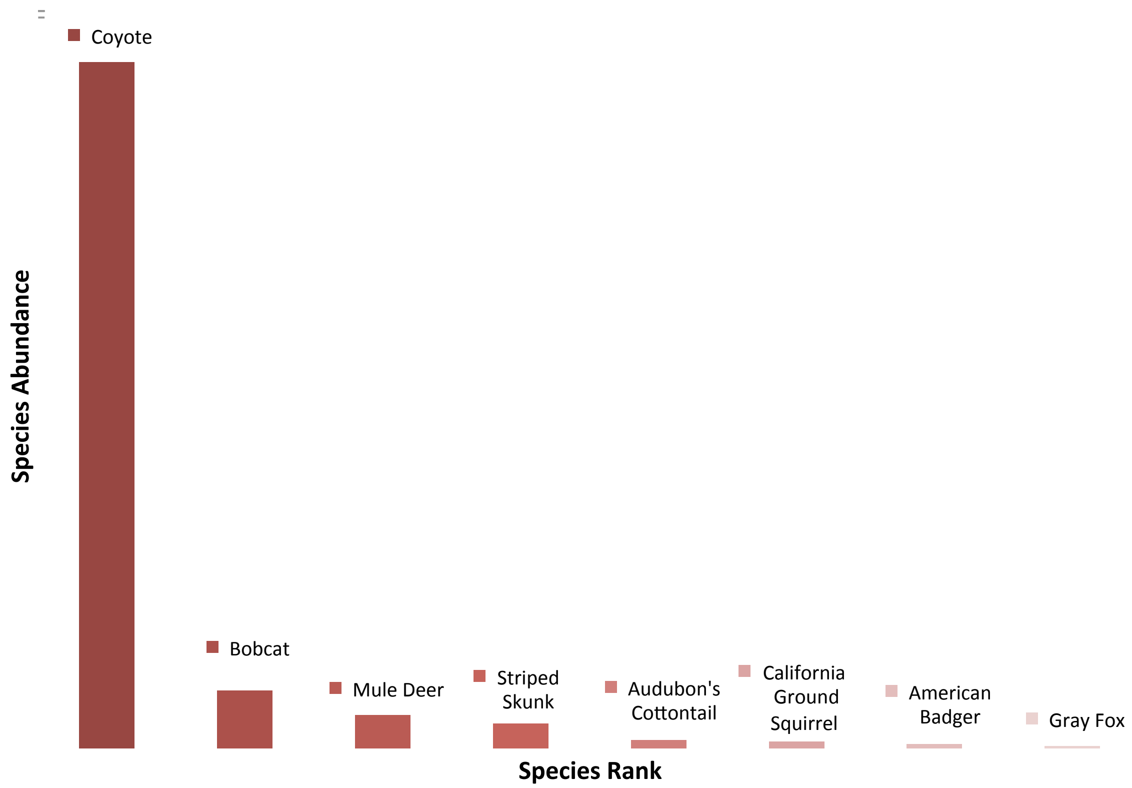


Figure 10. Species Rank Abundance for wildlife only.

The species rank abundance shows a clear representation of which animals had a higher number of triggers than others (Figure 9 and Figure 10). The graphs were calculated by taking the total number of triggers of all species and dividing by the individual total for a particular species. When comparing rank abundance with anthropogenic influences, such as vehicles and people, all wildlife except coyote is considerably less abundant (Figure 9). If only wildlife is compared, coyote is still most prominent, but many of the other species were found at similar rates of abundance (Figure 10). From these graphs it is clear that coyotes were the most prevalent wildlife species in our study area with over 80% of the wildlife triggers and about half as many triggers as all of the people and vehicle triggers combined.

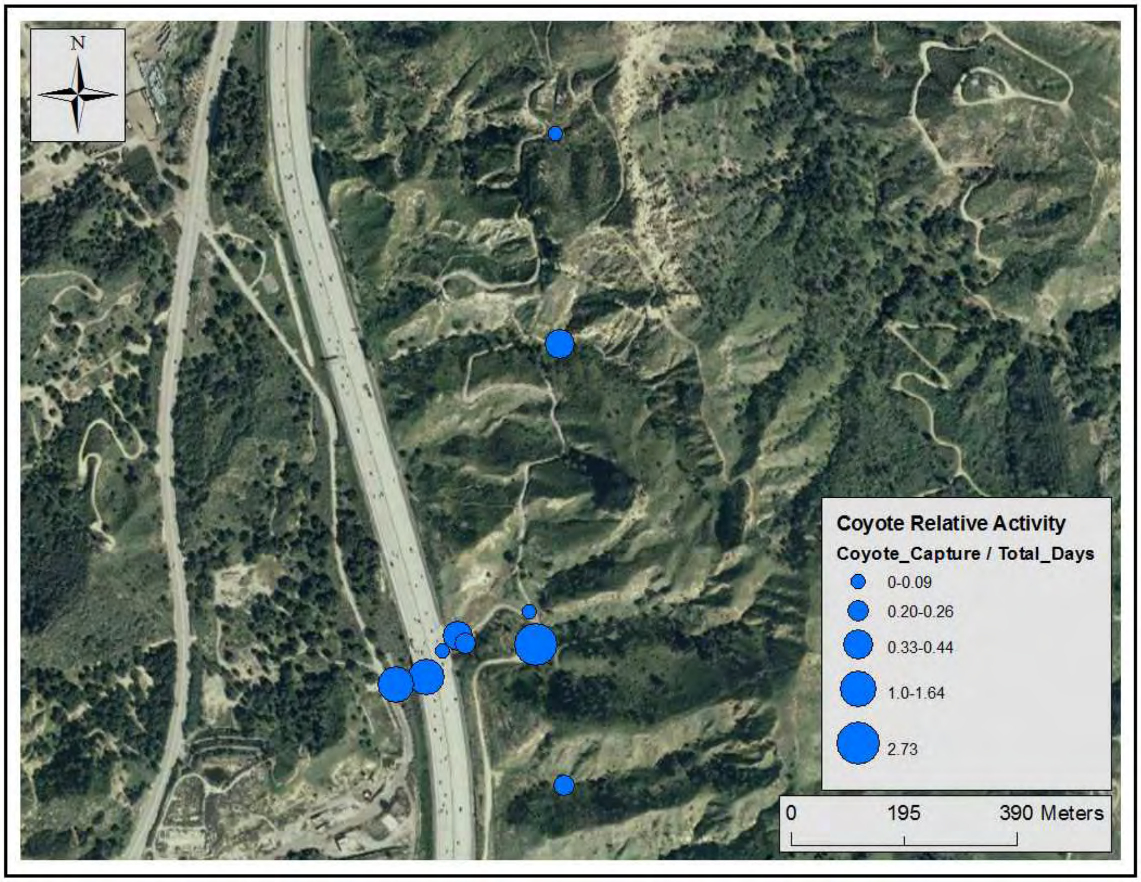


Figure 11. Map of coyote relative activity (total coyote captures per camera/trap nights per camera).

To show the spatial activity patterns of wildlife species, relative activity was calculated for the three most detected species: coyote, bobcat, and mule deer (

Table 2). Relative activity was estimated for each camera trap by calculating the number of images captured of each individual species divided by the number of trap nights (George and Crooks 2006). Although number of trap nights per camera differed among the ten cameras, relative activity is represented as a percentage of species captures specific to each camera.

Coyote activity was most frequent along Los Piñetos Road, with cameras U1 and U2 achieving an average of at least one coyote per trap night, camera C1 capturing an average of at least one coyote every 2.3 trap nights, and camera C4 capturing an average of over two coyotes per trap night (Figure 9).

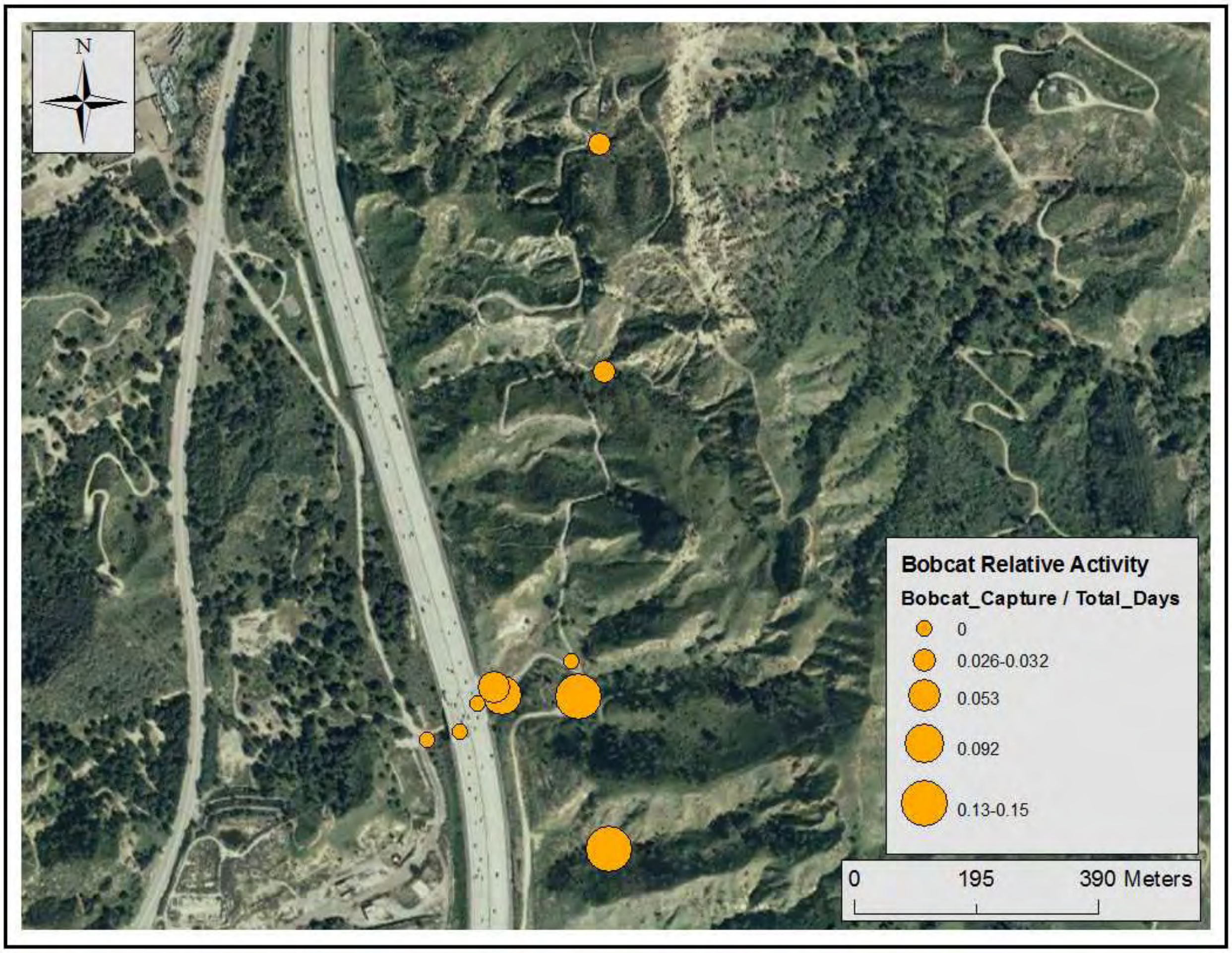


Figure 12. Map showing bobcat relative activity (total bobcat captures per camera/total trap nights per camera).

Bobcat activity was also most frequent along Los Piñetos Road, with camera C1 and C2 capturing an average of one bobcat per 18.8 trap nights and 10.8 trap nights respectfully, and camera C4 capturing an average of one bobcat per 6.8 trap nights (Figure 12). None of the U cameras captured any bobcat images, but the shorter duration of trap nights may account for this. Although the F cameras were further away from human activity, only F1 had frequent bobcat activity with an average of one bobcat every 7.5 trap nights (Figure 12).

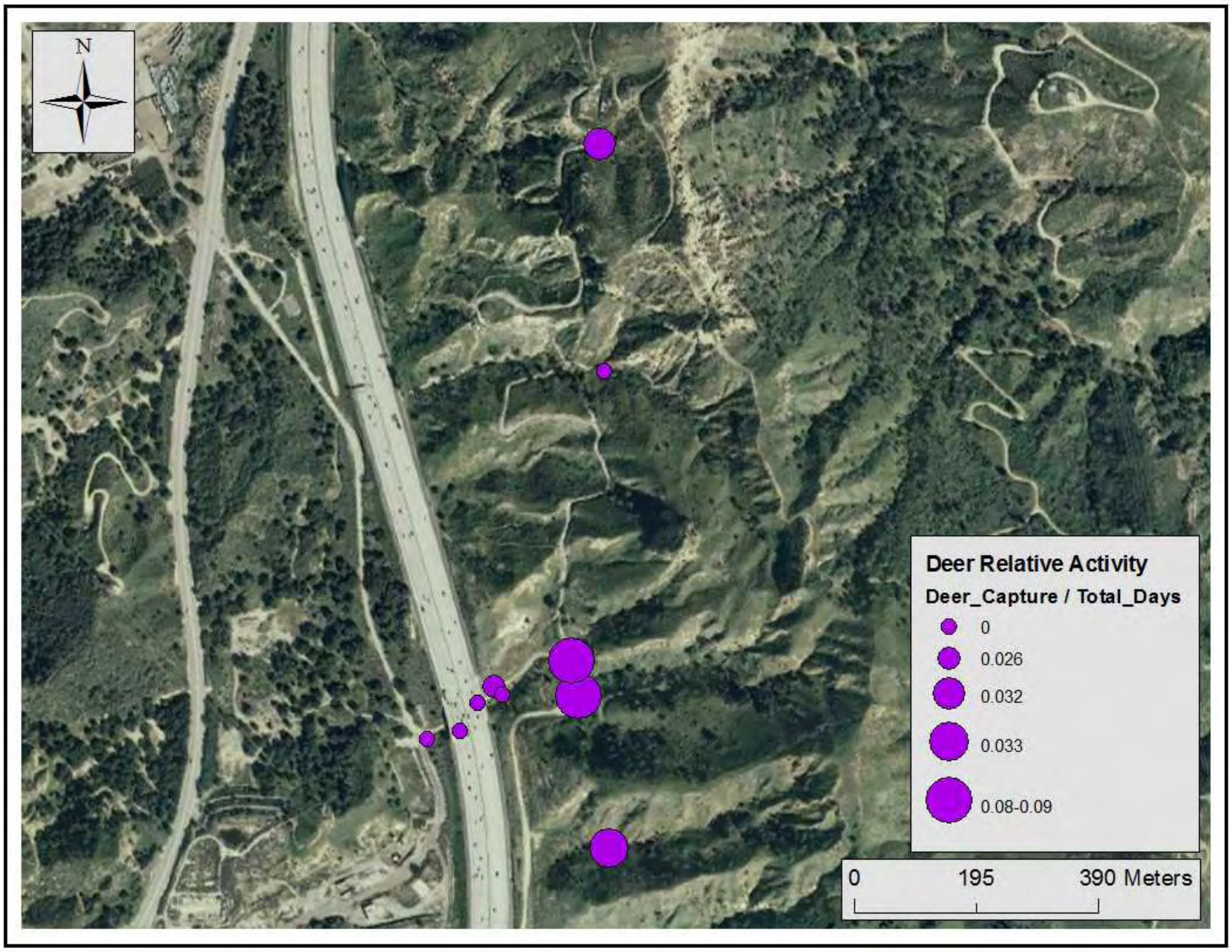


Figure 13. Map showing mule deer relative activity (total mule deer captures per camera/total trap nights per camera.)

Mule deer activity differed from coyote and bobcat activity in that mule deer activity was more frequent at the farthest C cameras and not along Los Piñetos Road (Figure 13). Cameras C3 and C4 captured an average of one mule deer per 12.5 trap nights and 10.7 trap nights respectively, whereas C2 did not capture any mule deer (Figure 13).

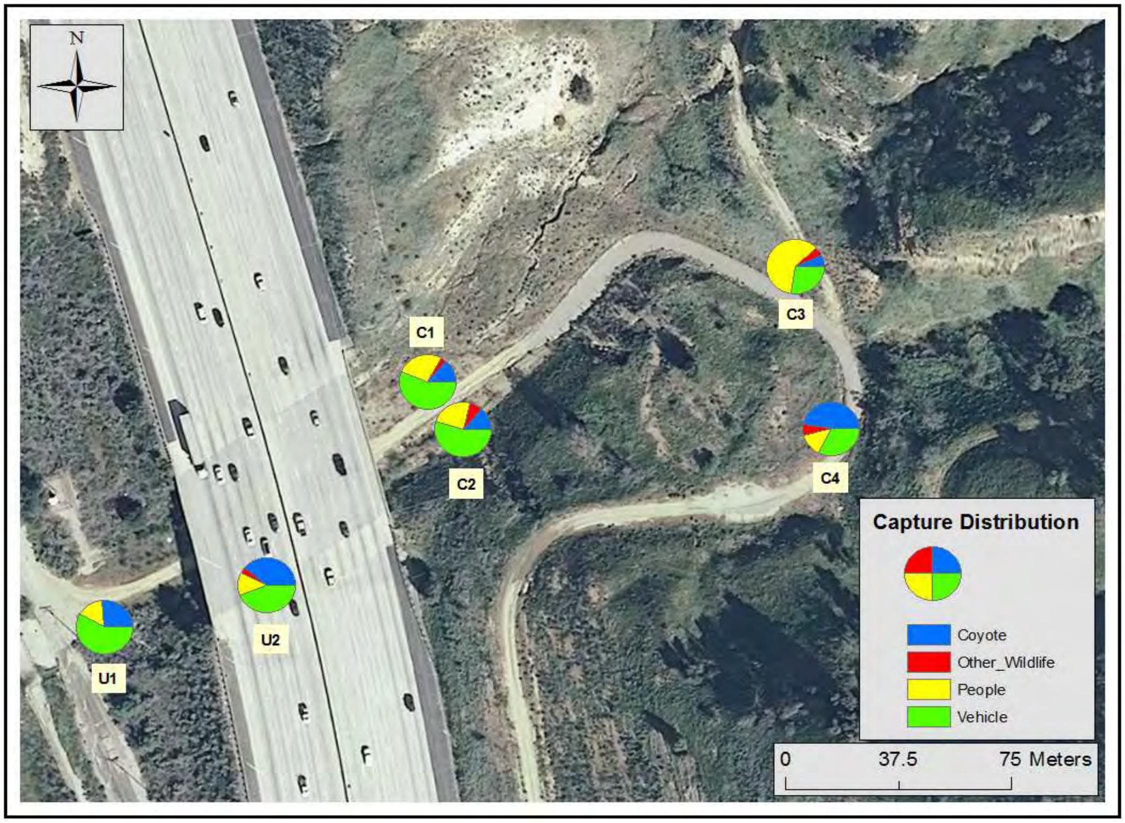


Figure 14. Map showing the distribution of coyote, people, vehicle, and other wildlife photographic captures for cameras U1, U2, C1, C2, C3, and C4.

To understand relative use of the study site, we determined the distribution of coyote, people, vehicles and other wildlife, which included all species except coyote (Figure 14). Due to their location away from human activity, the F camera series did not capture humans or vehicles, while the U and C camera series did. Of the six cameras, C2 and C4 caught the greatest proportion of activity by other wildlife. Vehicles dominated the distribution of the four cameras closest to the underpass: U1, U2, C1 and C2. People were captured at all U and C cameras, and were captured more frequently than coyotes and other wildlife combined at half of the cameras. The other three cameras (U1, U2 and C4) caught more coyotes than people.

Effect of Human Activity on Wildlife

After the placement of a lock on the gate leading up to the underpass on March 17, 2011, there was a decrease in vehicle and people activity in the surrounding area, which appears to be correlated with increased coyote activity (Figure 15). There seems to also be a negative correlation between human activity and coyote activity in the underpass itself, although this data is limited by fewer trap nights (Figure 16). Average hour of peak coyote activity differed significantly in areas with and without human activity, although coyote capture sample size in areas without human activity (F) was small (Figures 17a and b).

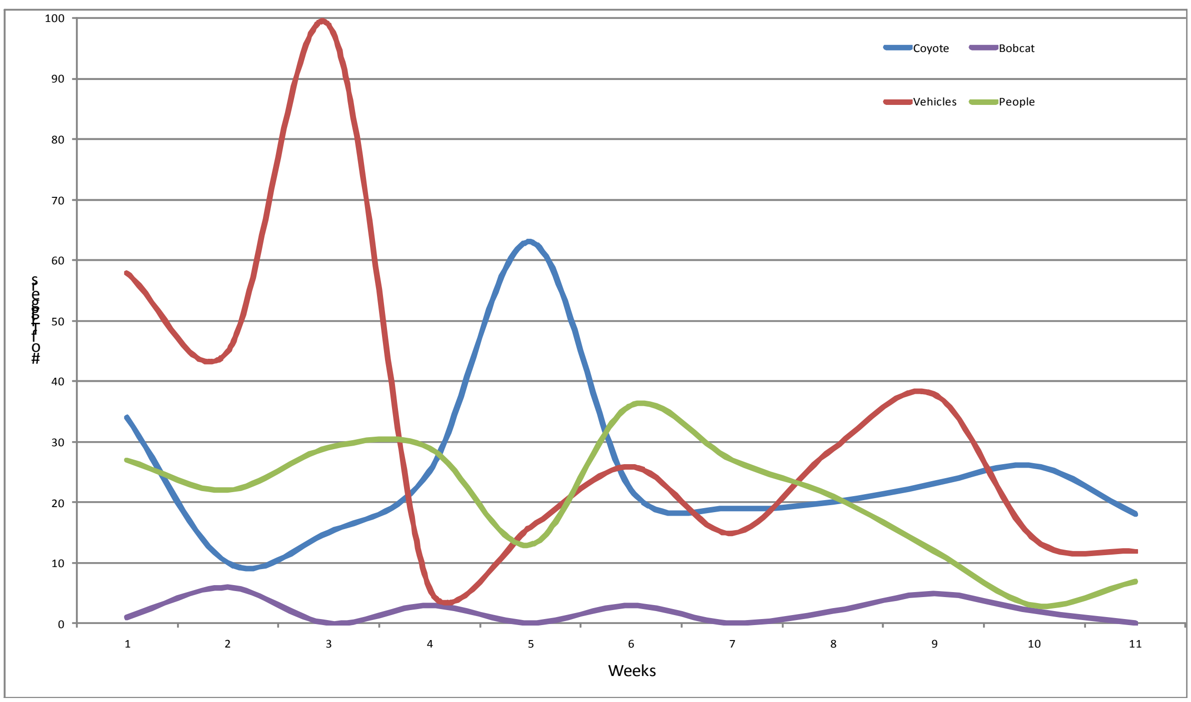


Figure 15. Total trap success by week of camera series C measured in the number of photos taken of each species per week.

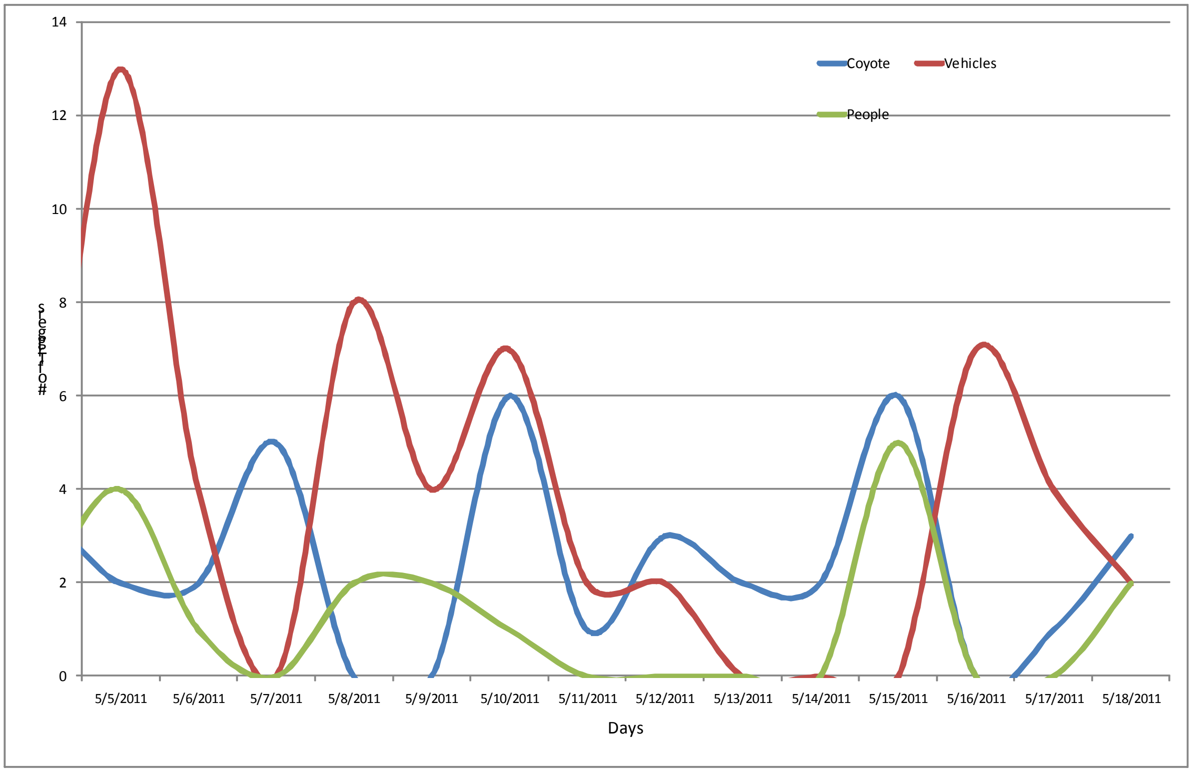
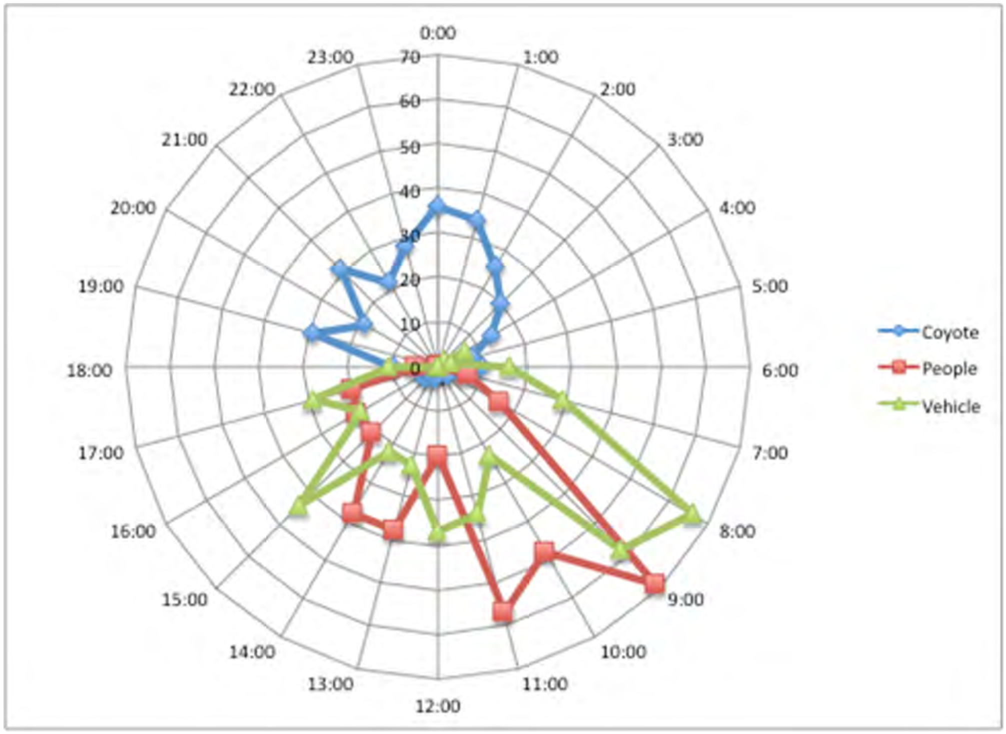
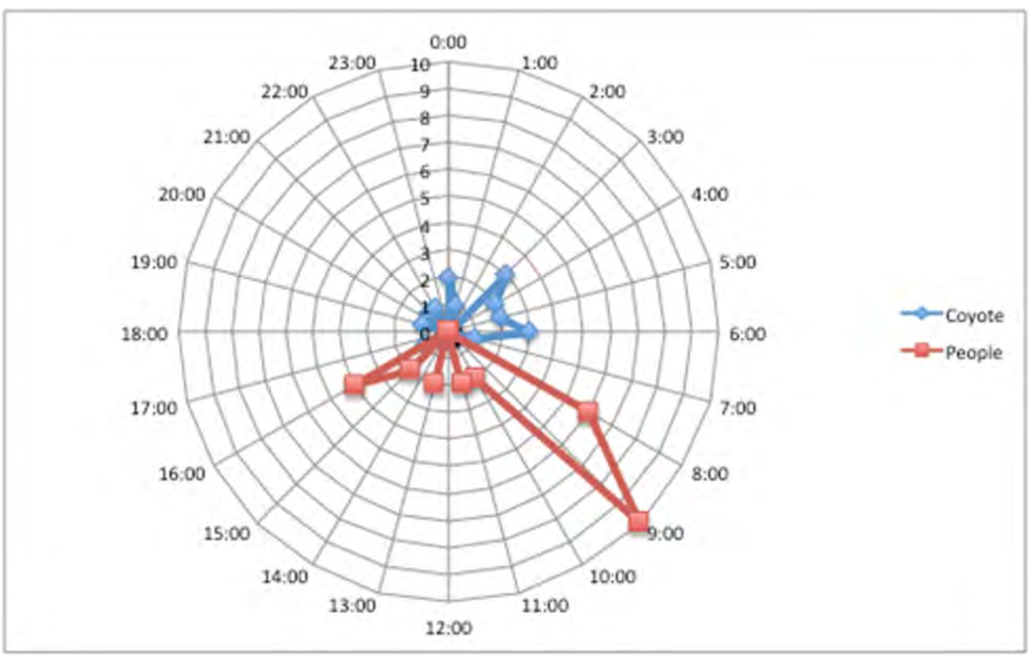


Figure 16. Total trap success by week of camera series U measured in the number of photos taken of each species per day.



a)



b)

Figure 17. a) Circular depiction of hourly species activity in C and U camera series. Time in hours is represented on the circumference of the graph and number of camera triggers is represented on the radius. b) Circular depiction of hourly species activity in F camera series.

When comparing peak hours of activity, coyote has a significantly different temporal distribution than people and vehicle. People and vehicle activity peaks during the daytime hours, while coyote activity peaks during the crepuscular and nocturnal hours (Figure 15a). Coyote peak temporal activity was different in areas near (C and U series) and away (F series) from human disturbance (Figures 15a and 15b). It appears that coyote peak activity time away from human disturbance is shifted toward the early morning and dawn hours, while coyote activity in areas of human disturbance tends to occur in the nighttime hours (Figures 15a and 15b). However, the small sample size of the F series prevents statistical analysis of this finding.

Wildlife Use of Underpass

We confirm use of the underpass by coyote and American badger, and infer that bobcat and mule deer are also using the underpass due to captures at cameras immediately surrounding the underpass (Table 3). There was no significant directionality of coyote or other animals through the underpass – only five more captures of coyote traveling northeast toward protected land were documented than captures of coyote traveling toward the area of potential development (Table 4). Upon exiting on the southwest side of the underpass, wildlife seems to continue traveling in the southern direction toward possible development (Table 5). Directionality was calculated without determining whether any individual animals turned around and were photographed again in the opposite direction.

Table 4. Directionality of wildlife taken from Cameras C1, C2 and U2.

	Southwest (toward development)	Northeast (toward MRCA land)
Camera C1 and C2		
Coyote	19	24
All other wildlife	8	8
Camera U2		
Coyote	10	11
All other wildlife	2	0

Table 5. Directionality of wildlife taken from Camera U1.

	North	South	Undetermined
Exit Direction	0	9	1

Discussion

Wildlife in the Surrounding Area

Our initial goal was to get a baseline for animal activity both close to and away from the underpass. Due to frequent human use of the area immediately surrounding the underpass, the far set of cameras (F) was placed away from the underpass and freeway in order to determine a baseline of wildlife activity less affected by human activity. These far cameras caught coyote, bobcat, mule deer, gray fox and striped skunk. Significantly, these cameras caught no human activity other than our own activity during the weekly data retrieval. These far cameras caught four different species in approximately half as many trap nights as it took the close cameras to catch the same number of species, indicating that species richness is higher in areas farther away from the underpass (Figures 6a, 6b, and 6c). Also important is the presence of gray fox, which was not caught in cameras close to or in the underpass, signifying that gray fox is present but may be avoiding areas of human activity. Similar avoidance of human activity has been documented in mountain lions where "road intensity", or the frequency of road use during a given time, affects mammalian carnivores, particularly mountain lions (Markovchick-Nicholls et al. 2008).

The cameras immediately surrounding the underpass (C) had the longest surveillance time and the highest frequency of wildlife and human triggers. These cameras caught coyote, bobcat, mule deer, striped skunk, and some squirrel and rabbit activity. At the C camera set, the highest species activity was people, vehicles, and coyote. High coyote activity may be due to this species adapting to human activity (Markovchick-Nicholls et al. 2008). The highest coyote relative activity of this camera set occurred uphill from the underpass at camera C4 located at an intersection of a draw/gully and Los Piñetos Road. This location had frequent wildlife activity including coyote, mule deer, bobcat, striped skunk, squirrel, and rabbit. This is possibly due to the location being a main wildlife thoroughfare to and from the underpass. The camera with the least coyote relative activity was camera C3, which may not be a preferred route for coyotes or there may be alternate paths around the camera that animals use and thus avoid being caught by the camera. The discrepancy in the number of coyote triggers between cameras C1 and C2 is attributed to the cameras facing different directions. Other species including bobcat, deer, and striped skunk had much lower camera triggers in this camera set possibly indicating that they have lower abundance in comparison to coyotes in this location. Lower abundance can be attributed to multiple factors including but not limited to human activity, road/vehicular activity, proximity to freeway, noise, or no need to cross under the underpass.

Wildlife Underpass Use

The last set of cameras to be installed was the three under the underpass (U), thus they also had the fewest capture nights. Species caught using the underpass included coyote and American badger. It is interesting to note that the cameras right outside the underpass caught many animals that the cameras in the underpass did not. For instance, mule deer, bobcat, and striped skunk were caught in cameras C1, C2, and C4; we infer that the animals captured at cameras C1 or C2 did in fact use the underpass. Unfortunately, possibly due to the small number of trap nights in the underpass, we were only able to capture coyote on a daily basis. Coyotes were the most frequent, and only regular, users of the underpass in the limited study time (15 nights with two traps). In other areas of Southern California, coyotes have also been found to use underpasses containing trails or roads with high human activity (Ng et al. 2004). Directionality of the species was about 50% in each direction with coyotes having a low tendency to travel towards MRCA protected land (Tables 4 and 5). Our underpass contains Los Piñetos Road and was also frequently utilized by humans and vehicles. Interestingly, bobcat was not seen inside the actual underpass although we predict that this species does use the underpass due to its frequency of camera triggers on the cameras immediately surrounding the underpass. The cameras surrounding the underpass (C) caught bobcat going toward and away from the underpass with time differences about one hour suggesting that bobcats are going through the underpass and then returning some time later. A possible hypothesis as to why bobcats were not caught in the underpass is that they may stay to the extreme sides of the underpass to retain some cover and thus are missed by the cameras which were not situated to capture animals on the very sides of the underpass. Also of interest is that American badger was caught only on the cameras in the underpass (U), suggesting that badger evaded the C cameras surrounding the underpass but still utilized the underpass. This may be because badgers prefer cover rather than using the open road where the C cameras were pointed. It has been documented that mule deer prefer underpasses with large cross-sectional areas, much like our study site (Ng et al. 2004). While mule deer were documented at the C cameras as well, with some pictures indicating they headed toward the underpass, our U cameras did not catch deer in the process of using the underpass.

The large size and openness of the Los Piñetos Road underpass appears to make this underpass an ideal crossing structure for many different species (Clevenger and Waltho 2005). Its openness allows animals to see from one side to the other, even though it is some distance across. The underpass itself has dirt, not pavement, all the way through and contains only sparse vegetation along its edges, which leaves minimal cover for animals. Deer preference of underpass attributes has been documented and found that deer prefer a minimum underpass height of 12 feet and relatively open underpasses to allow for a greater possibility of clear visibility of habitat on the other side (Donaldson 2005). Donaldson (2005) also found that deer species tend to prefer underpasses with natural floors, and that structures preferred by deer also tended to be used by other species including raccoon and coyote. In underpass height, visibility, and natural floors, the underpass has all the ideal characteristics for deer preference. The area surrounding the underpass has some vegetation and there is fencing along the freeway that can funnel wildlife into the underpass, rather than over and across the freeway. Research supports that fencing along wildlife pathways to underpass openings greatly increases effectiveness of corridors, specifically by guiding deer toward the underpass (Donaldson 2005). Although the literature supports the use of the Los Piñetos underpass by deer, we did not find any deer actually using the underpass during the two weeks we were able to monitor.

Wildlife has been documented to shift their peak activity times in areas with high human activity in order to avoid humans (Kitchen et al. 2000). Bobcat, particularly female bobcat, sensitivity to developed land is documented (Riley et al. 2003). Although coyotes take advantage of urban and suburban areas, they prefer natural and undisturbed areas and try to avoid humans (Riley et al. 2003; Gehrt et al. 2009). By comparing coyote temporal activity from the C and U cameras to the temporal activity from the F cameras, it appears that coyote peak activity in areas away from human disturbance is shifted toward the early morning and dawn hours, while coyote activity in areas of human disturbance is shifted toward the nighttime hours (Figures 15a and b). This shift in coyote peak temporal activity suggests that coyotes alter their behavior in response to human disturbance. Because this result has not been statistically analyzed due to the small sample size, we recommend further data collection in areas away from human activity.

We found that placement of a lock on the gate leading up to Los Piñetos Road greatly reduced vehicle traffic and human activity and was correlated with an increase in some wildlife activity. This finding is important regarding park management because it underscores the impact of simple measures, such as a lock, to reduce human disturbances on wildlife.

Wildlife Activity after Using the Underpass

Once wildlife crosses through the underpass heading west/southwest and exit our study area, we conclude that most wildlife veers left onto Remsen St / Clampitt Rd and heads south towards the abandoned oil field. This conclusion is speculative as we only had one camera documenting this specific area and this camera had little surveillance time. This conclusion is significant because it indicates that wildlife is traveling into an area of proposed development. Land developers have a proposed a wildlife corridor, but the proposed corridor plan was made without any cameras or studies done to determine what wildlife is using the land threatened by development and where that wildlife goes once on the land. Considering we have confirmed use of the underpass by coyote and badger, and inferred use by deer and bobcat, we can assume both the protected land and the area at risk of development are both important parts of the home ranges of these animals.

We confirm use of the underpass by coyote and American badger, even though the Gate-King development Environmental Impact Report did not find presence of American Badger in the area. In other carnivore studies, badger had been found rarely and only in large swaths of habitat (Crooks 2002). Badger has been documented to be a species sensitive to fragmentation (Crooks 2002). It is also highly probable that bobcat and mule deer are using the underpass as well. Further research on both the direction that wildlife is traveling upon exiting the underpass and on what species are present in the proposed area of development is recommended to determine what land wildlife is utilizing and how development will affect wildlife activity, although we would predict far less wildlife use of this underpass if this area is developed.

Literature Cited

Brown, J. and S. D. Gehrt. 2009. The basics of using remote cameras to monitor wildlife. The Ohio State University: Agriculture and Natural Resources.

Carbone, C., S. Christi, K. Conforti, T. Coulson, N. Franklin, J. R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D. W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D. J. L. Smith, M. Sunquist, R. Tilson, and W. N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. Animal Conservation **4**: 75–79.

Clevenger, A and N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. Biological Conservation **121**, 453–464.

Crooks, K.R. 2002. Relative Sensitivities of Mammalian Carnivores to Habitat Fragmentation. *Conservation Biology* **16**, 488–502.

Cutler, T.L. and D. E. Swann. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin **27**: 571–581.

Donaldson, B. M. 2005. The Use of highway underpasses by large mammals in Virginia and factors influencing their effectiveness. VTRC 06-R2.Virginia Transportation Research Council.

Expert Owner's Manual, Cuddeback Digital. Non Typical, Inc. 860 Park Lane, Park Falls, WI

Forman, R. T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology **14**: 31–35.

Gehrt, S. D., C. Anchor, and L. A. White. 2009. Home range and landscape use of coyotes in a metropolitan landscape: conflict or coexistence? Journal of Mammalogy **90**: 1045–1057.

George, S. L., and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. Biological Conservation **133**: 107–117.

Grilo, C., J. A. Bissonette, and M. Santos-Reis. 2008. Response of carnivores to existing highway culverts and underpasses: implications for road planning and mitigation. Biodiversity and Conservation **17**: 1685–1699.

Hilty, J. A. and A. M. Merenlender. 2004. Use of Riparian Corridors and Vineyards by Mammalian Predators in Northern California. *Conservation Biology* **18**, 126-135.

Karanth, K.U. 1995. Estimating tiger *Panthera tigris* populations from camera-trap data using capture–recapture models. Biological Conservation. **71**: 333–338.

Kauffman, M.J., M. Sanjayan, J. Lowenstein, A. Nelson, R. M. Jeo, and K. R. Crooks. 2007. Remote camera-trap methods and analyses reveal impacts of rangeland management on Namibian carnivore communities. Oryx **41**: 70–78.

Kitchen, A. M., E. M. Gese, and E. R. Schauster. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. Canadian Journal of Zoology **78**: 853–857

Long, E. S., D. R. Diefenbach, B. D. Wallingford, and C. S. Rosenberry. 2010. Influence of roads, rivers, and mountains on natal dispersal of White-Tailed Deer. Journal of Wildlife Management **74**: 1242–1249.

Markovchick-Nicholls, L., H. M. Regan, D. H. Deutschman, A. Widyanata, B. Martin, L. Noreke, and T. A. Hunt. 2008. Relationships between human disturbance and wildlife land use in urban habitat fragments. Conservation Biology **22**: 99–109.

McDonald, W. and C. C. St Clair. 2004. Elements that promote highway crossing structure use by small mammals in Banff National Park. Journal of Applied Ecology **41**: 82–93.

Morrison, S. A. and W. M. Boyce. 2009. Conserving connectivity: some lessons from mountain lions in southern California. Conservation Biology **23**: 275–285.

Ng, S. J., J. W. Dole, R. M. Sauvajot, S. P. D. Riley, and T. J. Valone. 2004. Use of highway undercrossings by wildlife in southern California. Biological Conservation **115**: 499–507.

O'Connell, A.F., J. D. Nichols, and K. U. Karanth. 2011. Camera traps in animal ecology: methods and analyses. Springer, New York, New York.

Penrod, K., C. Cabañero, P. Beier, C. Luke, W. Spencer, and E. Rubin. 2006. South Coast Missing Linkages Project: a linkage design for the Peninsular-Borrego connection. Produced by South Coast Wildlands, Idyllwild, CA. www.scwildlands.org, in cooperation with California State Parks.

Penrod, K., R. Hunter, and M. Merrifield. 2001. Missing Linkages: Restoring Connectivity to the California Landscape, Conference Proceedings. Cosponsored by California Wilderness Coalition, The Nature Conservancy, U.S. Geological Survey, Center for Reproduction of Endangered Species, and California State Parks.

Pettorelli, N., A. L. Lobora, M. J. Msuha, C. Foley, and S. M. Durant. 2010. Carnivore biodiversity in Tanzania: revealing the distribution patterns of secretive mammals using camera traps. Animal Conservation **13**: 131–139.

Riitters, K. H., and J. D. Wickham. 2003. How far to the nearest road? Frontiers in Ecology and the Environment 1: 125–129.

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

Silveira, L., A. T. A. Jacomo, and J. A. F. Diniz-Filho. 2003. Camera trap, line transect census and track surveys: a comparative evaluation. Biological Conservation **114**: 351–355.

Spencer, W.D., P. Beier, K. Penrod, K. Winters, C. Paulman, H. Rustigian-Romsos, J. Strittholt, M. Parisi, and A. Pettler. 2010. California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration.
Crooks, K.R. 2002. Relative Sensitivities of Mammalian Carnivores to Habitat Fragmentation. Conservation Biology **16**: 488–502.

Tigas, L.A., D. H. Van Vuren, and R. M. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation **108**: 299–306.

Wegge, P., C. P. Pokheral, and S. R. Jnawali. 2004. Effects of trapping effort and trap shyness of estimates of tiger abundance from camera trap studies. Animal Conservation **7**: 251–256.

Whitaker, J. O. 1996. National Audubon Society: field guide to North American mammals. Alfred A. Knopf, Inc., New York.