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Wildlife Underpass Use and Environmental Impact Assessment: A Southern California Case Study

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Environmental planners often rely on transportation structures (i.e., underpasses, bridges) to provide connectivity for animals across developed landscapes. Environmental assessments of predicted environmental impacts from proposed developments often rely on literature reviews or other indirect measures to establish the importance of wildlife crossings. Literature-based evaluations of wildlife crossings may not be accurate, and result in under-estimation of impacts or establishment of inappropriate mitigation measures. To investigate the adequacy of literature-based evaluations, we monitored wildlife use of a freeway underpass that had been identified as critically important to wildlife connectivity, and which was evaluated in an environmental review document. Photographs were obtained from a network of trail cameras over 3 years. Six mid- to large-sized native mammal species used the underpass and two other mammal species were photographed near the underpass but not using it. American badger (*Taxidea taxus*) was photographed at a higher rate in the underpass than in the surrounding area. Gray fox (*Urocyon cinereoargenteus*) was rarely detected in the underpass relative to surrounding habitats, whereas the absence of mule deer (*Odocoileus hemionus*) in the underpass was unexpected, given relatively frequent detection in adjacent habitats. These results differed from the environmental assessment in that American badger was listed as "potentially" present while mule deer were expected to use the underpass. Results underscore importance of gathering data to document wildlife use of corridors, because some species do not or rarely take advantage of apparently suitable corridors, while others may be present when assumed to be absent.

Keywords
Connectivity, environmental impact analysis, underpass, carnivores, ungulates

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INTRODUCTION

Coastal southern California encompasses extensive urban sprawl and consequently local wildlife species face habitat fragmentation and loss (Ng et al. 2004, Beier et al. 2006, Burdett et al. 2010). Roads, especially primary highways, threaten wildlife survival not only via vehicular collisions but by fragmenting and reducing available habitat, isolating populations, and disrupting daily and seasonal movements (Forman and Alexander 1998, Coffin 2007, Delaney et al. 2010). These negative effects may be mitigated by the presence of wildlife-friendly underpasses, which can allow safe movement across barriers and provide connectivity (Clevenger et al. 2001, Forman et al. 2003, Dodd Jr. et al. 2004, Sawyer et al. 2012, Riley et al. 2014). Certain parameters of an underpass (e.g., size, vegetation presence/type) may determine its effectiveness and the importance of those parameters may vary depending on frequency of use by humans (Clevenger and Waltho 2000, Glista et al. 2009).

Native California species for which road underpasses may be important include large mammals such as mule deer (*Odocoileus hemionus*), and mammalian carnivores such as American badger (*Taxidea taxus),* bobcat (*Lynx rufus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and mountain lion (*Puma concolor*). Mule deer are affected by collisions with vehicles and by habitat fragmentation due to roads (Gordon and Anderson 2004, Sawyer et al. 2012), which may result in reduced gene flow across roads as shown in white-tailed deer and mule deer (Robinson et al. 2012, Mitelberg and Vandergast 2016). Mule deer may be reluctant to cross through an underpass in proximity to a town or development (Nicholson et al. 1997, Clevenger and Waltho 2000, Lendrum et al. 2012), or near roads with high traffic volumes (Rost and Bailey 1979). It is also suggested that underpass openings of at least 2.5 m high may be needed to accommodate this species (Gordon and Anderson 2004, Clevenger and Huijser 2011). Gray fox are negatively affected by proximity and intensity of urbanization (Ordeñana et al. 2010) and have a tendency to avoid roads (Markovchick-Nicholls et al. 2008), suggesting culverts or corridors may need to include more secluded or hidden avenues of dispersal in developed landscapes. The population densities and extensive home ranges of American badger and mountain lion require habitat connectivity for individuals to locate mates, access foraging habitat, and maintain a diverse gene pool (Beier 1995, Crooks 2002, Jager et al. 2006, Wilmers et al. 2013, Vickers et al. 2015). Although underpass use by American badger has been documented in Arizona (Gagnon et al. 2011), Utah (Cramer 2013), Wyoming (Sawyer et al. 2012), Montana (Allen 2011), and California (Ordeñana et al. 2010), information is sparse regarding the rate of use. Mountain lions use underpasses for dispersal, but tend to avoid areas with artificial lighting and obvious human activity (Beier 1995). While bobcats also tend to avoid human activity and development (Crooks 2002, Tracey et al. 2013), they have been found using a variety of corridors, underpasses, and culverts to access habitats in urban areas (Tigas et al. 2002, Riley et al. 2003, Alonso et al. 2014). Coyotes readily use underpasses and other habitat connections and thus, are relatively less threatened by habitat interruption (Lehner 1976, Ordeñana et al. 2010).

Connectivity between major blocks of habitat is one of the keystones of modern conservation planning and, by extension, of high importance in environmental impact analyses. Environmental planners often face decisions about assessing impacts to areas with likely wildlife movement, but lack data about which species are using identified corridors. Despite various research efforts on mammal use of corridors in southern California (Ng et al. 2004, Elliott 2006, Ordeñana et al. 2010, Alonso et al. 2014), many important connections through developed landscapes between conserved habitats have not been evaluated for wildlife use. In such situations, preparers of environmental impact analyses often rely on reviews of published literature and sometimes initiate short-term field investigations.

In this paper, we report on a case study in which we recorded wildlife use of an existing road underpass that had been considered in an environmental review process for a proposed adjacent development. The linkage in this case study had been identified as providing an essential route between two large conserved habitat blocks (Penrod et al. 2000, South Coast Wildlands 2008, Spencer et al. 2010) and had been assessed in an Environmental Impact Report (EIR) prepared under the California Environmental Quality Act (City of Santa Clarita 2003). This underpass was described in the EIR as “Best crossing associated with site. … mule deer, rabbit, and coyote documented” (City of Santa Clarita 2003), although the EIR did not provide any documentary evidence of use of the underpass by these species, except noting tracks “in the area.” We investigated this underpass in an extended field study to pursue the following objectives relevant to the environmental review process and conservation management of the site: (1) to document which species used the underpass, (2) to compare relative frequency of detection of different species, and (3) to evaluate if human use of the underpass influenced wildlife activity. Achieving these objectives would inform conservation management guidelines that could partly mitigate effects of habitat fragmentation in the urbanized landscape, and more generally, provide insight on the adequacy of impact assessments that rely on limited or short-term data to determine corridor use by wildlife.

MATERIALS AND METHODS

Study Area

Los Piñetos underpass (34° 21' 1.34" N, 118° 30' 15.23" W) extends under the 10 lanes of California State Route 14 (SR-14) in Santa Clarita, Los Angeles County, California, which carried an annual average daily traffic in 2013 of 109,000 vehicles (Figure 1). Regionally, the location lies within an identified wildlife linkage that connects the San Gabriel Mountains on the east with the Santa Susana Mountains on the west across the San Fernando Pass (South Coast Wildlands 2008). Locally, the underpass provides a passage from the Elsmere Canyon Protected Open Space, owned by the Mountains Recreation and Conservation Authority (MRCA) to the east, and the City of Santa Clarita’s Gate-King Protected Open Space to the northwest (City of Santa Clarita 2003). Wildlife species must cross a small plot of privately owned land west of SR-14 and the four-lane Sierra Highway to be able to move between these two protected open spaces (Figure 1). The surrounding vegetation includes annual grasslands, coastal sage scrub, chaparral, and oak woodlands. Hiking trails within Elsmere Canyon Open Space are open to the public and are frequented by hikers, bikers, horseback riders, and domestic dogs. The underpass is a dirt road that goes under a large highway (i.e., a bridge underpass). A series of other bridges potentially providing a connection for wildlife are located 1.3 km southwest from the Los Piñetos underpass, but the higher development intensity and activity in this area makes it an unlikely site for movement of sensitive wildlife species.

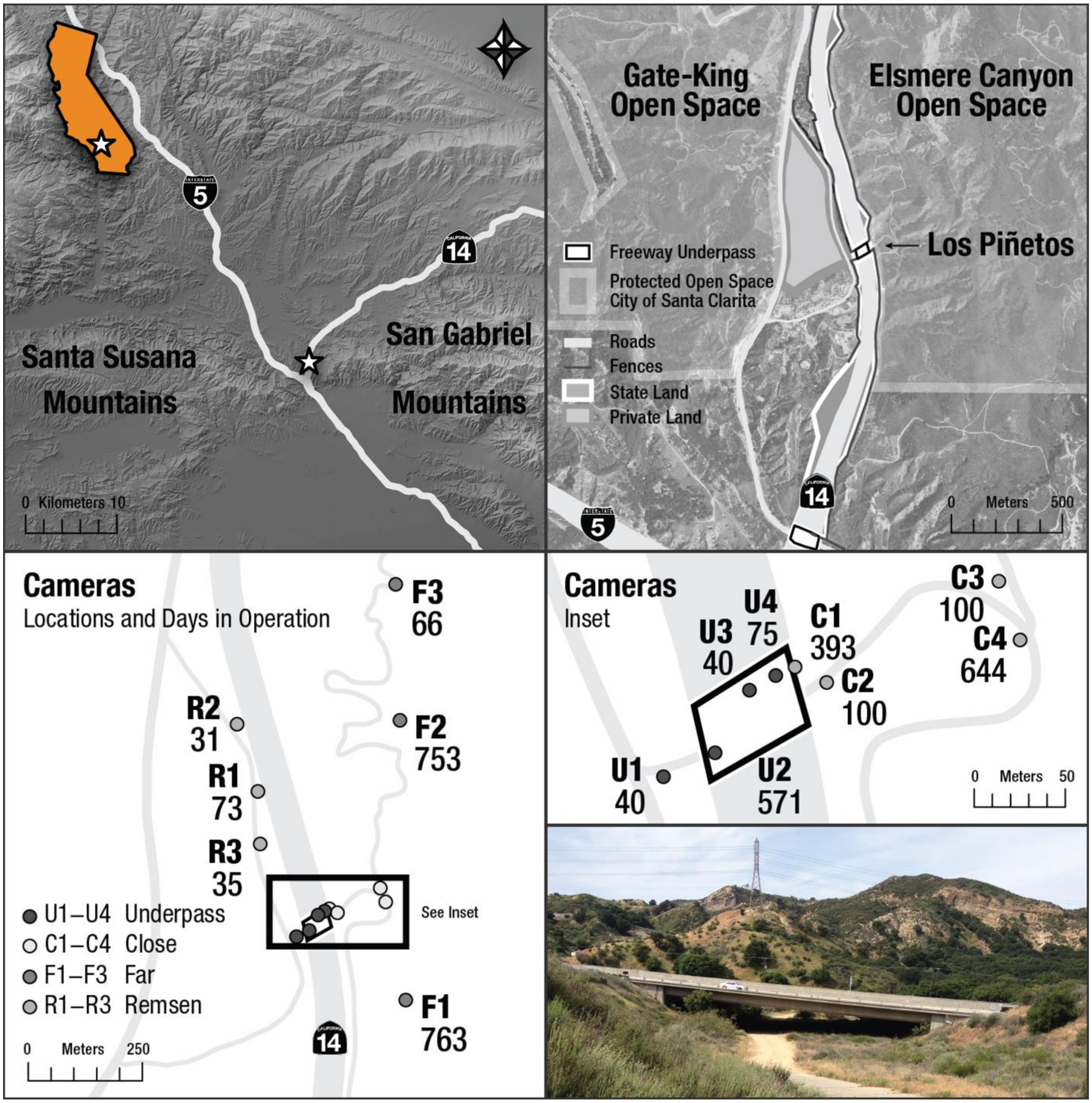

Figure 1. Location of the study site. Upper Left) Regional context between San Gabriel and Santa Susana Mountains. Upper Right) Los Piñetos underpass location between protected open spaces, with fence lines and breaks along State Route 15. Lower Left) Location of Camera traps on either side of underpass showing days in operation between March 2011 and May 2013. Lower Right) Detail of camera traps in and close to the underpass showing days of operation and view of underpass looking west from Elsmere Canyon Open Space.

To provide an overview of the site and its constituents we assessed several parameters important to wildlife movement. We measured dimensions of the Los Piñetos underpass and noted the vegetation cover surrounding it. We scouted fences along highway (SR-14) in the field, and recorded locations of breaks that could be used by wildlife with a Garmin™ eTrex Vista

HCx GPS unit. Fences in the study area were digitized in ArcGIS (Esri, Redlands, California) from field data and aerial imagery where they were inaccessible due to steepness of the terrain.

We monitored 14 remotely triggered camera traps (McCallum 2013) that we installed varying distances from the Los Piñetos underpass during March 2011–May 2013 (Figure 1). We installed 10 cameras in 2011 and added 4 more in 2013. They were located under and within 25 m of the underpass (U), close to (C; 60–250 m) and (F; 730–1800 m) from the underpass in the large protected habitat block of Elsemere Canyon Open Space and along Remsen Road on the development site within (R; 230-480 m from the underpass). We secured cameras in metal cases affixed 0.5 m high to square metals posts installed in the ground. The first 10 cameras were 3-megapixel Cuddeback® Expert Digital Scouting Camera C3300 (white flash; Cuddeback® Expert; NonTypical Inc, Park Falls, WI), most of which were subsequently switched to 12-megapixel LTL Acorn Scouting Camera (infrared flash; Green Bay, WI) to avoid potential activity disturbance by a visible flash camera (Wegge et al. 2004, McCallum 2013). Camera sites were visited every one to three weeks to retrieve data and monitor camera condition. To avoid excessive false triggers at locations with extensive vegetation, we removed some vegetation within the camera's sensing range.

We sorted digital images within the file hierarchy of personal computer systems by camera, species, and number of subjects (Harris et al. 2010, Sanderson and Harris 2013). We used a set of free computer programs to analyze digital images from camera traps (Harris et al. 2010). We categorized images of humans by mode of transportation (e.g., hiker, biker, equestrian). To prevent counting the same individual multiple times as it passed by a camera, images captured within 60 seconds of a previous image were eliminated from further analysis.

Seasonal patterns, species richness, and species accumulation curves were calculated by DataAnalyze (Harris et al. 2010) and visualized with JMP® statistical software (SAS Inc., Cary, North Carolina) or Excel (Microsoft, Redmond, Washington). The number of subjects of each species at each camera location was divided by number of days that camera operated to obtain an average number of individuals per trap night per location. Trap rates for cameras under, "close to", and "far from" the underpass were compared as a measure of underpass use relative to species activity. Trap rates for species pairs mule deer and humans were tested for association with a linear regression because mule deer are sensitive to human presence (Reed et al. 1975, Vogel 1989).

DataAnalyze calculated chi-square similarity in trap rates at the different cameras between pairs of species (Harris et al. 2010). We plotted hourly activity data (presented as number of images per hour) on a radar graph with which we could compare species. With circular statistics, we determined mean direction of each data set and plotted data on respective graphs (Zar 1996). We used the Rayleigh z test to determine significance of the mean direction for each species (Zar 1996). Similarity of temporal activity patterns for species pairs of interest was tested with the Watson U^2 test (Zar 1996). We set the *P*-value or equivalent significance threshold at 0.05 for all tests.

RESULTS

We deployed fourteen cameras for 3,684 camera trap days from 2011 to 2013 (Table 1). Some cameras were vandalized, malfunctioned, or were installed later in the project, so that length of service ranged 75–571 days for traps in the underpass, 100–644 days for traps near the underpass to the east, 31–71 days for traps near the underpass to the west (Remsen Street), and 66–753 days for traps far from the underpass (Figure 1).

Table 1. Description of camera traps installed near Los Piñetos underpass, Santa Clarita, California, March 2011–May 2013.

Camera	Camera Type	Distance from Underpass (m)	Distance from Freeway Median (m)	Date Range of Images
F1	Cuddeback	730	168	4/9/11–5/10/13
F2	Cuddeback/ Ltl Acorn	1000	290	4/9/11–4/30/13
F3	Cuddeback	1800	330	4/9/11–6/13/11
C1	Cuddeback	60	33	3/6/11–4/1/12
C2	Cuddeback	62	60	3/6/11–6/13/11
C3	Cuddeback	200	150	3/6/11–6/13/11
C4	Cuddeback/ Ltl Acorn	250	155	3/6/11–5/9/13
U1	Cuddeback	23	50	5/5/11–6/13/11
U2	Cuddeback/ Ltl Acorn	0	19	5/5/11–4/7/13
U3	Cuddeback	0	9	5/5/11–6/13/11
U4	Ltl Acorn	0	23	2/25/13–5/10/13
R1	Ltl Acorn	330	47	2/18/13–5/1/13
R2	Ltl Acorn	480	53	2/25/13–3/27/13
R3	Ltl Acorn	230	71	4/7/13–5/11/13

Of >50,000 triggers, 10,583 subjects were captured, some of which were captured in the same image. The remaining 39,417 images were false triggers. More than 60% of the photographs containing subjects were of humans hiking, biking, riding horses, or in vehicles. Except for a small fraction (<1%), the remainder were of mammals, including eight native mid-sized to large species: mountain lion, American badger, bobcat, coyote, mule deer, gray fox, raccoon, and striped skunk (Figure 2). Of these, only mule deer and mountain lion were not detected in the underpass. Species accumulation curves for the eight mid-sized to large, native mammals show rapid species accumulation at the camera near the underpass (C4) but slower accumulation and fewer overall species in the underpass (U2) (Figure 3). Animals were coming close to the underpass, but not going through, which we confirmed with several series of photographs taken the same night as animals moved past several of the close cameras, but not in the underpass.

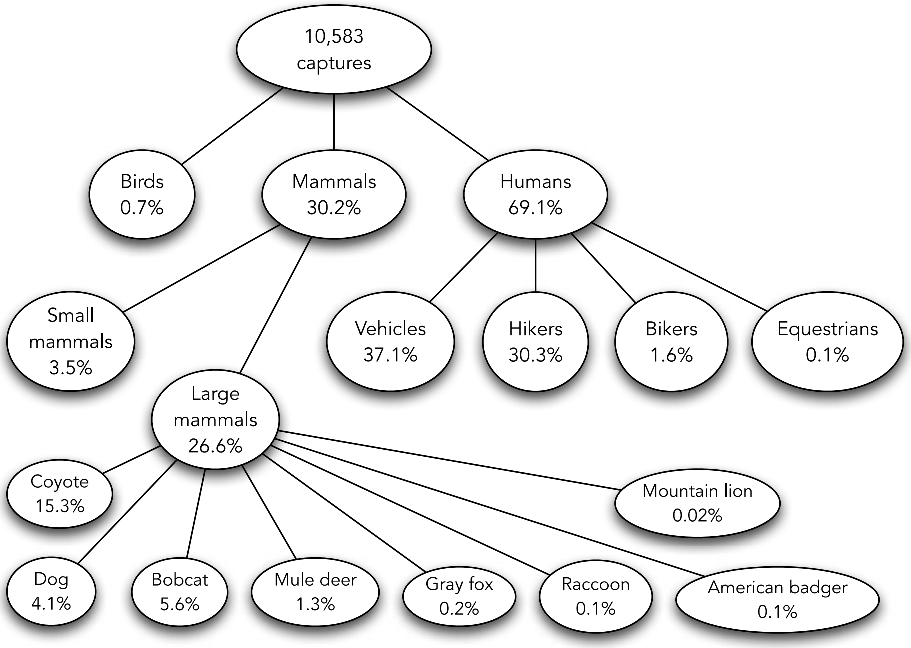

Figure 2. Species observed in automatically triggered camera traps in and near the Los Piñetos underpass, Santa Clarita, California, March 2011–May 2013, showing percent of total images captured.

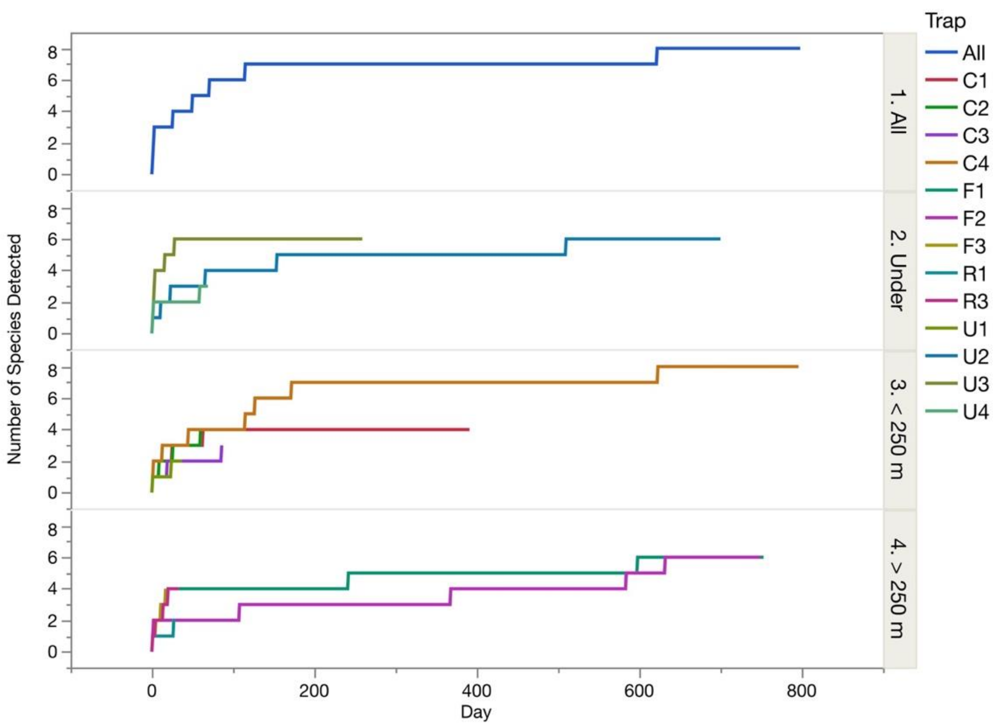

Figure 3. Species accumulation of eight mid-sized to large native mammals at all cameras, and individual cameras under, < 250 m from, and > 250 m from the Los Piñetos underpass, March 2011–May 2013.

Mean numbers of photographs per day near the underpass for native mammals were 0.0003 for mountain lion, 0.003 for American badger, 0.005 for gray fox, 0.16 for bobcat, and 0.44 for coyote. American badger, bobcat, and coyote were found in the underpass at a greater rate than they were detected at cameras nearby, whereas gray fox was photographed in the underpass at 20% of its rate in habitat away from it (Figure 4). Mule deer were detected at 0.04 photographs per trap-night near the underpass (but not using it), a rate higher than gray fox and American badger, both of which used the underpass.

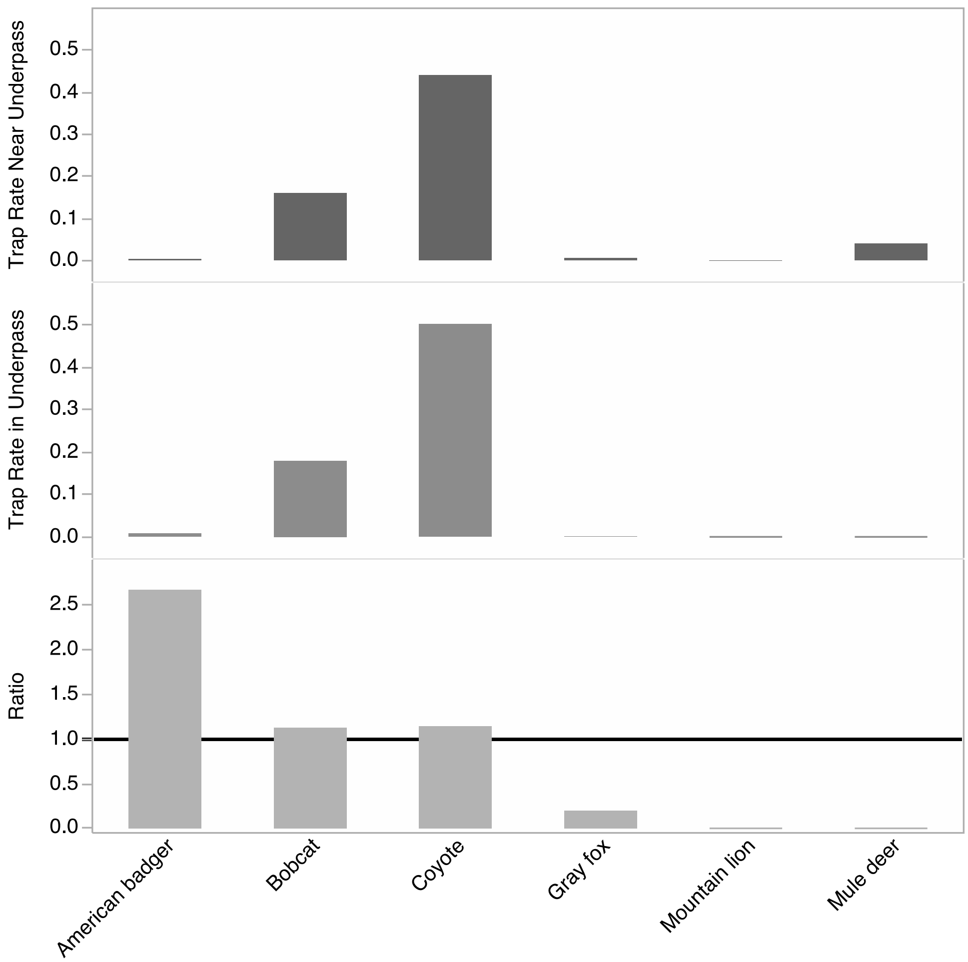

Figure 4. Camera trap rates (subjects photographed per day) in and near Los Piñetos highway underpass for six mammal species of interest. Ratio of rate of capture in underpass to rate of capture near underpass shows use greater or less than predicted by activity nearby. Species with a ratio >1 are found in the underpass with greater frequency than their occurrence near the underpass, while a ratio <1 shows less use of underpass than occurrence nearby.

Native mammals and humans showed diel niche partitioning, with humans active during daylight hours and coyotes, bobcat, mule deer, and gray fox active throughout the night (Figure 5). Watson U^2 test indicated that deer and human diel activity patterns were statistically different from each other (P<0.05), whereas coyote and fox were not statistically different from each other. A linear regression for number of photographs of humans against number for mule deer for each location was not significant ($F_{1, 12}$=0.521; r^2=0.042; P=0.48), indicating temporal rather than spatial partitioning. Overall, common native mammals (coyote, bobcat, striped skunk, and mule deer) had similar temporal activity patterns to each other, as did categories of humans (hikers, bikers, and vehicles) with each other.

Our results differed from the description of the presence and use of the site by native mammals in the environmental assessment (City of Santa Clarita 2003). The assessment reported surveys for American Badger, found none, and judged the species as “potentially present,” while we confirmed presence and use of the underpass. We also confirm use of the underpass by gray fox, which the EIR noted as being “in the area.” The assessment claimed that mule deer and coyotes were “documented” to use the Los Piñetos underpass (without providing documentary evidence) and we were unable to confirm use by mule deer after >700 days of monitoring.

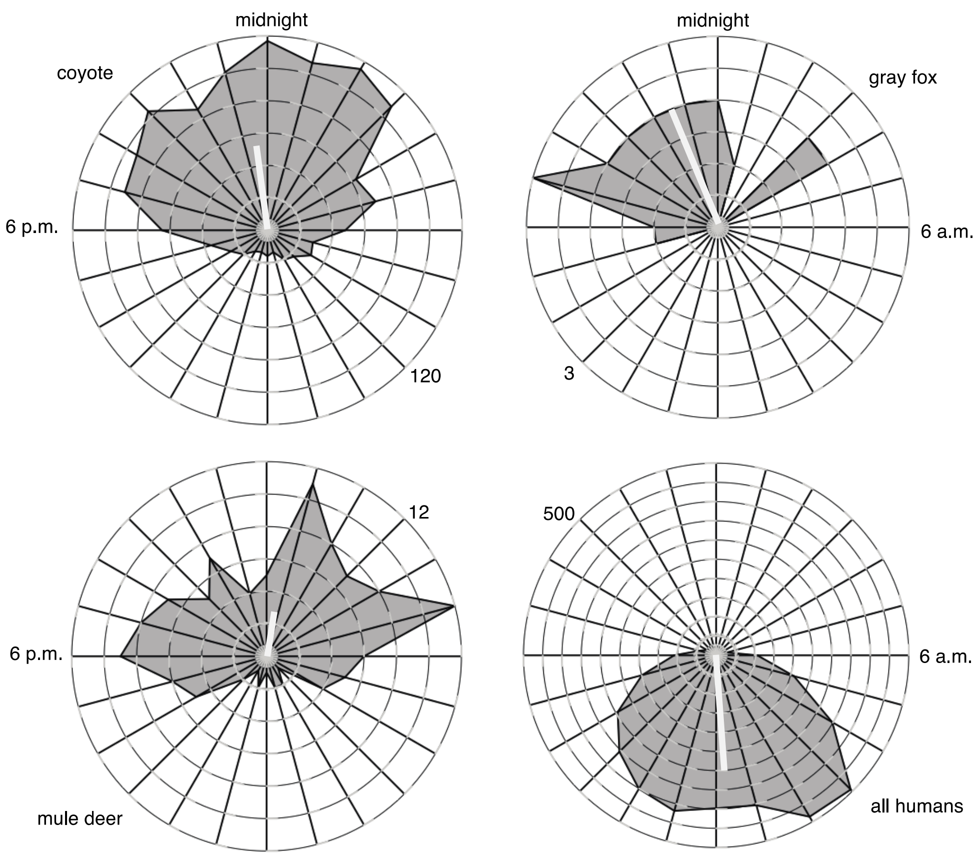

Figure 5. Diel segregation of activity of selected species at and near Los Piñetos underpass, Santa Clarita, California, March 2011–May 2013. Number of individuals observed indicated by distance of lines from the origin, with maximum number indicated on the outside of the circle. Hourly totals are connected by lines, with direction of mean vector (light gray) showing average hour of activity and its length (r) representing strength of daily pattern: coyote, N=1,413, r=0.433; gray fox, N=20, r=0.673; mule deer, N=128, r=0.528; and all humans (including hikers, bikers, equestrians, and vehicles), N=4,490, r=0.629.

DISCUSSION

Valuable insights are gained by comparing multiple underpasses (Ng et al. 2004, Ordeñana et al. 2010), but our in-depth monitoring of a single underpass produced additional information (i.e., certain species' presence near, but avoidance of, an underpass) and reduced the probability that a species passed by undetected. Our camera network allowed us to record and track individual animals in consecutive images as they moved near the underpass, approached it, exited the other side, and, in some instances, returned in the same night. This information increased confidence in our observations of use and non-use of the underpass.

Our trapping effort in the underpass should have been adequate to detect all but the most infrequent use by a species. No mule deer were photographed in 1,065 trap-nights in the underpass over the course of 700 days. Mule deer were detected 8 times more frequently than gray fox at other locations, yet gray fox was observed in the underpass and mule deer was not. Incidental to checking the camera traps, we looked for deer tracks in the sandy soil of the underpass and never observed any. If mule deer are using the underpass, they are doing so extremely rarely. By comparison, a newly constructed culvert-style wildlife underpass in the Puente Hills in southern Los Angeles County documented use by mule deer within weeks of opening (Elliott 2006).

Important characteristics affecting use of underpasses by mule deer are noise level, corridor dimensions, lack of deep water, screening from roads and trails, presence of native habitat on both sides of the underpass, presence of a dirt floor and human activity (Clevenger and Waltho 2000, Ng et al. 2004). The Los Piñetos underpass is wider and more open than other underpasses in the region that mule deer use (Ng et al. 2004) and at a value of 3.3 m, the openness metric greatly exceeds previously recommended metrics for mule deer of 0.6 (Reed et al. 1975, Haas 2000) and 0.3 (Gordon and Anderson 2004). The crossing was not screened from roads or trails that were frequented by people, but is characterized by a lack of deep water, the presence of a dirt floor, and native habitat on either end. Los Piñetos underpass has scant vegetation in and around it that could be used as cover by deer, which may be the most significant variable influencing use (Beier et al. 2006).

Our results confirm temporal niche partitioning by humans (daytime) and native mammals (nighttime), consistent with other studies (Grubbs and Krausman 2009, Murphy-Mariscal et al. 2015). Wildlife species activity peaks at night when human activity is at a minimum (Patten and Burger 2018). Thousands of pictures of humans were recorded, with a large proportion because of vehicle presence, but mostly during daylight hours.

These results can be used to improve assessments of the environmental impacts from proposed developments and to guide conservation planning. Despite the lack of documented use by mule deer, Los Piñetos underpass is part of an important wildlife corridor that is used by many native mammal species, which should confirm its importance in any review of the effects of any future development in the area. Development in the area would likely adversely affect diversity and number of native mammal species using the underpass and reduce the probability that animals that came through the underpass would be able to access the nearby Gate King Open space (Figure 1). Furthermore, this underpass represents the best possibility for maintaining connectivity for wildlife species between the San Gabriel and Santa Susana mountains (South Coast Wildlands 2008). Another underpass exists to the south, but it is much more urbanized and is heavily used by vehicles. Fence breaks were found along SR-14 but any animals attempting to cross 10 lanes of highway traffic are at great risk of collision with vehicles.

This case study illustrates that assumptions based on literature reviews and short-term field assessments, which encompass the majority of current environmental analyses, can be inaccurate in unpredictable ways. All previous discussion of the underpass implicitly assumed use by mule deer and unlikely use by American badger. Unfortunately, it is not an uncommon occurrence for predictions and assumptions made in environmental impact assessment to be proven inaccurate later (Ferrer et al. 2012). Even when surveys are conducted for environmental assessments they frequently do not detect rare species that are present (e.g., Garrard et al. 2014). Sometimes environmental assessors simply assume that all sensitive species that might be present are indeed present, but this also presents a problem, because it eliminates the ability of project planners to preferentially avoid impacts where the species is actually present. Conversely, assuming absence due to inadequate surveying reduces the ability of planners to identify and avoid or mitigate for significant impacts. For this case study, an investigation with camera traps of modest scope for the environmental assessment would have dramatically improved knowledge about species presence and activity at a site already identified as regionally important for wildlife connectivity.

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