Evaluation of Functional Connectivity for Medium- to Large-bodied Carnivores and Mule Deer across Colima Road in the Puente Hills Preserve, City of Whittier, California

Prepared for

City of Whittier

In association with

Puente Hills Habitat Preservation Authority

Prepared by

SWCA Environmental Consultants

January 2012

Evaluation of Functional Connectivity for Medium- to Large-bodied Carnivores and Mule Deer across Colima Road in the Puente Hills Preserve, City of Whittier, California

Prepared for

City of Whittier
13230 Penn Street
Whittier, CA 90602

In association with

Puente Hills Habitat Preservation Authority
7702 Washington Avenue, Suite C
Whittier, CA 90602

Prepared by

SWCA Environmental Consultants
295 Interlocken Blvd., Suite 300
Broomfield, CO 80021
Phone: 303.487.1183 / Fax: 303.487.1245
www.swca.com

January 4, 2012

TABLE OF CONTENTS

Page

INTRODUCTION 1
Focal Species 2
Bobcat 3
Coyote 3
Mule Deer 3
OBJECTIVES 4
METHODS 4
Study Area 4
Linkage Assessments 4
Linkage Assessment Area 4
Linkage Assessment Method 6
Evaluation Criteria 8
RESULTS 10
General Road Characteristics 10
Structures 10
Fill/Cut Slopes 10
At-grade Areas 11
AVCs 12
DISCUSSION 12
Priority Connectivity Areas 12
Recommended Wildlife Crossing Structure Location and Design 14
Other Measures to Improve Wildlife Connectivity 22
Research/Monitoring along Colima Road to Determine/Improve Underpass Success 23
CONCLUSION 23
LITERATURE CITED 24

TABLE OF CONTENTS (continued)

LIST OF FIGURES

Figure **Page**

1 Results of linkage assessment along Colima Road through the Puente Hills Preserve, including locations of at-grade crossings, underpasses, fence breaks, fill slopes, and animal-vehicle collisions (AVCs). Barbed wire fencing is located along all non chain-linked fencing portions of Colima Road. 5
2 Example of a fill slope (fill slope 4). 6
3 Cut slopes along Colima Road. 11
4 Two locations identified to improve wildlife connectivity across Colima Road. 13
5 Looking east along upper Arroyo Pescadero along the northbound lands (east side) of Colima Road from site of the proposed underpass location, east portal. 16
6 Looking west along upper Arroyo Pescadero along the southbound lands (west side) of Colima Road from site of the proposed underpass location, west portal. 17
7 Looking west along Arroyo San Miguel (left drainage) and upper Arroyo Pescadero (right drainage) at the proposed underpass location, east portal. 18
8 Looking west along upper Arroyo Pescadero at the proposed underpass location, east portal. 19
9 Looking east along upper Arroyo Pescadero (right drainage) at the proposed underpass location, west portal. 20
10 Looking east along upper Arroyo Pescadero (right drainage) at the proposed underpass location, west portal. 21

INTRODUCTION

Habitat fragmentation is one of the most serious threats to biodiversity worldwide (Wilcox and Murphy 1985; Saunders et al. 1991). One of the principal factors contributing to habitat fragmentation has been the construction of roads (Meffe et al. 1997) and in southern California, the effects of roads on wildlife populations and movement have been well documented. Wide-ranging species such as large carnivores are particularly vulnerable to localized extinction in fragmented habitats because of large home ranges, low densities, slow population growth rates, long range dispersal, and direct persecution by humans (Noss et al. 1996; Woodroffe and Ginsberg 1998; Crooks 2000, 2002). In fact, the disappearance of large carnivores from habitat fragments may generate trophic cascades that ripple down the food web (Crooks and Soulé 1999; Henke and Bryant 1999; Estes et al. 2001; Ripple et al. 2001). In fragmented habitats in San Diego, Crooks and Soulé (1999) concluded that extirpation of dominant predators such as coyotes can contribute to ecological release of smaller predators and increased extinction rates of their avian prey.

To counteract the negative impact of roads on wildlife, different types of techniques have been identified to maintain or enhance wildlife connectivity while providing safety to the traveling public by reducing the threat of wildlife-vehicle collisions (see review in Huijser et al. 2007). These techniques have ranged from methods used to influence driver behavior (e.g., road warning signs, animal detection systems), influence animal behavior (e.g., deer reflectors and mirrors, olfactory repellants), and physically separate wildlife from road surfaces (e.g., wildlife fencing). The safest technique for both wildlife and drivers is to prevent wildlife from accessing roadway surfaces and use other structures such as underpasses and overpasses to allow for animal movement across roads. Structures underneath roads from small culverts to wide-span bridges exist for a variety of purposes not related to maintaining habitat connectivity, but these structures are receiving attention for their potential to allow safe passages of wildlife across roads (Mansergh and Scotts 1989; Foster and Humphrey 1995; Yanes et al. 1995; Rodriguez et al. 1996; Clevenger and Waltho 2000). In urbanizing landscapes in southern California there has been an increasing amount of research devoted to determining the usefulness of underpasses for medium- to large-bodied carnivores (Crooks and Jones 1998; Haas 2000; Lyren 2001; Ng et al. 2004; Lyren et al. 2006; Haas and Crooks in prep.).

The majority of techniques incorporated to facilitate the safe passage of wildlife across roadways have focused on large-bodied, wide-ranging mammals. Throughout urbanized areas of southern California, populations of larger-bodied mammals (e.g., mountain lion, bobcat, coyote, and mule deer) have minimum-area requirements that are typically much larger than the wildland management units that currently exist in the habitat fragments across this highly developed landscape (Beier and Barrett 1993; Riley et al. 2003; Lyren et al. 2006). Specifically, the numerous roads that bisect the Puente Hills and open space areas to the east may inhibit movement of larger mammals, either through impeding normal movements of individual animals in search of resources and mates, impeding animals in moving away from or into recently burned habitats, or through death and injury by being struck by vehicles. Road kill mortality may lead to significant declines in larger mammal populations over time, either from the outright loss of individuals in a population or from unfavorable changes to the demographic composition of a population, even if minimum-area requirements for habitat are maintained.

The portion of Colima Road within the city of Whittier north of Mar Vista Street and south of Hacienda Heights is a contrast in roadway design that can facilitate safe wildlife passage across the roadway. The southern portion of the road contains chain-link fencing that likely limits wildlife movement onto the roadway shoulder but contains a large underpass which has seen carnivore and mule deer movement through the structure. Alternatively, the northern portion of Colima Road contains barbed-wire fencing that is less of a barrier to wildlife movement but contains no appropriate crossing structures to facilitate the safe passage of wildlife across Colima Road. Numerous road kills of carnivores and deer have been documented and observed along this northern portion of Colima Road (Lucas 2010; Los Angeles County 2011). As required by a Condition of Approval for the recently-approved Whittier Main Oil Field Development Project, the City of Whittier commissioned an investigation to determine the most appropriate location and type of structure to improve wildlife movement along upper Colima Road to help maintain the overall health of wildlife populations in the area. The need for a structure along upper Colima Road has been identified to provide an additional opportunity for wildlife to safely travel across the road as they respond to existing (e.g., recreation, noise pollution, light pollution, and development) and future (i.e., oil extraction facility) threats to wildlife movement.

A first step towards identifying synergistic or compatible opportunities is to identify critical specific locations along roads that are important to regional wildlife movement. Such locations can be considered "linkages" because they are locations where allowing for animals to travel across the road allows for habitats on either side of the road to remain ecologically connected. Here we undertook a linkage assessment within a portion of the Puente Hills Preserve (PHP) bordering Colima Road between the city of Whittier and Hacienda Heights, California, to identify the optimal location to site a new wildlife crossing structure in order to improve regional wildlife movement and enhance habitat connectivity.

FOCAL SPECIES

For a linkage analysis, it is important to identify a suite of species on which to base evaluations. The concept of focal species in reserve design is a central theme in large-scale conservation planning (Miller et al. 1998; Soulé and Terborgh 1999), and focal species have been chosen to symbolize ecological conditions that are critical to healthy, functioning ecosystems (Lambeck 1997). For this linkage analysis, bobcat, coyote, and mule deer were selected as target species. Large carnivores are ecologically pivotal organisms whose status can indicate functional connectivity of ecosystems, and using mammalian carnivores in conservation planning adds a critical layer of conservation strategy that may provide a robust method for protecting other species with less demanding needs (Lambeck 1997; Miller et al. 1998; Carroll et al. 1999). Mule deer are also important as a focal species because they are more sensitive to smaller underpass dimensions than carnivores (Haas 2000; Ng 2000). Thus, safe crossing locations for mule deer may be even more limited than for carnivores. Focal species, listed in descending order of management priority, include the following.

Bobcat

Bobcats are valuable indicators of connectivity at smaller, more local, spatial scales in developing landscapes. They are less sensitive to fragmentation and have smaller dispersal distances and home ranges than larger-ranging carnivores such as mountain lions (southern California: 1.4–8.1 km^2 [0.5–3.1 $mile^2$; 346–2,000 acres], see Lyren 2001:Table 1.11; Riley et al. 2003). Therefore, bobcats can persist in smaller habitat fragments, but only those that have adequate connections to larger natural areas (Crooks 2002).

Coyote

Although coyotes are widespread and relatively abundant throughout the region, they can be absent from habitat fragments that are too small, disturbed, or isolated (Crooks and Soulé 1999; Crooks 2002). Further, the decline and disappearance of coyotes from urban habitat fragments may contribute to increased numbers and activities of smaller predators such as domestic cats, raccoons, and gray foxes, and thus increase predation pressure on a variety of small prey species, including scrub-breeding birds (Crooks and Soulé 1999).

Mule Deer

Mule deer are essential for managing chaparral and other scrub communities for a disturbance regime that maintains natural successional stages. Furthermore, mule deer comprise the majority of mountain lion diet (Beier and Barrett 1993; Beier 1996). Due to their large body size and relatively large ranges, the long-term persistence of deer populations in fragmented systems may ultimately depend on their ability to move successfully among fragmented patches of habitat. George and Crooks (2001) report field observations and communication with longtime residents suggesting that mule deer may have declined, and in some instances disappeared, from small habitat patches within urbanized areas of Orange County.

Wildlife crossing structures vary in shape and size and when designing structures for multiple species it is difficult to accommodate passage for every type of wildlife species. Rather, identifying a suite of focal species may be more appropriate. For the focal species identified above, both wildlife underpasses and overpasses have proven to be effective measures for allowing safe passage of these species across roadways. Arch culverts, box culverts, and circular drainage pipes underneath roads have been used extensively by bobcats and coyotes throughout southern California. Overpasses provide a less constrained passage route, particularly for mule deer, and use of these structures by the focal species has been documented; however, much less than underpass use simply due to the low number of wildlife overpasses, particularly in urban areas. Although the size and shape of a structure is an important indicator as to the frequency of use by certain wildlife species, the location of that structure is a more important predictor in whether the structure will be utilized or not (Haas 2000).

OBJECTIVES

The primary goal was to conduct a wildlife linkage assessment by identifying existing and potential areas of wildlife crossing locations, potential barriers and hazards to movement, and locations that represented ideal sites to address wildlife-crossing construction opportunities. Following this assessment, drawing from field surveys and existing data, the best location to maintain or enhance wildlife crossing opportunities across Colima Road was identified based on several evaluation criteria. Bobcat, coyote, and mule deer were the focal species for this study, and they have minimum-area requirements that are typically associated with numerous road crossings that would be required as these species traverse portions of the PHP. A site assessment was conducted along Colima Road, and current wildlife distribution and movement data along with animal-vehicle collision (AVC) records along the portion of Colima Road bisecting the PHP were synthesized.

METHODS

STUDY AREA

The linkage assessment was conducted along the portion of Colima Road bisecting PHP lands (Figure 1); the southern limit was the entrance to the Arroyo Pescadero trailhead across from the ball field and the southern entrance was the residential development bordering the northern boundary of the PHP. The PHP, in general, consists of a series of undeveloped lands contained within the cities of Whittier and La Habra Heights and unincorporated portions of Hacienda Heights and Rowland Heights. These lands contain a mix of coastal sage scrub, chaparral, riparian, walnut, and coast live oak woodland, and annual grassland communities primarily dominate the PHP. Colima Road bisects the Arroyo Pescadero/Arroyo San Miguel portion of the PHP; Arroyo Pescadero is located west of Colima Road and Arroyo San Miguel is located east of Colima Road.

LINKAGE ASSESSMENTS

Linkage Assessment Area

The linkage assessment was conducted on December 2, 2011, along the portion of Colima Road bisecting PHP lands. The start and end locations along Colima Road represented the general limits of the PHP, which in this location is owned by the City of Whittier and managed by the Puente Hills Habitat Preservation Authority. Specifically, the northern limit was the southern boundary of a residential development located south of Casino Drive and Skyline Drive; the southern limit was a baseball field located directly east of the entrance to the Arroyo Pescadero trailhead parking lot.

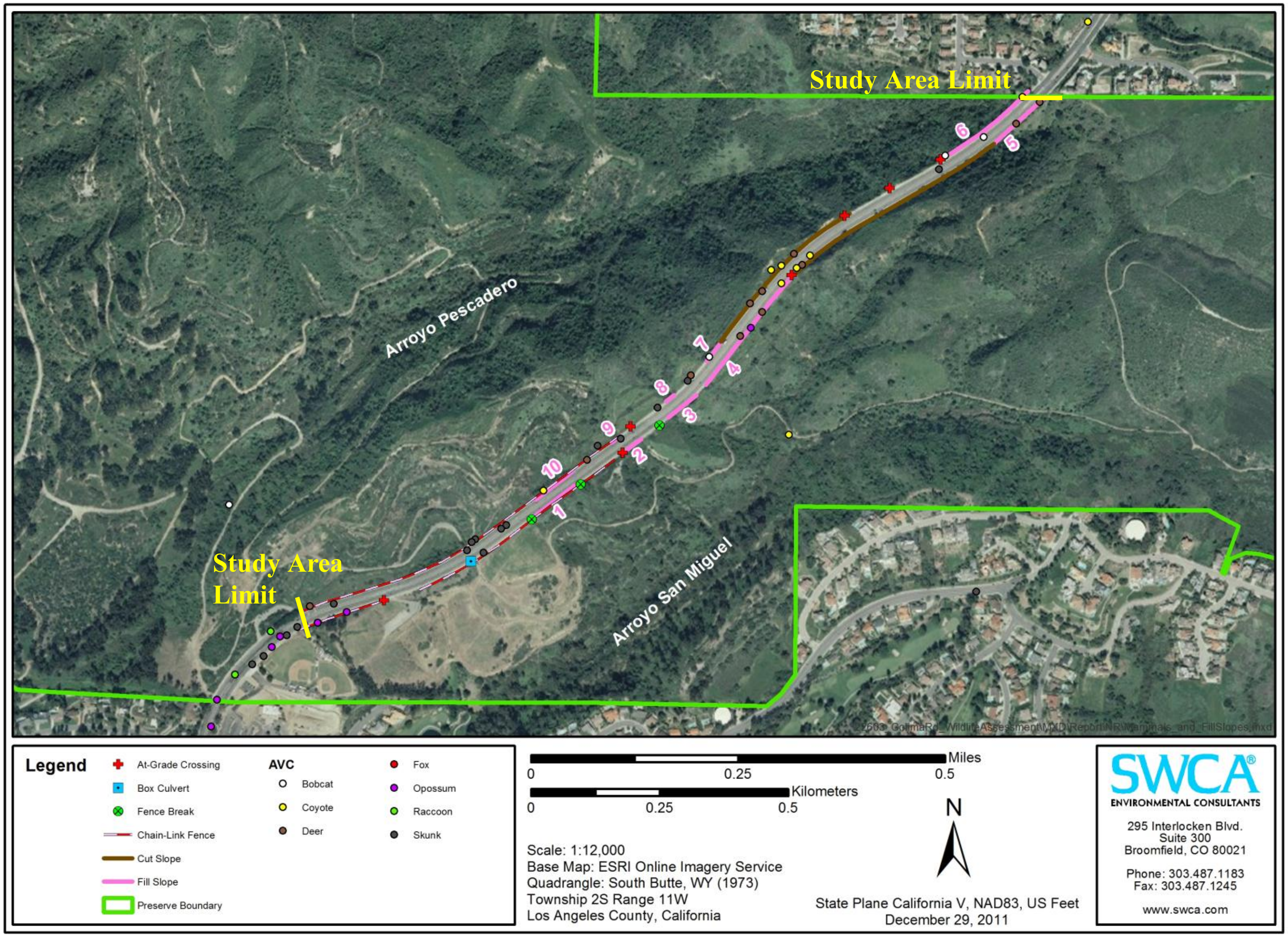

Figure 1. Results of linkage assessment along Colima Road through the Puente Hills Preserve, including locations of at-grade crossings, underpasses, fence breaks, fill slopes, and animal-vehicle collisions (AVCs). The true chain-link fencing alignment is not depicted; rather the portions of Colima Road bordered by fencing are shown. Barbed wire fencing is located along all non chain-linked fencing portions of Colima Road.

Linkage Assessment Method

The linkage assessments consisted of the following approaches.

Identify and assess potential crossing structures or locations beneath Colima Road that might facilitate wildlife movement across the roads.

Three types of unique situations that could have potentially served as a wildlife crossing locales were identified: 1) structures, 2) fill/cut slopes, and 3) at-grade areas. Structures were any bridge or culvert that could have provided for the safe passage of the focal species underneath the road. Structural dimensions (length, width, and height) were recorded, and percent vegetative cover was measured (by percent category) within a 100-meter (m) radius around each entrance to the structure. Structures with a diameter less than 1 m were not considered as a potential wildlife crossing structure for the focal species. The percent category of vegetative cover surrounding each structure entrance (on opposite sides of the road) was averaged to yield a percent category of cover for vegetation less than and greater than 1 m in height, thereby differentiating between low grass or shrub cover and higher shrub and tree cover.

Fill slopes were any location where the road was elevated relative to the surrounding topography and positioned on top of dirt fill, and typically occurred where the road bisected a drainage (Figure 2).

Figure 2. Example of a fill slope (fill slope 4).

Fill slopes represent candidate sites for which to develop various types of wildlife crossing opportunities since 1) they typically bisect drainages (which often signify wildlife movement routes); 2) the slopes leading up to the road from the drainage floor often tend to concentrate wildlife movement to a discrete location along the road; and 3) the vertical distance between the roadbed and the drainage floor may allow for the installation of a larger wildlife crossing structure than the typical drainage pipes that are often located at the bottom of the fill slope and which convey water underneath the road. For all fill slopes, the fill height and width were measured. Fill height was the height of fill between the road and the natural, non-fill slope on either side of the roadbed, and fill imprint was the distance along the road occupied by the fill (i.e., the width of the filled drainage bisected by the road). Instances in which the road traversed the side of a ridge where one side of the road (e.g., northbound lanes) was on top of the fill slope and the opposing side (e.g., southbound lanes) was cut into the adjacent slope were not classified as a fill slope, as they did not represent an opportunity to install a wildlife crossing structure. Rather, fill slopes were locations where the fill occurred on both sides of the road, thus representing a candidate location to install an appropriately sized wildlife-crossing structure under the road. Cut slopes, alternatively, were any location where the road was cut into the surrounding topography, and typically occurred where the road bisected a ridgeline. These locations represent candidate sites for which to develop wildlife overpasses since they take advantage of the adjacent elevated topography, which also serve as movement routes for wildlife species, which would facilitate a crossing structure spanning the below-grade roadbed.

At-grade areas were other road attributes that were not usually point locations. Rather, they incorporated longer stretches of the road (typically 0.25 mile in length). These locations frequently included areas of road parallel to a drainage or riparian area, places where a particular vegetation type approached or abutted the road shoulders, or locations where wildlife were funneled to a particular point by other natural or man-made constrictive features in the landscape. At-grade crossings represent other areas in addition to fill slopes or underpass locations where wildlife activity may also be focused due to various topographic, vegetative, or other land use features, thus representing locations where wildlife may encounter a road.

<u>Identify and assess landscape or human-made features that might concentrate or impede wildlife movement across the roads.</u>

Roadway barriers to wildlife movement were characterized by various road elements that could influence whether or not an animal would attempt a surface crossing of that road. These elements included the number of lanes and presence of shoulder barriers, median barriers, guard rails, and other adjacent land use features. Additional miscellaneous features along the road that could hinder wildlife movement across roads or act as soft barriers (e.g., various fencing types and configurations) to species movement were also recorded. One such example was fence breaks. Fence breaks were locations where fencing (chain-link or barbed wire) was torn, missing, or otherwise altered to a point where wildlife could easily pass through to access the roadway. We differentiate these breaks from at-grade areas since they may not necessarily direct wildlife movement to that area, as opposed to at-grade locations, and can be repaired easily to prevent additional crossings in the future.

<u>Identify and assess previous and existing ungulate and carnivore crossing locations along or across the roads.</u>

Two methods to identify crossing locations for the focal species were used. First, all sign of focal species activity along both roads, including tracks, scat, game trails, carcasses, and visual sightings were recorded during the field visit. Such information provided baseline documentation where animals have recently been active along the highway shoulder, and served as preliminary locations for evaluating the potential for future roadway modifications to promote the safe passage of wildlife across the roads.

Secondly, existing literature pertinent to the study area was reviewed to locate any past results documenting the presence of the focal species in the area or their use of the existing undercrossings. Following is a chronological list of the reports and sources we used.

- Haas, C., and K. Crooks. 1999. Carnivore Abundance and Distribution Throughout the Puente/Chino Hills. Prepared for the Mountains Recreation and Conservation Authority and California Department of Transportation. Final Report.
- Haas, C. 2000. Distribution, Relative Abundance, and Roadway Underpass Responses of Carnivores Throughout the Puente-Chino Hills. Master Thesis. California State Polytechnic University, Pomona.
- Haas, C., and G. Turschak. 2002. Responses of Large and Medium-bodied Mammals to Recreation Activities: the Colima Road Underpass. Prepared for Puente Hills Landfill Native Habitat Preservation Authority. U.S. Geological Survey, Western Ecological Research Center.
- Lucas, S. 2010. Changes in Large and Medium-bodied Mammal Activity Following Eight Years of Recreation and Other Activities: The Colima Road Underpass and Vicinity. Technical Report. Puente Hills Landfill Native Habitat Preservation Authority. 30 pp.

In addition, AVC reports between 1997 and 2011 from the Habitat Authority and the Los Angeles County Department of Animal Care and Control were reviewed.

We emphasize that the aforementioned efforts to determine wildlife crossing areas and locations that offer the best sites for which to construct a future wildlife crossing structure are not comprehensive, as these methods only elucidate conditions existing within a small window of time. Furthermore, AVC data only indicate those locations along Colima Road where crossing attempts by wildlife were unsuccessful. Successful crossings across roads can only be directly measured by monitoring existing structures that provide for the safe movement of wildlife underneath the highway or through behavioral studies monitoring fine-scale movement patterns relative to the highway (i.e., telemetry studies), including at-grade surface crossings. Additional methods to identify crossing locations should be considered in future studies. Such methods may include focused AVC surveys, remotely triggered camera surveys, and track surveys, and strategies to incorporate these methods are identified in the Discussion section below.

Evaluation Criteria

Four criteria were used to select a location that best represented siting a wildlife crossing structure to enhance wildlife connectivity across Colima Road. Short-term strategies, such as installing/repairing fencing, are addressed on a site-specific basis and are independent of the evaluation criteria. The crossing structure selection criteria are listed below, in order of priority.

Criteria 1: Underpass Spacing

Bissonette and Adair (2008) used the scaling properties of species movement as an ecological basis for effective spacing of wildlife crossing structures and determined that underpass spacing should occur at the square root of the species home range size ($HR^{0.5}$) to provide population-level connectivity. They estimated this spacing from the square root of the animal's home range, which is a squared linear measure related to dispersal distance, thus resulting in a linear measurement. Based on information about species' home range sizes within the project area or the surrounding region, we estimated the following minimum spacing requirements for wildlife-friendly crossing structure placement:

- Mule deer: 5 km^2 (1.9 $mile^2$; 1,235 acres) maximum home range (Taber and Dasmann 1958), 2.2 km (1.4 miles) underpass spacing.
- Coyote: average female home range of 2.8 km^2 (1.1 $mile^2$; 692 acres) (Riley et al. 2003), 1.6 km (1 mile) underpass spacing; female home ranges used since they are smaller than male home ranges.
- Bobcat: average female home range of 1.5 km^2 (0.58 $mile^2$; 371 acres) (Riley et al. 2003), 1.2 km (0.75 mile) underpass spacing; female home ranges used since they are smaller than male home ranges.

To be conservative, it was estimated that an average spacing distance of 1.2 km between suitable undercrossings would allow for population-level connectivity in the PHP for these three species.

Criteria 2: Proximity to AVC Areas

AVC data along Colima Road were used to determine where these reports occurred relative to a structure, fill slope, and at-grade crossing. It was then determined which structures, fill slopes, or at-grade crossings were within a 0.25-mile radius of a stretch of road subject to a relatively higher rate of focal species road kills than adjacent stretches. Locations of AVCs are presented in Figure 1.

Criteria 3: Expected Bobcat, Coyote, and Mule Deer Crossing Zones

Each structure, fill slope, and at-grade crossing was evaluated to determine whether that location was used or had the potential to be used by bobcats, coyotes, or mule deer, as determined by track, scat, and motion-triggered camera data collected on PHP lands adjacent to Colima Road. Distribution and relative abundance data were obtained from Haas and Crooks (1999), Haas (2000), Haas and Turschak (2002) and, more recently, Lucas (2010). Although surveys did not collect data from every potential crossing route or drainage bisected by Colima Road, data from these studies were used to reinforce the selection/decision of that location.

Criteria 4: High Fill Slopes and Cut Slopes

Fill slopes were assessed to determine whether their height could accommodate a structure sufficient in height and width to facilitate passage of mule deer. This was to identify candidate locations for either enlarging existing structures or constructing new structures in fill slopes where no structure large enough to permit such passage existed. Alternatively, cut slopes were also assessed to determine whether the height of the surrounding landscape above Colima Road was adequate to construct an overpass structure that would allow clearance for vehicles passing underneath the structure.

RESULTS

GENERAL ROAD CHARACTERISTICS

Colima Road is a four-lane divided highway for its entire length across the PHP (approximately 1.3 miles). An additional turnout lane is present adjacent to the median at the southern end (northbound lane turning into the Arroyo Pescadero trailhead) and the northern end (northbound land turning onto Casino Drive). The two northbound and southbound lanes are separated by a concrete median elevated approximately 6 inches above the road.

Daily traffic volume along Colima Road north of its intersection with Mar Vista Street was measured at 35,704 vehicles in 2010 (Marine Research Specialists 2011). Peak hour volume in the morning was measured at 2,999 vehicles; peak hour volume in the evening was measured at 3,136 vehicles.

Fencing along Colima Road consisted primarily of 6-foot-high chain-link fencing and four-strand barbed-wire. Chain-link fencing was located along the southern portion of the study area and extended along the east side of Colima Road to the northern end of fill slope 1 and the western side of Colima Road to the northern end of fill slope 9 (Figure 1). North of these respective fill slopes, fencing along Colima Road consisted of barbed wire fence. Although barbed wire is much more permeable to wildlife than chain-link fencing, breaks in barbed-wire fencing could focus crossing activity onto the shoulder of the road; several fence breaks within both the chain-link and barbed wire fences were documented (Figure 1).

STRUCTURES

One underpass was identified within the study area (Figure 1) and consisted of a box culvert (Colima Road service tunnel) measuring 170 feet in length, 14 feet high, and 17 feet wide. Monitoring results indicate that this structure has been historically used by all three focal species (Haas and Crooks 1999; Haas and Turschak 2002) and use has been more recently documented in 2010, although bobcat use of this structure has declined compared to previously monitored levels in 1998–1999 and 2001–2002 (Lucas 2010).

Reported AVCs in the immediate area of this crossing only consist of skunk (Figure 1).

FILL/CUT SLOPES

Along Colima Road, 10 fill slopes and two cut slopes (on opposing sides of Colima Road) were identified; the locations of fill/cut slopes are presented in Figure 1. In several instances, due to the nature of the surrounding topography, certain stretches of road had one long fill slope along the eastern side of Colima Road and a smaller fill slope along the western side of the road. Such was the case with fill slopes 4 and 7. The east side (northbound lane) was a continuous fill slope that bordered the western slopes of Arroyo San Miguel; the west side had several side drainages that drained into Arroyo San Miguel but were bisected by Colima Road, creating many smaller fill slopes along the southbound lanes. We measured these smaller fill slopes to capture the potential opportunities to create additional structures that could facilitate wildlife passage.

One large cut slope was located at the crest of Colima Road. The adjacent topography on either side of the road was considered substantial enough (i.e., high enough above the road grade) to facilitate the construction of an overpass structure. Cut slopes were recorded on the east side of Colima Road between fill slopes 4 and 5 and along the west side of Colima Road between fill slope 6 and the northern limit of fill slope 4 (Figure 3).

Figure 3. Cut slopes along Colima Road.

AT-GRADE AREAS

Several at-grade crossing areas were located along Colima Road, mostly represented by game trails approaching the shoulder of the road. In one location along the northbound lanes, an access road diverged from the highway shoulder to the east. The presence of the road, combined with a break in the chain-link fencing along the shoulder, may serve to funnel animals up this road and attempt at-grade crossings, however no AVCs have been recorded in the immediate area of this crossing. These types of access roads can offer opportunities for wildlife to travel out of canyon bottoms to the highway shoulder, particularly if there is no adequate crossing structure in the canyon bottom that would allow for the safe passage of wildlife under the road.

Several game trails were also identified approaching the Colima Road shoulder. These trails, along with breaks in the roadside fencing, were monitored over a three-day period following the site visit; gypsum powder track stations were placed across each game trail leading to the roadway shoulder. Results indicated small mammal activity (rodents, rabbits, and squirrels) at the majority of track stations; a coyote visit was documented at the at-grade crossing location (represented by a game trail leading northeast and southeast from the east side of Colima Road) immediately north of fill slope 4.

AVCS

Reported AVCs were concentrated along the northern edge of fill slope 7 where it transitions to the cut slope at the crest of the ridgeline between Arroyo Pescadero and Arroyo San Miguel. It appears as if coyotes in particular may be crossing the portion of Colima Road between the northern end of fill slope 4 (along the eastern side of Colima Road) and the cut slope bordering the west side of Colima Road. Mule deer AVC were also clustered around fill slope 4, with seven reported incidents between the southern limit of fill slope 4 and the cut slope immediately north of fill slope 7 (Figure 1). Bobcat (two reported AVCs), mule deer (two reported AVCs), and coyote (one reported AVC) were also reported at fill slopes 5 and 6, which bisect the upper reaches of Arroyo Pescadero. The only other bobcat AVC reported along this stretch of Colima Road was at fill slope 7, which is across from the large fill slope (fill slope 4) bordering the east side of Colima Road.

DISCUSSION

PRIORITY CONNECTIVITY AREAS

The 2-km (1.25-mile) stretch of Colima Road that bisects the PHP currently has one single structure that is large enough to facilitate the movement of the three focal species; all three species have been recently documented using this structure (Lucas 2010). Thus, on average, this segment provides an underpass spacing of one structure per 2.0 km, which meets the underpass spacing requirements for mule deer. Placement of another structure along this stretch would meet the underpass spacing criteria for coyote and bobcat and, to maintain that spacing criteria, a structure would need to be located north of the existing box culvert.

The portion of Colima Road between the existing box culvert and the northern boundary of the PHP is approximately 1.4 km long. AVC records revealed ten mule deer, six coyotes, and three bobcats were killed along this stretch between 2001 and 2011. At least two options exist to improve connectivity along this stretch of road: 1) an overpass structure 150 feet north of the northern limit of fill slope 4, or 2) an underpass structure at the southern limit of fill slope 5 (Figure 4). These locations were selected for the following reasons.

Wildlife overpass location

- The crossing location is located 0.9 km from the existing box culvert under Colima Road.
- There is a high concentration of AV’s within the immediate area (five coyotes and three mule deer).
- The site is located along a ridgeline, which represents a potential travel route for wildlife species.
- Track stations placed at the northern end of fill slope 4 indicated coyote activity along the shoulder of Colima Road.

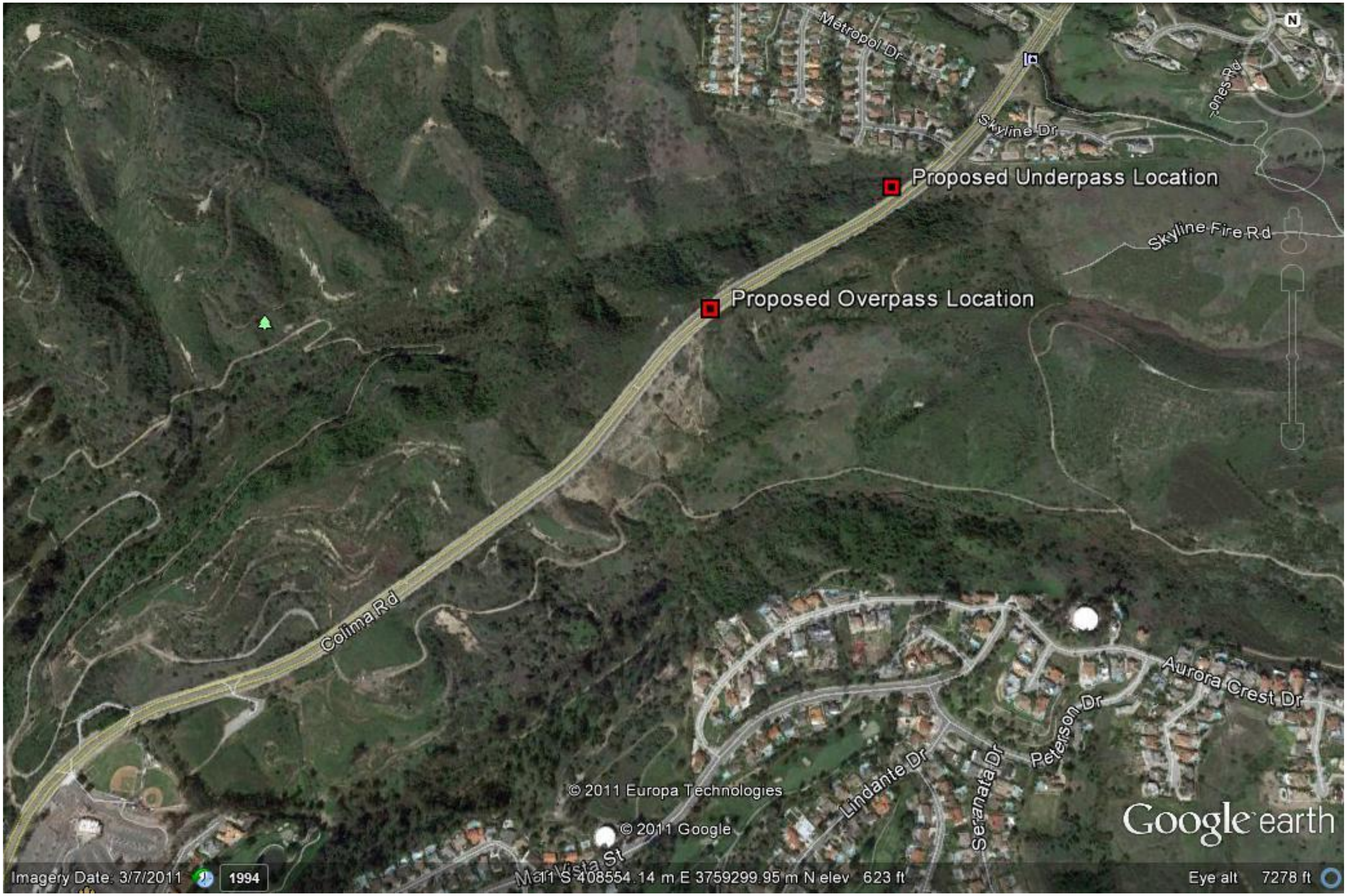

Figure 4. Two locations identified to improve wildlife connectivity across Colima Road.

Wildlife underpass location

- The crossing location is located 1.3 km from the existing box culvert under Colima Road.
- There is a concentration of AVCs within the immediate area (two bobcats, two mule deer, and one coyote).
- The site is located at the head of Arroyo Pescadero, which represents a potential travel route for wildlife species.
- Bobcat activity in Arroyo Pescadero is the highest of all areas surveyed within the Colima Road vicinity, thus it represents a high use area for a high-priority management species.

Other locations within the study area were discounted based on the following:

- no other locations provided an opportunity to span Colima Road with a wildlife overpass;
- high fill slopes suitable to construct a wildlife underpass that could facilitate mule deer passage did not have a corresponding fill slope on the opposite site of the road; and
- fill slopes that did have a corresponding fill slope on the opposite side of the road were not high enough to facilitate mule deer passage.

RECOMMENDED WILDLIFE CROSSING STRUCTURE LOCATION AND DESIGN

Based on the two sites identified as potential locations to install a wildlife crossing structure, it is determined that the underpass location at fill slopes 5 and 6 represents the best location to provide movement for bobcats, coyotes, and mule deer across Colima Road. This determination is based on the physical setting of the potential crossing location combined with the evidence of bobcat activity both at this portion of Colima Road and in Arroyo Pescadero. The topographic and vegetative characteristics in Arroyo Pescadero, combined with the distance it is located from the next suitable crossing structure (box culvert under Colima Road to the south), the presence of bobcat road kill locations, high bobcat use observed in the lower portion of the Arroyo Pescadero canyon, and the fill slope attributes (suitable fill height to construct an underpass: 10–12 m) all serve as attributes that would maximize the use of this structure by bobcat species, which has been identified as the primary focal species to develop an appropriate crossing structure along upper Colima Road. Coyote and mule deer have also been documented as having unsuccessful crossing attempts at this location, thus it is evident that they are crossing the road at this location and would benefit by having a suitable crossing structure connecting the upper reaches of Arroyo Pescadero which have been bisected by Colima Road. While the ridgeline where the potential overpass location was identified is likely to contain wildlife movement (as evidenced by AVC north of fill slope 4), it does not show any evidence of unsuccessful bobcat activity. Furthermore, it is uncertain what the success of an overpass structure in this setting would be; more evidence points to the merits of similar wildlife underpasses throughout the Puente-Chino Hills and their success at facilitating bobcat, coyote, and mule deer passage.

The structural dimensions for this structure must consider the sensitivities of mule deer to the height (i.e., clearance) of the underpass. The existing box culvert under Colima Road has a height of 14 feet and a corrugated metal arch culvert recently installed in 2006 under Harbor Boulevard to the east was 17 feet high; both of these structures have had mule deer use (Elliot and Stapp 2008; Stapp and Cashin 2009; Lucas 2010). Similar structures placed along CA State Highway 71 were 15 feet high and were also used by mule deer (Haas 2000). Given that mule deer throughout the Puente Hills and locations east have been documented using underpass heights in the range of 14 to 17 feet, the length of the underpass also factors into decisions on how high a structure should be so as to avoid a tunnel effect (the perception by wildlife, particularly mule deer, of constricted passage due to low structure height, narrow width, and longer passage distance [i.e., length]) and cause avoidance of the structure by mule deer. Underpass lengths of the existing structures identified above ranged from approximately 150 to 170 feet. The estimated length of the proposed structure would be 140 feet. Underpass width also increases the openness effect of a structure. Underpass widths of the existing structures identified above ranged from 17 to 20 feet. Considering all these dimensions, combined with the estimated length that the structure would need to be in order to facilitate mule deer passage and the fill slope heights on both the east and west sides of Colima Road at this location, the following structural criteria are recommended:

- Underpass is estimated to be 140 feet in length.
- This length assumes that concrete retaining walls can be built immediately adjacent to the road shoulder so as to effectively minimize the final length of the underpass as much as possible; length can also be minimized by ensuring that the underpass is perpendicular to the direction of Colima Road at this location.
- Recommended underpass height = 15 feet.
- Recommended underpass width = 20 feet.
- Recommended underpass type and material: corrugated metal arch culvert with soft bottom.

To further maximize use by the focal species and other, smaller wildlife species, these additional criteria are recommended:

- Placement of woody debris or other material (e.g., stumps, logs) throughout the underpass to serve as cover for smaller wildlife species.
- Plantings (e.g., coastal sage shrub or chaparral) surrounding the entrances to the underpass to provide adequate shelter and cover leading up to the underpass approaches.
- No recreation activity permitted through the structure.

The rationale for providing a structure large enough for mule deer, even though the spacing requirements for an appropriately sized crossing structure for deer are currently met along this stretch of Colima Road, are to ensure that if there are changes in mule deer movement patterns over time which could cause a decrease in use or avoidance of the existing structure, another suitable structure north of the existing one could provide an optional safe crossing route for this species across Colima Road. Examples of possible events/actions that could influence future use of the existing underpass include increased recreational activity and domestic animal use at the underpass and surrounding area; large-scale fire/changes in vegetation community; restoration activities; and noise, light, and traffic associated with the proposed oil extraction facility.

Photographs of Arroyo Pescadero Canyon extending east and west from the proposed underpass location are provided in Figures 5 and 6, respectively. Aerial imagery of the proposed location is provided in Figures 7 through 10. These images depict the specific location of the structure relative to the urban edge to the north. Siting the structure as far away from the residential neighborhood to the north yet constructing it on the southern edge of fill slope 5 will achieve the following:

- Minimize potential noise and light pollution.
- Utilize the existing edge of fill slope 5 where it meets toe of slope of ridgeline to south (this optimizes existing travel routes by wildlife as opposed to centering the structure along the middle of the fill slope).

Based on preliminary siting estimates, the edge of residential development would be approximately 380 feet and 250 feet from the eastern and western entrances, respectively.

Figure 5. Looking east along upper Arroyo Pescadero along the northbound lands (east side) of Colima Road from site of the proposed underpass location, east portal.

Figure 6. Looking west along upper Arroyo Pescadero along the southbound lands (west side) of Colima Road from site of the proposed underpass location, west portal.

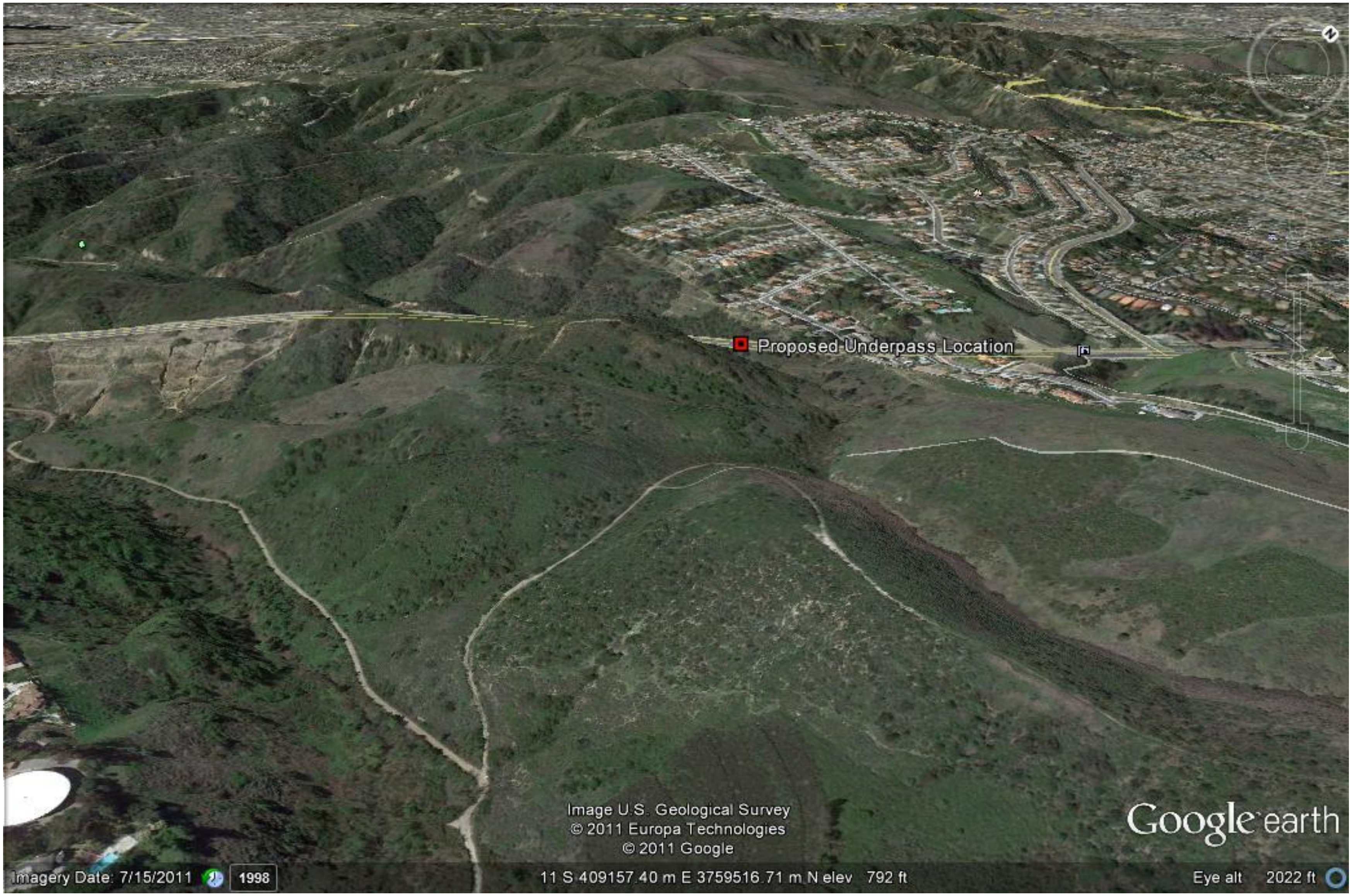

Figure 7. Looking west along Arroyo San Miguel (left drainage) and upper Arroyo Pescadero (right drainage) at the proposed underpass location, east portal.

Figure 8. Looking west along upper Arroyo Pescadero at the proposed underpass location, east portal.

Figure 9. Looking east along upper Arroyo Pescadero (right drainage) at the proposed underpass location, west portal.

Figure 10. Looking east along upper Arroyo Pescadero (right drainage) at the proposed underpass location, west portal.

OTHER MEASURES TO IMPROVE WILDLIFE CONNECTIVITY

Wildlife Fencing

Wildlife fencing would further serve to minimize and, if effective, significantly reduce the number of surface crossings over Colima Road by bobcats, coyotes, and mule deer; this in turn would reduce the number of AVCs on Colima Road. However, fencing the entire stretch of Colima Road, while theoretically reducing AVCs, may pose a more significant barrier to medium- and large-bodied carnivores and mule deer if these species become more sensitive to using underpasses under Colima Road. If underpass use by wildlife decreased due to changes in land use patterns and human activity (i.e., recreation), and if the entire stretch of Colima Road were fenced, wildlife species may have limited opportunities to disperse, forage, and conduct other daily and seasonal use patterns across Colima Road, which could pose a greater risk to population dynamics and long-term viability than the risk of several individuals being struck by vehicles due to the absence of suitable wildlife fencing along Colima Road.

It is recommended that an iterative approach be taken to decide whether or not wildlife fencing is appropriate within the immediate vicinity of the proposed underpass location. Stapp and Cashin (2009) completed a three-year post-construction monitoring program along Harbor Boulevard following construction of a wildlife underpass and concluded that coyote AVCs were significantly lower three years after underpass construction than they were prior to and one year following underpass construction. This decrease occurred even in the absence of wildlife fencing, indicating that there may be a behavioral aspect to underpass use by certain species over time thus potentially lessening the need for wildlife fencing. A similar monitoring (see Research/Monitoring Along Colima Road section below) should be implemented at least one year prior to and continuing to a minimum of three years following underpass construction to establish baseline, pre- and post-construction AVC rates and locations. If after underpass construction, AVCs are determined to be above acceptable levels, wildlife fencing should be considered to either extend from the residential development fencing at the northern end of the PHP boundary south, over the underpass 1) to certain geographical locations at the southern end of the fill slope (i.e., where the cut slope begins) or 2) to the existing chain-link fencing located along the southern portion of Colima Road. Wildlife fencing should be designed to follow the right-of-way line and then funnel toward the underpass entrance. Existing wildlife fencing (i.e., the chain-link fencing along the southern portion of Colima Road) should not be removed, as it is likely maximizing the use of the existing wildlife underpass (service tunnel).

An added feature of relocating wildlife fencing to an area immediately adjacent to a highway is that it can provide an appropriate opportunity for wildlife escape structures to be constructed and which could allow wildlife (primarily deer) access back to the non-roaded side of the fencing. Escape ramps (or jump-outs) have proven effective at providing escape routes from the highway shoulder for deer that have obtained access to the roadside by passing through gaps in wildlife fencing (Bissonette and Hammer 2000; see review in Huijser et al. 2007). Even in the event that proper maintenance and repair of fencing should occur, escape ramps at strategic locations could reduce deer mortality if animals continue to use portions of fencing that become broken, cut, or damaged to the extent where they allow passage onto the highway shoulder. Several locations of breaks in fencing were observed within the study area. Escape ramps should be paired with each other (i.e., one ramp along the southbound shoulder and one ramp along the northbound shoulder), so that mule deer would not have to cross the highway in order to escape the road shoulder.

RESEARCH/MONITORING ALONG COLIMA ROAD TO DETERMINE/IMPROVE UNDERPASS SUCCESS

Road kill datasets have the potential to be highly valuable in evaluation of functional connectivity but this information is currently underutilized. Although these data have been collected in the past and they continue to be collected by various agencies and jurisdictions, they have not been collected on a systematic basis nor are the exact mortality locations typically recorded. To provide more accurate information, the agencies responsible for collecting such data should record specific locations where road killed animals were collected using GPS units. The Habitat Authority has been collecting AVC data on a regular basis and collecting accurate locations of road kill; these efforts should continue in order to provide a larger data set of AVCs along this stretch of Colima Road.

CONCLUSION

The results of this investigation indicate the upper portion of Arroyo Pescadero is the best location for which to construct a wildlife crossing structure along upper Colima Road. The evaluation criteria used to determine this location take into consideration population dynamics, existing wildlife movement patterns, and AVC locations, in addition to evaluating the surrounding landscape which could facilitate an appropriate crossing structure. By providing a structure in this location, habitat connectivity and wildlife movement across Colima Road can be enhanced, thus providing an effective measure to maintain and potentially enhance wildlife populations throughout the Puente Hills.

LITERATURE CITED

Beier, P. 1996. Metapopulation models, tenacious tracking and cougar conservation. *In*: Metapopulations and Wildlife Conservation (edited by D.R. McCullough), pp. 293–323.Washington, D.C.: Island Press.

Beier, P., and R.H. Barrett. 1993. The Cougar in the Santa Ana Mountain Range, California. Unpublished Final Report, Orange County Cooperative Mountain Lion Study.

Bissonette, J.A., and W. Adair. 2008. Restoring habitat permeability to roaded landscapes with isometrically-scaled wildlife crossings. Biological Conservation 141:482–488.

Bissonette, J.A., and M. Hammer. 2010. Effectiveness of earthen return ramps in reducing big game highway mortality in Utah. Final Report. Utah Department of Transportation. Salt Lake City, UT.

Carroll, C., W.J. Zielinski, and R.F. Noss. 1999. Using presence-absence data to build and test spatial habitat models for the fisher in the Klamath Region, U.S.A. Conservation Biology 13:1344–1359.

Clevenger, A.P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology 14:47–56.

Crooks, K.R. 2000. Mammalian carnivores as target species for conservation in southern California. *In*: Second Interface Between Ecology and Land Development in California (edited by J.E. Keeley, M. Baer-Keeley, and C.J. Fotheringham), pp. 105–112: U.S. Geological Survey. Open-File Report 00-62.

———. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488–502.

Crooks, K.R., and D. Jones. 1998. Monitoring Program for Carnivore Corridor Use in the Nature Reserve of Orange County. Annual Report to Nature Reserve of Orange County, Santa Ana, CA.

Crooks, K.R., and M.E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563–566.

Elliot, D., and P. Stapp. 2008. Effects of a Purpose-Built Underpass on Wildlife Activity and Traffic-Related Mortality in Southern California: The Harbor Boulevard Wildlife Underpass. California State University, Fullerton Technical Report.73 pp.

Estes, J., K. Crooks, and R. Holt. 2001. Ecological role of predators. *In*: Encyclopedia of Biodiversity (edited by Levin, S.), pp. 857–878. San Diego, California: Academic Press.

Foster, M.L., and S.R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23:95–100.

George, S., and K. Crooks. 2001. Monitoring Program for Mammalian Carnivores in The Nature Reserve of Orange County. Santa Ana, CA: Annual Report to the Nature Reserve of Orange County.

Haas, C.D. 2000. Distribution, relative abundance, and roadway underpass responses of carnivores throughout the Puente-Chino Hills. Master Thesis. California State Polytechnic University, Pomona, CA. 122 pp.

Haas, C.D., and K.R. Crooks. 1999. Carnivore Abundance and Distribution throughout the Puente-Chino Hills. Final Report submitted to the Mountains, Recreation, and Conservation Authority and State of California Department of Transportation.

———. *In prep*. Factors Influencing Carnivore and Ungulate Underpass Activity Across an Urban Wildlife Corridor.

Haas, C.D., and G. Turschak. 2002. Responses of Large and Medium-bodied Mammals to Recreation Activities: The Colima Road Underpass. U.S. Geological Survey Technical Report. 22 pp.

Henke, S.E., and F.C. Bryant. 1999. Effects of coyote removal on the faunal community in western Texas. Journal of Wildlife Management 63:1066–1081.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith, and R. Ament. 2007. Wildlife-Vehicle Collision Reduction Study. Report to Congress. U.S. Department of Transportation, Federal Highway Administration. Washington, D.C.

Lambeck, R.J. 1997. Focal species: A multi-species umbrella for nature conservation. Conservation Biology 11:849–856.

Los Angeles County Department of Animal Care and Control. 2011. Animal-vehicle collision dataset. Excel spreadsheet database.

Lucas, S. 2010. Changes in Large and Medium-bodied Mammal Activity Following Eight Years of Recreation and Other Activities: The Colima Road Underpass and Vicinity. Puente Hills Landfill Native Habitat Preservation Authority Technical Report. 28 pp.

Lyren, L.M. 2001. Movement patterns of coyotes and bobcats relative to road underpasses in the Chino Hills are of Southern California. Master Thesis. California State Polytechnic University, Pomona, CA. 119 pp.

Lyren, L.M., G.M. Turschak, E.S. Ambat, C.D. Haas, J.A. Tracey, E.E. Boydston, S.A. Hathaway, R.N. Fisher, and K.R. Crooks. 2006. Carnivore Activity and Movement in a Southern California Protected Area, the North/Central Irvine Ranch. U.S. Geological Survey Technical Report. 115 pp.

Mansergh, I.M., and D.J. Scotts. 1989. Habitat continuity and social organization of the mountain pygmy-possum restored by tunnel. Journal of Wildlife Management 53:701–707.

Marine Research Specialists. 2011. Whittier Main Oil Field Development Project, Revised Environmental Impact Report, Final. Prepared for City of Whittier.

Meffe, G.K., R.C. Carroll, and contributors. 1997. Principle of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.

Miller, B., R. Reading, J. Strittholt, C. Carroll, R. Noss, M. Soulé, O. Sanchez, J. Terborgh, D. Brightsmith, T. Cheeseman, and D. Foreman. 1998. Using focal species in the design of nature reserve networks. Wild Earth 8:81–92.

Ng, S.J. 2000. Wildlife use of underpasses and culverts crossing beneath highways in southern California. Master's Thesis. California State University, Northridge.

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.

Noss, R.F., H.B. Quigley, M.G. Hornocker, T. Merrill, and P.C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10:949–963.

Riley, S.P.D., R.M. Sauvajot, T.K. 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.

Ripple, W.J., E.J. Larsen, R.A. Renkin, and D.W. Smith. 2001. Trophic cascades among wolves, elk, and aspen on Yellowstone National Park's northern range. Biological Conservation 102:227–234.

Rodriguez, A., G. Crema, and M. Delibes. 1996. Use of non-wildlife passages across a high-speed railway by terrestrial vertebrates. Journal of Applied Ecology 33:1527–1540.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5: 18–32.

Soulé, M.E., and J. Terborgh. 1999. Continental Conservation: Scientific Foundations of Regional Reserve Networks. Washington, D.C.: Island Press.

Stapp, P., and S. Cashin. 2009. Final Report: Continued Monitoring of the Harbor Boulevard Wildlife Underpass. California State University, Fullerton Technical Report. 17 pp.

Taber, R.D., and R.F. Dasmann. 1958. The Black-tailed Deer of the Chaparral. Calif. Dept. Fish and Game, Game Bull. No. 8. 163 pp.

Wilcox, B., and D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. The American Naturalist 125:879–997.

Woodroffe, R., and J.R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science 280:2126–2128.

Yanes, M., J.M. Velasco, and F. Suárez. 1995. Permeability of roads and railways to vertebrates: the importance of culverts. Biological Conservation 71:217–222.