Responses of Large and Medium-bodied Mammals to Recreation Activities: the Colima Road Underpass

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ABSTRACT

Surveys were conducted between August 2001 and July 2002 to determine responses in the distribution, relative abundance, and underpass use of large and medium-bodied mammals to the onset of recreation activities on property managed by the Puente Hills Landfill Native Habitat Preservation Authority (PHLNHPA). Track transects were placed on the east and west sides of Colima Road, a four-lane roadway bisecting the property; one transect was located on both sides of Colima Road. After the property was opened to the public, there was a significant increase in rabbit and human visits (hiking/running) to track transects; striped skunk activity decreased. No other species showed a response to the opening of the property. A remotely triggered camera monitored wildlife and human activity through an underpass located along Colima Road. Species showing the highest levels of activity through the underpass were bobcat, coyote, domestic dog, and mule deer. Similar to the track transect results, hiking/running through the underpass increased significantly after the property was opened to the public. This same activity was also greater during weekdays after the opening. Road kill surveys along Colima Road detected four coyotes, two striped skunks, and one mule deer. Given the increase in human recreation activities on the property and through the underpass, the rate of wildlife visits to both the track stations and the underpass are similar to those rates prior to the property being opened to the public. However, the impact of human activity on wildlife may have occurred prior to the onset of this study, as previous data (1997-1999) documented no human or domestic dog activity through the underpass. We recommend that any future increases in recreation activities throughout the property consider impacts to wildlife movement through the underpass.

INTRODUCTION

Recreation impacts on wildlife have been well documented, and a variety of nonconsumptive recreation activities, including hiking, wildlife observation, and nature photography, have been reported as having adverse effects on populations of birds, mammals, and herpetofauna (Boyle & Samson 1985). Additionally, human activity has detrimental impacts on the movement of large mammals through roadway crossing structures (i.e. wildlife underpasses, culverts, bridges) (Clevenger & Waltho 2000).

The Puente-Chino Hills contains numerous parcels of public land open to multiple forms of recreation. Many studies throughout this region have documented the diversity of vertebrates across this region (Robertson et al.; Swift et al. 1993; Schlotterbeck 1998; Haas & Crooks 1999; Scott & Cooper 1999; Cooper 2000; Haas 2000; Haas et al. 2002). However, while several of the studies have related anthropogenic factors (i.e. residential development, road density, vehicles) to possible causes of vertebrate distribution and relative abundance patterns (Swift et al. 1993; Cooper 2000; Haas 2000; Haas et al. 2002), none have directly measured the impacts of various forms of recreation activities on these populations. Such information is critical, particularly in urban areas where sensitive large mammal species continue to persist.

Given the potential effects of human activity on sensitive large mammal species, we initiated a study to test large and medium-bodied mammal activity relative to increases in recreation. Our specific focus was to monitor wildlife movement through the Colima Road underpass before and after the property adjacent to Colima Road was opened to the public for recreation purposes. Across the Puente-Chino Hills, many species have been documented using underpasses to safely cross roadways bisecting habitat (Haas 2000). Previous research at the service tunnel under Colima Road has documented use by five large and medium-bodied mammal species, including (in order of decreasing abundance) bobcat, mule deer, gray fox, opossum, and striped skunk (Haas & Crooks 1999). Additionally, the habitat immediately west of Colima Road contains the highest levels of bobcat abundance west of Chino Hills State Park (Haas & Crooks 1999). Combined with the presence of mule deer and coyote (two species that in addition to the bobcat are focal large mammal species of conservation), this area is of high conservation value since it serves as a vital link between habitat east and west of Colima Road (Haas 2000). Therefore, maintaining the successful movement of target species across Colima Road is critical. Avoidance of the underpass could cause animals to attempt at-grade crossings of Colima Road, thus subjecting them to being struck by vehicles. Wildlife-vehicle mortality has been documented along this stretch of Colima Road (Swift et al. 1993) and has been identified as the primary source of coyote mortality in the Chino Hills/Prado Basin area (Lyren 2001).

Historically, the underpass and property adjacent to it were utilized by rangers, various utility companies, and occasional trespassers (hikers, joggers, bicyclists, equestrian riders). Therefore, there was relatively little human influence at the underpass and in the surrounding habitat east and west of the underpass. However, we hypothesized that human activity would increase given the fact the property was opened to the public on Saturday, March 9.

The goal of this study is two-fold and will compare spatial and temporal responses of the wildlife community to recreation activities through comparison of 1) the relative abundance of species throughout the property and 2) species activity at the underpass before and after the property is opened for recreation. Specifically, it will determine if the rate activity along transects and through the underpass by the three target species (coyote, bobcat, and mule deer) changes in response to human activity throughout the property.

METHODS

Track and camera surveys were conducted on property managed by the PHLNHPA between August 2001 and July 2002 (Figure 1). Three 1000 m track transects were established along dirt roads throughout the study area (Figure 2). Sampling locations were selected based on previous studies (Haas & Crooks 1999). Both the East and West transects consisted of five scent stations spaced at approximately 250 m intervals; the Central transect consisted of four scent stations, with the midpoint of the transect represented by the underpass. So as not to influence species visiting the underpass, there

was no scent station placed at this location. Each scent station consisted of a 1 m^2 plot of finely sifted gypsum powder and a rock, placed in the middle of the station, baited with two artificial scent lures every other day (Russ Carman's Pro Choice and Canine Call). Stations were checked for visitation for five consecutive mornings. Tracks on the station were identified to species and the station was cleared and resifted. Scent stations were surveyed monthly between August 2001 and July 2002 (Table 1).

To obtain an index of relative abundance, the number of visits by each species was divided by the total sampling effort. This track index was calculated using the following equation:

$$I = \{v_j/(s_j n_j)\}$$

where, I = index of species activity at transect j
v_j = number of stations visited by species at transect j
s_j = number of stations in transect j
n_j = number of nights that stations were active in transect j

Any scent station in which tracks were too difficult to read was omitted from the sampling night. Thus, the true sampling effort was:

$$\{s_j n_j\} - o_j$$

where, o_j = number of omits in transect j

This index does not provide data on the absolute number of individuals. Instead, the index is used to compare relative abundance of species across space and time (Conner et al. 1983; Sargeant et al. 1998).

A remotely triggered digital camera (Game-Vu; Nature Vision, Inc., 521 Dogwood Drive, Baxter, MN, 56425) was stationed at the entrance to the underpass located along Colima Road, approximately 0.9 km north of Mar Vista. Batteries were checked at least every two weeks. An index of underpass use (camera index) was determined by dividing the number of photos of each species entering or exiting the underpass by the number of nights the camera was active.

Frequency of underpass use, however, may be partially a function of the relative abundance of target species in the vicinity of the underpass (Yanes et al. 1995; Clevenger & Waltho 2000). Thus, for each species, we accounted for differences in species abundance in the vicinity of each underpass (Yanes et al. 1995; Clevenger and Waltho 2000) by dividing the camera index by the average track index for the East and West transects; we did not include track indices from the Central transect since it spanned both sides of Colima Road. This ratio therefore weighted the frequency of underpass use by the relative abundance of that species within the adjacent habitat patches. We did not, however, conduct this analysis for any of the recreation activities. The reason for this is

due to the low probability of a human actually visiting a scent station. Although forms of human disturbance have been documented to scent stations previously (Haas & Crooks 1999), it is not in a consistent manner that would accurately reflect human abundance throughout the property.

To test the effects of recreation on underpass use by large and medium bodied mammals, we utilized a before-after approach to monitoring. The "before" portion of the study monitored underpass activity prior to the property being opened to the public (March 9, 2002) and represented "control" conditions. The "after" portion of the study continued for an additional five months thereafter. Sampling was concluded on July 31. 2002. We tested for differences in wildlife and human activity between these two periods at the track transects and underpass. Four types of activity were analyzed: 1) monthly activity at track transects, 2) monthly activity at the underpass, 3) weekday/weekend activity at the underpass, and 4) hourly activity at the underpass. For the first three types of activity, we used a Student's t-test to determine if there were differences in activity between the "before" and "after" sessions (Zar 1984). Weekly activity patterns (weekday rates vs. weekend rates) were pooled at monthly intervals and were compared in two fashions. First, we tested for differences between weekday and weekend rates using a paired sample t-test (Zar 1984). These analyses were conducted for both the "before" months and "after" months. Second, we tested for differences in weekly rates before and after the property was opened using a Student's t-test (Zar 1984). Thus, for this second test, two sets of analyses were conducted: differences in weekday rates before and after the opening and differences in weekend rates before and after the opening. To determine differences in hourly activity at the underpass before and after the property was opened, the day was broken into 4 periods: 24:00-6:00, 6:00-12:00, 12:00-18:00, and 18:00-24:00. For each month, we tallied the total number of passes by a species during each of the four 6-hour categories. A 4-factor Analysis of Variance (ANOVA) was used to determine if underpass use varied over the course of the day (Zar 1984). This analysis was conducted for both phases of the study.

Additionally, we recorded all incidental road killed large and medium bodied wildlife along the portion of Colima Road between Hacienda Boulevard and Mar Vista. Road kill surveys coincided with track survey dates, however additional road-killed individuals were reported by rangers between sampling dates. In these instances, the exact date of kill was unknown since there was no systematic survey conducted along the road. However, this data represents the minimum rate of road mortality along this stretch of road. Locations were marked with a GPS unit. Date of kill, lane direction (northbound or southbound), and, if possible, sex and age were recorded.

RESULTS

Nine wildlife species were detected at track transects throughout the property (Table 2). Domestic dogs and human and equestrian activity was also documented at several track stations. Prior to the property opening to the public, coyote, domestic dog, striped skunk, and rabbit were the four most common species detected at each transect. Seven species

(mule deer, coyote, raccoon, striped skunk, rabbit, squirrel, and domestic dog) were detected on all three transects. Bobcat activity was only recorded at the West and East transects and opossum and spotted skunk activity was recorded at the Central and East transects. After the property was opened to the public, coyote and domestic dog were the most frequent visitors to each transect. Five species (coyote, striped skunk, rabbit, squirrel and domestic dog), as well as hikers/runners, were detected on all three transects. Bobcat activity was recorded on the West and Central transects, opossum activity was recorded on the East transect, and spotted skunk activity was recorded on the Central and East transects.

When testing for differences in track indices at a transect before and after the opening of the property, only one species showed a decrease in activity: striped skunk on the Central transect ($t = 2.31$, $p = 0.043$, $df = 10$). Rabbit indices increased on both the East ($t = 4.81$, $p < 0.001$, $df = 10$) and West transects ($t = 3.94$, $p = 0.002$, $df = 10$). Hiker/runner activity increased on the West transect ($t = 3.18$, $p = 0.009$, $df = 10$). When pooling all three transects, thus analyzing the entire property as a whole, both rabbit and hiker/runner indices were significantly greater after the property was opened to the public (rabbit: $t = 2.83$, $p = 0.007$, $df = 34$; hiker/runner: $t = 2.31$, $p = 0.026$, $df = 34$,). Striped skunk activity declined after the opening ($t = 2.10$, $p = 0.043$, $df = 34$).

The camera monitored the underpass for a total of 292 camera nights. Four wildlife species were detected using the underpass, including mule deer, coyote, bobcat, and raccoon (Table 3). Domestic dogs and various forms of recreation (biking, horseback riding, and hiking/running) were also recorded. Domestic dog activity was recorded whether they were or were not accompanied by people and showed no correlation to hiker/runner activity before or after the opening of the property. Prior to the opening of the property, bobcats were the most frequent species traveling through the underpass, followed by, in decreasing level of activity, coyote, domestic dog, mule deer, and raccoon. However, hiking/running activity was higher than bobcat activity. Bobcats remained the most frequent species using the underpass after the property was opened. Other species detected at the underpass during this period included, in decreasing activity, coyote, domestic dog, and mule deer; raccoons were not detected at the underpass during the last five months. Similar to activity levels prior to the property being opened, hiking/running activities were higher than bobcat activity. The only significant difference in underpass activity before and after the opening of the property was that of hiking/running, which was higher after the property was opened ($t = 3.27$, $p = 0.009$, $df = 9$).

No species showed a difference in weekday or weekend activity at the underpass either before or after the property was opened to the public. However, hiker/runner activity through the underpass was higher during the weekdays after the underpass was opened ($t = 2.19$, $p = 0.055$, $df = 9$).

Prior to the property being opened to the public, all wildlife species using the underpass did so with equal frequency throughout the entire day. Thus, the frequency of underpass

use was similar during each of the four 6-hour periods. Alternatively, bikers, hikers/runners, and domestic dogs frequency of underpass use was greater during the "daylight" (6:00-12:00 and 12:00-18:00) hour categories than the "nocturnal" (18:00-24:00 and 24:00-6:00) hour categories (bikers: $F = 7.91$, $p = 0.001$, $df = 23$; hikers/runners: $F = 13.24$, $p < 0.001$, $df = 23$; domestic dogs: $F = 5.36$, $p = 0.007$, $df = 23$). After the opening of the property, hiking/running frequencies during the 6:00-12:00 and 12:00-18:00 hour categories were greater than the frequencies during the 18:00-24:00 and 24:00-6:00 hour categories ($F = 7.37$, $p = 0.002$, $df = 19$) (Figure 3). Biker frequency during the 12:00-18:00 hour categories was greater than the frequencies during the 18:00-24:00 and 24:00-6:00 categories ($F = 4.127$, $p = 0.024$, $df = 19$). Two wildlife species showed differences in hourly underpass use after the property was opened: coyote and mule deer. Coyote frequency of underpass use during the 24:00-6:00 hour category was greater than the frequencies of use during both the 6:00-12:00 and 12:00-18:00 hour categories ($F = 7.94$, $p = 0.001$, $df = 19$) (Figure 4). In addition, coyote frequency of underpass use during the 18:00-24:00 hour category was greater than use during the 12:00-18:00 hour category. Mule deer activity was higher during the 6:00-12:00 hour category than the 12:00-18:00 hour category (Figure 5).

Seven road-killed animals were detected along Colima Road, including coyote (4 individuals), striped skunk (2 individuals), and mule deer (1 individual) (Table 4). All four coyotes and the mule deer were located in the southbound lane. Figure 6 depicts locations of road kill along Colima Road.

DISCUSSION

As predicted, there was a significant increase in level of hiking/running activities subsequent to the opening of the property in March. Prior to March, human visits to track transects was relatively low; the West transect did not receive a single "visit" to a track station. Again, track stations did not specifically target humans, and are not an adequate indicator of human abundance relative to other species; however we assumed that humans were neither more or less likely to "visit" a track station after the property was opened. Therefore, given the similarity in detection probability of humans over the course of this study, we could justify comparing visitation rates before and after the property was opened to the public.

In contrast to indices at track stations, hiking/running indices at the underpass, prior to March, were higher than any other species index, indicating that there was already a high level of human activity through the underpass, even before the property was opened to the public. This level of human activity is especially high given the fact that Haas and Crooks (1999) did not document any human activity through the underpass several years ago. With the influx of people recreating after March 9, the rate of human activity through the underpass increased two-fold; it was the only underpass index that increased after the opening of the property. The rate of hiking/running activities through the underpass was greater during weekdays following the opening than during weekdays

prior to opening; there was no difference in the weekend rates for these activities during these two periods.

Given the significant increase in human activity across the property and at the underpass, the target species showed no positive or negative responses in either their spatial (as evidenced by the track transect and underpass visits) or temporal (as evidenced by the weekly and daily activity rates and patterns) distribution. Coyote indices at track transects were consistently high, and contributed the greatest number of visits to all transects during both phases of the study. Bobcat indices at transects were more variable; however they were documented on all three transects. Of particular interest was the fact that the Central transect, which occupied both side of Colima Road, documented bobcat activity during only one of the twelve months it was sampled (Mar-02). However the underpass, located at the midpoint of this transect, received high levels of bobcat activity. While it is difficult to explain this response, one possible explanation is that bobcats are spending less time in the immediate vicinity of the roadway, thus "ignoring" baited track stations as they attempt to quickly move from one side of the road to the other. This type of movement is also one possible explanation as to the variability in bobcat hourly activity through the underpass (Figure 7). Alternatively, in areas further removed from the effects of the roadway (i.e. East and West transects), bobcat activity (i.e. hunting, breeding) may be greater, thus subjecting them to more frequent encounters with track stations. Two wildlife species showed a change in visitation to track transects before and after the property was opened. Rabbit indices were greater during the months after the opening; striped skunk indices were greater during months before the opening. However, it is unlikely that this is a direct effect from the increase in human activity.

The three target species showed no increase or decrease in activity through the underpass after the property was opened. Human activity has been documented as having detrimental impacts on the movement of large mammals through roadway crossing structures (i.e. wildlife underpasses, culverts, bridges) (Clevenger & Waltho 2000). However, in such a highly urbanized area, bobcats and coyotes may be adapting strategies to cope with human presence. The fact that bobcats and coyotes may be adapting to these potential anthropogenic pressures is independent of the fact that these species still require larger areas in order to persist. This is particularly true in highly fragmented areas, where these species may need to navigate across roadways in order to satisfy daily and seasonal requirements. It is these requirements in which the potential effects of human activity become important; if animals are unable to utilize crossing structures under roadways, they are faced with either limiting their movements to areas away from human activity (thus reducing their home range size) or they are put into direct contact with vehicles (subjecting them to road mortality). Therefore, it is critical that bobcat and coyote movement through the Colima Road underpass is maintained despite the increases in human activity throughout the surrounding area. For the purposes of this study, that critical movement was maintained in light of significant increases in human activity through the underpass. Mule deer have often benefited from fragmentation and have increasingly become problematic in many urbanized localities (Noss and Cooperrider 1994). However, in highly fragmented areas they occur in

smaller, more isolated metapopulations that are more at risk to local extinctions. Therefore, although mule deer have adapted well to urbanized localities, their long-term persistence ultimately depends on their ability to disperse successfully between fragmented patches of habitat. Like bobcats and coyotes, mule deer activity through the underpass was not affected by the increase in human activity during the course of this study.

One interesting aspect of this study is the detection of spotted skunk and absence of gray fox. Haas and Crooks (1999) reported high levels of gray fox activity through the underpass and at track transects; alternatively no spotted skunks were detected during the study (1997-1999). During this study, spotted skunks were detected on both the Central and East transects. Furthermore, previous research documented no coyote activity through the underpass (Haas & Crooks 1999). However, coyote activity through the underpass during this study was relatively high. An increase in coyote activity can cause a temporal or spatial avoidance by gray fox (Crooks & Soulé 1999). Finally, no domestic dogs were detected through the underpass during previous studies (Haas & Crooks 1999). However, although new "visitors" to the underpass, domestic dog activity did not significantly increase or decrease at the underpass (or at the track transects) after the property was opened.

Another interesting point is the high proportion of road-killed animals on the southbound lane of Colima Road. This could be due to the high speed of traffic traveling down from the crest of the hill to the north or the differences in topography along the east and west side of the road. The fact that the habitat on the west side of the road is relatively level with the southbound side of Colima Road, whereas the habitat along the east side is below the grade of Colima Road may explain differences in road kill locations. Such differences are a possible explanation for the same trends along CA 71 between Chino Hills State Park and Prado Flood Control Basin (Lyren 2001). Although it is impossible to assess the impact of road kill mortality on the coyote population in a study of this nature, Lyren (2001) found that that juvenile and yearling coyotes were killed significantly more than adults. In this study, one juvenile coyote was killed along Colima Road.

Due to the fact that road kill mortality plays a significant role at removing juveniles from the population, it is important to ensure that these individuals continue to utilize the underpass. Of particular concern is the movement of juveniles in an east to west direction across Colima Road, as these individuals represent (on a regional scale) the source population from which genetic diversity west of Colima Road is dependent on. Although the camera documented which species were utilizing the underpass, it was unable to distinguish the sex, age, and social status of individuals traveling through the underpass. Such information is important in determining the level of interaction between populations on either side of Colima Road, and is best obtained through telemetry studies. Ideally, future studies should be aimed at determining the demographic characteristics of target species utilizing the underpass, the dispersal distances and success of juveniles in the population, and the reproductive success of individuals. In this

study, yearling activity was visually documented by the observation of 1) coyote pup visits to track stations and 2) three bobcat kittens with an adult female.

The western Puente Hills are surrounded by extensive urbanization to the north and south; to the west lies a tenuous link to the San Gabriel River via San Jose Creek, and it is unknown whether predators are navigating this route. Thus, the connection across Colima Road represents the most likely route for dispersing individuals to enter or exit the portions of habitat west of Colima Road. The long-term effects of inactivity by top predators like coyotes and bobcats across Colima Road, and specifically through the underpass, would likely cause the isolation and subsequent localized extinction of the predator population west of Colima Road. The disappearance of large predators from fragmented systems may have community-level implications, leading to the ecological release of mesopredators and alterations of prey communities (Crooks 1999; Henke & Bryant 1999; Terborgh et al. 1999).

CONCLUSION

In conclusion, the rate of human activity through the underpass increased significantly after the property was opened. Consequently, underpass use by the three target species (bobcat, coyote, and mule deer) did not differ from those rates prior to the property being opened to the public (August 2001-February 2002). However, the rate of activity documented in this study may have been affected by the onset of human activity between 1999 and September 2001, since no human or domestic dog activity was documented during surveys between 1997-1999 (Haas & Crooks 1999). However, it is impossible to conclude if the increase in human and domestic dog activity through the underpass between 1999 and September 2001 impacted the rate of bobcat, coyote, and mule deer movement documented during the previous study. The 1997-1999 surveys were not designed to test the potential impacts of recreation on wildlife activity through the underpass, and thus were not as intensive as the surveys conducted in this study. Therefore, we cannot determine whether or not the increase in human activity between 1999 and September 2001 had a detrimental impact on wildlife use of the underpass.

Future expansions in additional public access points and potential increases in various forms of human recreation locally (within the property) or regionally (at other parks surrounding the property) should still be met with caution. Whereas, local increases in recreation may serve to influence future mammalian movement patterns, increases in recreation at surrounding parks east and west of Colima Road may also influence movement, since people may utilize the property and underpass to gain access to other parks across the Puente-Chino Hills. We recommend monitoring of the underpass and the surrounding habitat in the future should recreation activities increase or expand over the next several years, as this area is an important link for connectivity across the Puente Hills.

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Table 1. Survey dates and total station nights for track transects.

Sample Period	*Start Date*	*End Date*	*Transect*	*Total Station Nights* [1]
1	08/21/2001	08/25/2001	West	25
			Central	20
			East	25
2	09/25/2001	09/29/2001	West	25
			Central	20
			East	25
3	10/23/2001	10/27/2001	West	25
			Central	20
			East	25
4	11/27/2001	11/29/2001[2]	West	15
			Central	12
			East	15
5	12/17/2001	12/20/2001[2]	West	20
			Central	16
			East	20
6	01/17/2002	01/21/2002	West	25
			Central	20
			East	25
7	02/14/2002	02/16/2002[2]	West	15
			Central	12
			East	15
8	03/11/2002	03/15/2002	West	25
			Central	20
			East	25
9	04/23/2002	4/23/2002[2]	West	5
			Central	4
			East	5
10	05/14/2002	05/18/2002	West	25
			Central	20
			East	25
11	06/11/2002	06/15/2002	West	25
			Central	20
			East	25
12	07/16/2002	07/20/2002	West	25
			Central	20
			East	25

[1] Total station nights = total stations per transect * total sampling nights (West = 5 stations; Central = 4 stations; East = 5 stations).

[2] Sampling period shortened due to rain.

Table 2. Track indices for species detected at transects on the east and west sides of Colima Road. Although scent stations did not target horses and hikers/runners, we present indices for each type of activity. No bikes were detected at track transects. Indices were averaged for sampling periods before (Aug-01 - Feb-02) and after (Mar-02 - Jul-02) public access. Each index is a function of the number of station visits to the transect divided by the number of stations in the transect and the number of nights that the stations were active (see Methods). Index values range from 0 to 1 and represent a species rate of visitation to the transect. An index of "1.000" would indicate that a species visited every station of the transect on every night that the transect was operated.

Transect/Month		*Deer*	*Coyote*	*Bobcat*	*Raccoon*	*Opossum*	*Striped Skunk*	*Spotted Skunk*	*Rabbit*	*Squirrel*	*Dog*	*Horse*	*Hiker/Runner*	*Human Activity*[1]
West	Aug-01	0.120	0.440	0.000	0.000	0.000	0.120	0.000	0.200	0.000	0.560	0.000	0.000	0.560
	Sep-01	0.000	0.500	0.042	0.000	0.000	0.000	0.000	0.250	0.083	0.583	0.000	0.000	0.583
	Oct-01	0.000	0.545	0.091	0.045	0.000	0.000	0.000	0.136	0.000	0.364	0.000	0.000	0.364
	Nov-01	0.000	0.857	0.000	0.000	0.000	0.143	0.000	0.071	0.000	0.214	0.000	0.000	0.214
	Dec-01	0.000	0.688	0.000	0.000	0.000	0.063	0.000	0.188	0.063	1.000	0.000	0.000	1.000
	Jan-02	0.000	0.840	0.080	0.040	0.000	0.160	0.000	0.240	0.000	0.400	0.000	0.000	0.400
	Feb-02	0.000	0.800	0.000	0.000	0.000	0.267	0.000	0.400	0.000	0.067	0.000	0.000	0.067
Avg Track Index:		**0.017**	**0.667**	**0.030**	**0.012**	**0.000**	**0.107**	**0.000**	**0.212**	**0.021**	**0.455**	**0.000**	**0.000**	**0.455**
	Mar-02	0.000	0.429	0.048	0.048	0.000	0.048	0.000	0.381	0.048	0.286	0.000	0.048	0.333
	Apr-02	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.750	0.000	0.250	0.000	0.000	0.250
	May-02	0.043	0.435	0.000	0.000	0.000	0.043	0.000	0.609	0.000	0.391	0.000	0.087	0.478
	Jun-02	0.000	0.560	0.000	0.000	0.000	0.120	0.000	0.320	0.000	0.360	0.000	0.120	0.480
	Jul-02	0.000	0.375	0.000	0.042	0.000	0.042	0.000	0.583	0.083	0.542	0.000	0.208	0.750
Avg Track Index:		**0.009**	**0.560**	**0.010**	**0.018**	**0.000**	**0.051**	**0.000**	**0.529**	**0.026**	**0.366**	**0.000**	**0.093**	**0.458**
Central	Aug-01	0.105	0.368	0.000	0.000	0.053	0.105	0.000	0.000	0.105	0.421	0.000	0.000	0.421
	Sep-01	0.000	0.611	0.000	0.000	0.000	0.056	0.000	0.056	0.111	0.611	0.000	0.000	0.611
	Oct-01	0.000	0.400	0.000	0.000	0.000	0.050	0.000	0.200	0.000	0.500	0.000	0.000	0.500
	Nov-01	0.000	0.583	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.417	0.083	0.000	0.500
	Dec-01	0.000	0.667	0.000	0.000	0.000	0.167	0.083	0.000	0.000	0.833	0.000	0.000	0.833
	Jan-02	0.000	0.900	0.000	0.050	0.050	0.150	0.000	0.050	0.000	0.450	0.000	0.000	0.450
	Feb-02	0.000	0.769	0.000	0.000	0.000	0.154	0.000	0.154	0.000	0.308	0.000	0.077	0.385
Avg Track Index:		**0.015**	**0.614**	**0.000**	**0.007**	**0.015**	**0.097**	**0.012**	**0.066**	**0.031**	**0.506**	**0.012**	**0.011**	**0.529**
	Mar-02	0.040	0.640	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.280	0.000	0.000	0.280
	Apr-02	0.000	0.600	0.000	0.000	0.000	0.000	0.200	0.000	0.200	0.200	0.000	0.000	0.200
	May-02	0.000	0.320	0.000	0.000	0.000	0.040	0.000	0.160	0.000	0.000	0.000	0.000	0.000
	Jun-02	0.000	0.360	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.600	0.000	0.160	0.760
	Jul-02	0.000	0.480	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.400	0.000	0.000	0.400
Avg Track Index:		**0.008**	**0.480**	**0.008**	**0.000**	**0.000**	**0.024**	**0.040**	**0.032**	**0.048**	**0.296**	**0.000**	**0.032**	**0.328**
East	Aug-01	0.000	0.739	0.043	0.087	0.043	0.435	0.087	0.000	0.043	0.913	0.000	0.000	0.913
	Sep-01	0.080	0.600	0.000	0.080	0.080	0.160	0.000	0.120	0.040	0.360	0.120	0.000	0.480
	Oct-01	0.083	0.750	0.000	0.000	0.042	0.208	0.000	0.000	0.042	0.375	0.000	0.000	0.375
	Nov-01	0.000	0.917	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.000	0.000	0.167
	Dec-01	0.000	0.615	0.000	0.000	0.000	0.231	0.000	0.000	0.000	0.615	0.000	0.077	0.692
	Jan-02	0.000	0.870	0.043	0.000	0.000	0.217	0.000	0.000	0.000	0.435	0.000	0.000	0.435
	Feb-02	0.000	0.800	0.067	0.000	0.000	0.133	0.067	0.067	0.000	0.267	0.000	0.067	0.333
Avg Track Index:		**0.023**	**0.756**	**0.022**	**0.024**	**0.024**	**0.198**	**0.022**	**0.027**	**0.018**	**0.447**	**0.017**	**0.021**	**0.485**
	Mar-02	0.000	0.667	0.000	0.000	0.000	0.067	0.133	0.067	0.000	0.867	0.000	0.000	0.867
	Apr-02	0.000	1.333	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.333	0.000	0.333	0.667
	May-02	0.000	0.700	0.000	0.050	0.050	0.100	0.000	0.250	0.000	0.500	0.000	0.000	0.500
	Jun-02	0.000	0.895	0.000	0.000	0.000	0.211	0.053	0.263	0.053	0.842	0.000	0.000	0.842
	Jul-02	0.000	1.000	0.000	0.000	0.000	0.250	0.000	0.350	0.050	0.550	0.000	0.000	0.550
Avg Track Index:		**0.000**	**0.919**	**0.000**	**0.010**	**0.010**	**0.125**	**0.037**	**0.253**	**0.021**	**0.618**	**0.000**	**0.067**	**0.685**

[1] Human activity = combined dog, horse, and bike/runner visits to track stations

Table 3. Camera indices for species detected at the Colima Road underpass before (Sep-01 - Feb-02) and after (Mar-02 - Jul-02) public access. Indices for each native species and domestic dogs were weighted against the average indices for those species at track transects on the east and west sides of Colima Road.

Month	*Deer*	*Coyote*	*Bobcat*	*Raccoon*	*Dog*	*Bike* [1]	*Horse* [1]	*Hiker/Runner* [1]	*Human Activity* [2]
Sep-01	0.337	0.129	0.245	0.000	0.170	0.200	0.100	1.250	1.720
Oct-01	0.124	0.020	0.154	0.000	0.165	0.032	0.000	0.806	1.003
Nov-01	0.000	0.177	0.200	0.000	0.252	0.267	0.167	0.633	1.319
Dec-01	0.000	0.234	0.258	0.000	0.232	0.226	0.032	0.581	1.071
Jan-02	0.000	0.556	0.790	0.000	0.228	0.097	0.419	0.839	1.582
Feb-02	0.000	0.608	0.415	0.048	0.326	0.333	0.524	0.714	1.898
Avg camera index:	**0.077**	**0.287**	**0.344**	**0.008**	**0.229**	**0.192**	**0.207**	**0.804**	**1.432**
Mar-02	0.065	0.438	0.882	0.000	0.389	0.258	0.452	2.645	3.744
Apr-02	0.133	0.246	0.633	0.000	0.284	0.133	0.300	1.933	2.650
May-02	0.196	0.204	0.040	0.000	0.083	0.080	0.360	1.160	1.683
Jun-02	0.333	0.354	0.111	0.000	0.174	0.167	0.000	1.278	1.618
Jul-02	0.226	0.287	0.032	0.000	0.063	0.032	0.129	1.419	1.643
Avg camera index:	**0.191**	**0.306**	**0.340**	**0.000**	**0.198**	**0.134**	**0.248**	**1.687**	**2.268**

[1] Camera indices were not weighted against indices at track transects since scent stations did not target these types of activities.

[2] Human activity = combined dog, bike, horse, and hiker/runner indices

Table 4. Sex, age, and location of road kill species detected on Colima Road between August 2001 and July 2002.

Date	*Species*	*Sex*[1]	*Age*	*Lane*[2]	*DEG.DEC.N*	*DEG.DEC.W*	*General Location*
Sep-01	Coyote		A	SB	33.9721	117.99006	Approximately 1.0 mile north of Mar Vista Street
Sep-01	Coyote		A	SB	33.9721	117.99006	Approximately 1.0 mile N of Mar Vista
Sep-01	Deer		A	SB	33.96623	117.99977	50 ft. N of Arroyo Pescadero parking lot
11/1/2001[3]	Coyote			SB			Nof Mar Vista between mile markers 1.00 & 1.25
1/4/2002[3]	Striped Skunk			NB			0.25 mile N of Mar Vista
1/18/2002[3]	Striped Skunk			?			Approximately 50 feet Sof Carretera Drive
06/12/2002	Coyote	F	J	SB	33.96825	117.99485	0.5 mile N of Mar Vista

[1] For unaged individuals, sex not determined due to condition of animal

[2] SB = Southbound; NB = Northbound

[3] incidental road kills collected by rangers

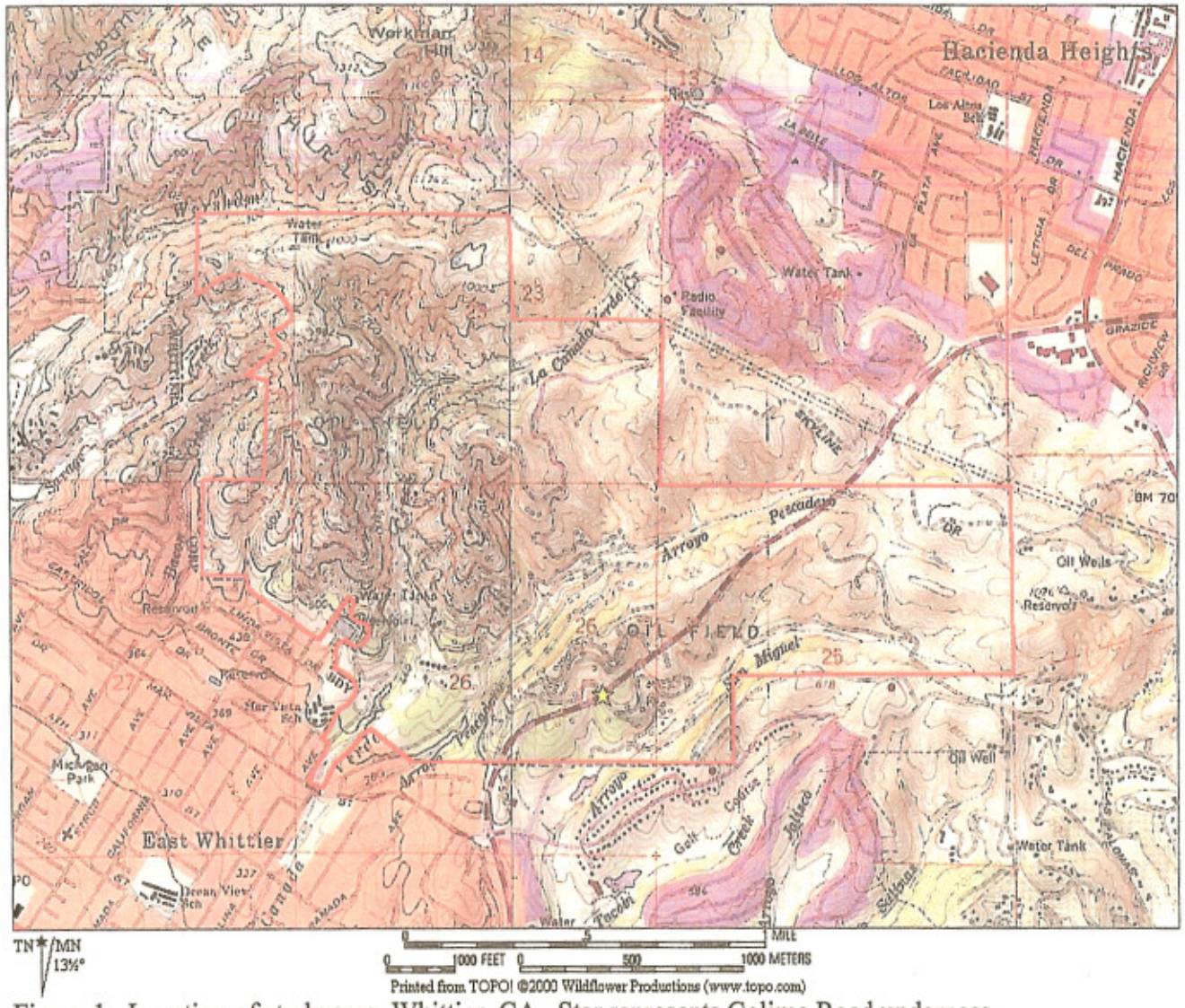

Figure 1. Location of study area, Whittier, CA. Star represents Colima Road underpass.

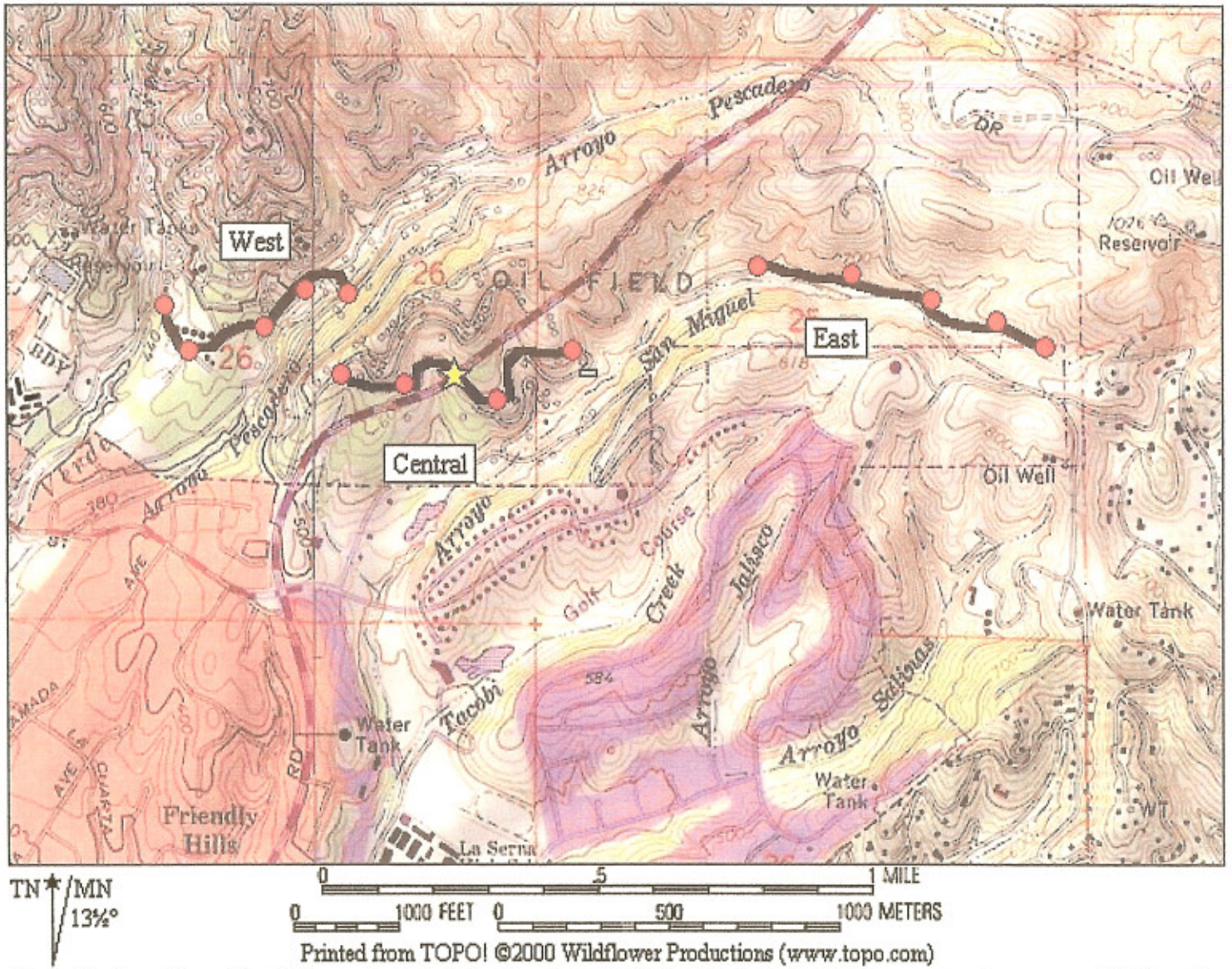

Figure 2. Location of track transects (black line) and scent stations (red circles). Star represents camera at Colima Road underpass.

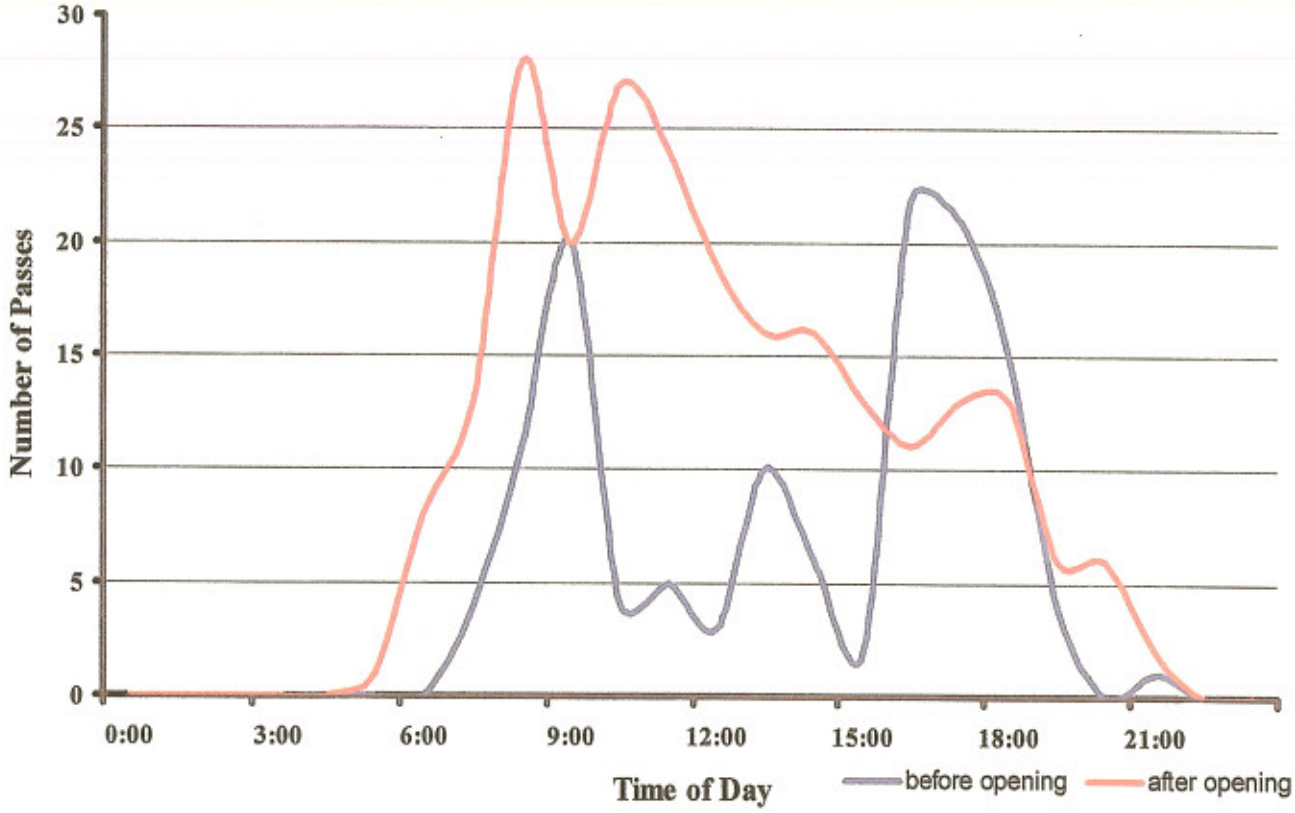

Figure 3. Hourly hiker/runner activity through the Colima Road underpass before and after the opening of the property.

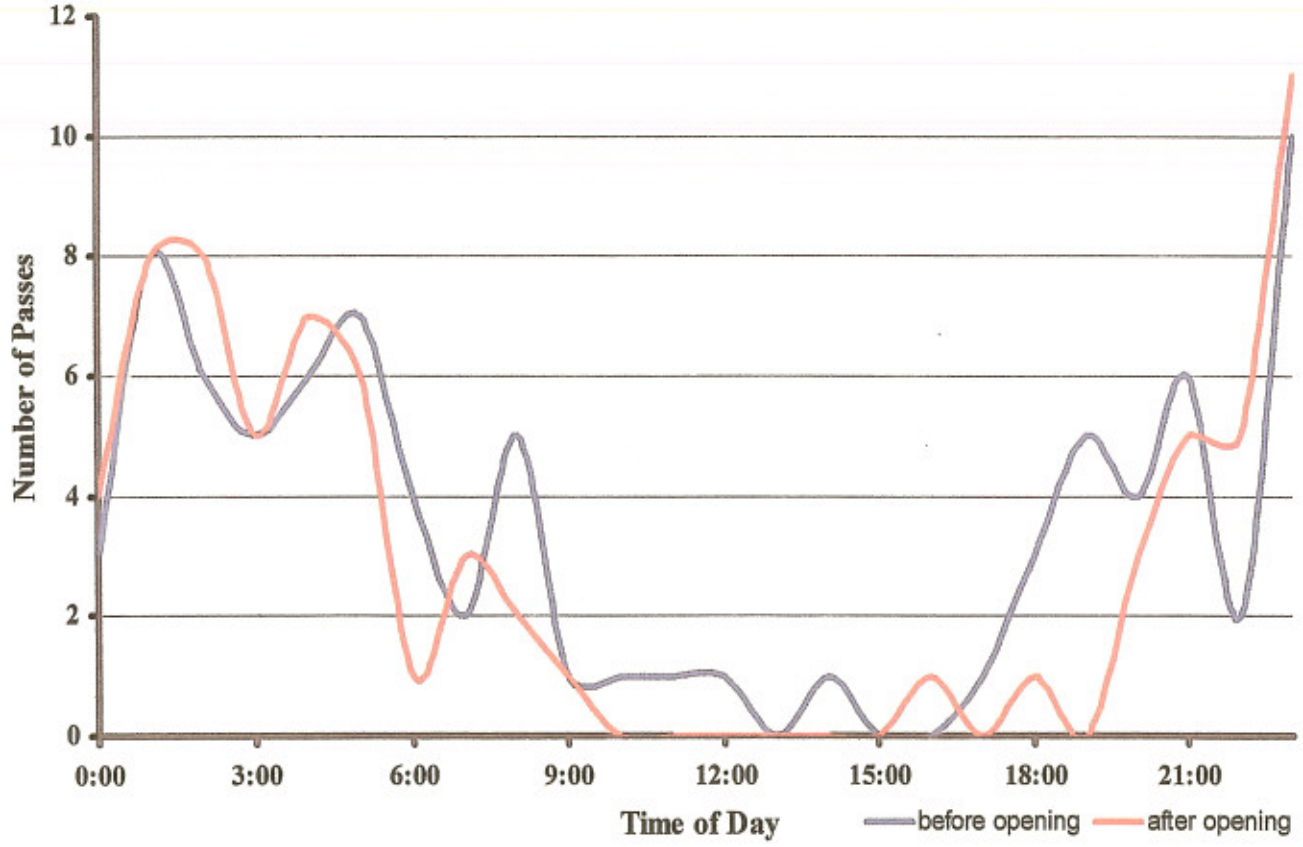

Figure 4. Hourly coyote activity through the Colima Road underpass before and after the opening of the property.

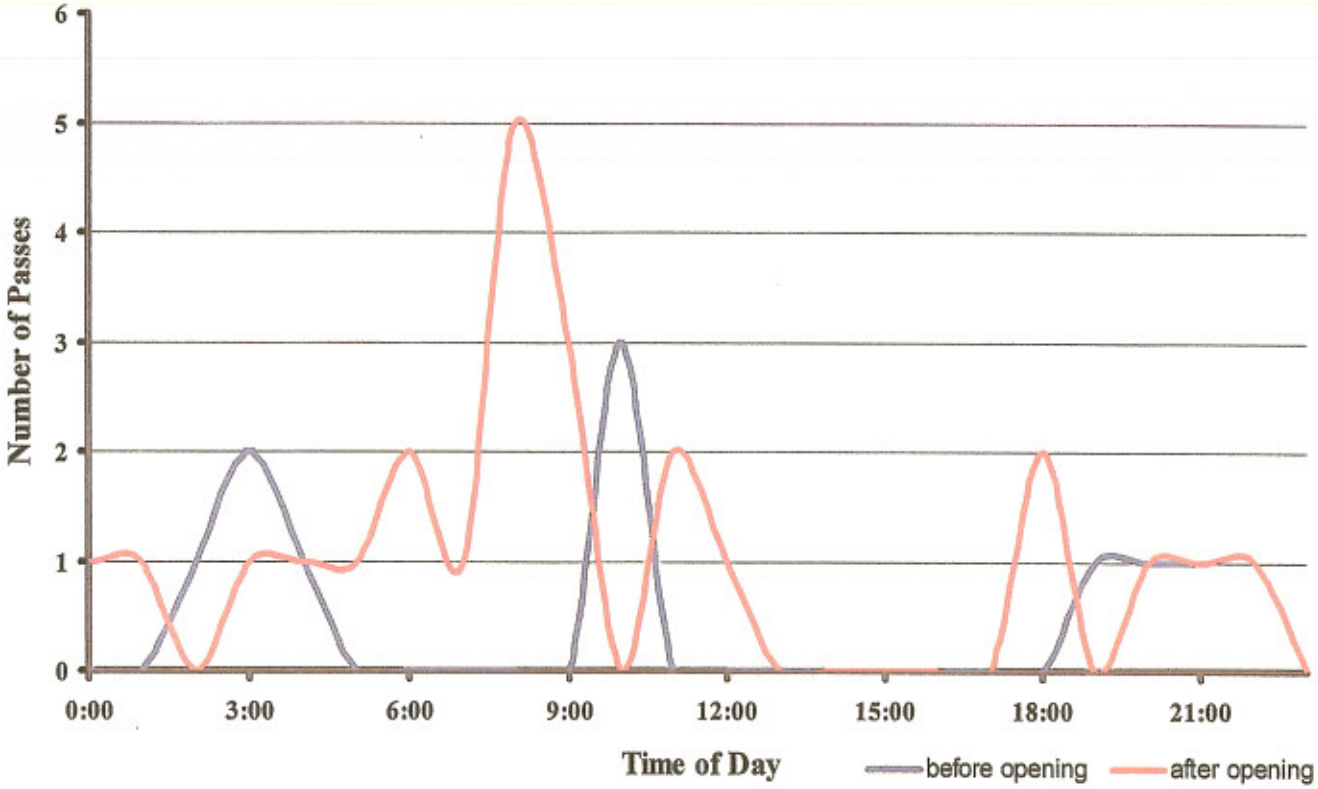

Figure 5. Hourly mule deer activity through the Colima Road underpass before and after the opening of the property.

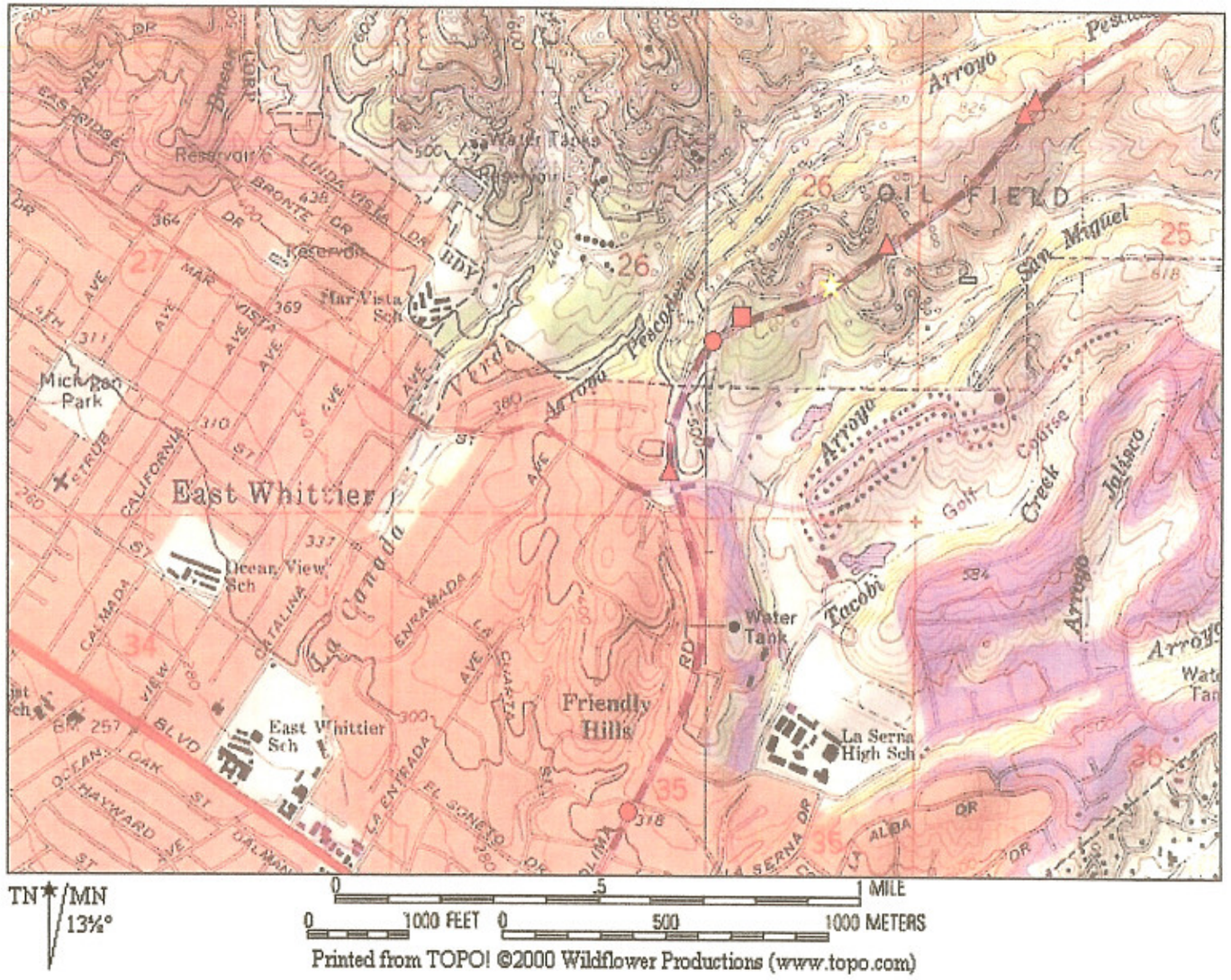

Figure 6. Road kill locations of coyotes (triangles), striped skunks (circles), and mule deer (squares) along Colima Road. Star represents Colima Road underpass.

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