Changes in Large and Medium-bodied Mammal Activity Following Eight Years of Recreation and Other Activities: The Colima Road Underpass and Vicinity

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BACKGROUND

The Puente Hills Preserve (Preserve) was established in 1994 and is managed by the Puente Hills Landfill Native Habitat Preservation Authority (Habitat Authority). The Preserve is located at the western terminus of the Puente-Chino Hills Wildlife Corridor, a corridor recognized for its regional significance to wildlife movement and habitat connectivity. The center of the Preserve contains property that is owned by the City of Whittier, which was acquired in 1995 from Chevron Oil Company. In 2002, a portion of this area was formally opened to public recreational access, and it supports several multi-use trails including the Arroyo Pescadero Trail, the Deer Loop, and the Arroyo San Miguel Trail, which leads under Colima Road through an old oil company service tunnel. See Figure 1 for a regional map. Another portion west of these trails, the Core Habitat, remains closed to public access for wildlife.

In 2001 and 2002, the U.S. Geological Survey (USGS) conducted a study of the existing service tunnel under Colima Road (previously used by oil companies) and vicinity to compare wildlife use immediately before and after the area was opened to recreational use in March 2002 (USGS 2002). This study found that the rate of use by the three target species (bobcat, coyote and deer) did not change significantly; however, there was a shift toward increased nocturnal activity by coyotes and deer. The lack of a change in activity by the target species was attributed, in part, to the fact that recreational activity was already occurring in the area before it was officially opened to public use. Currently, the Arroyo Pescadero trailhead is one of the most popular trailheads in the Puente Hills Preserve (Martino et al. 2006) and the long-term effects to wildlife from the recreational use of this area have not been evaluated.

Other activities have occurred in the area that may have also affected wildlife activity. In early 2008, the Los Angeles County Fire Department conducted a large-scale removal of eucalyptus trees on both sides of Colima Road in the vicinity of the tunnel; habitat restoration has been initiated in the area east of the tunnel for a coastal sage scrub mitigation project (seeding/planting to be implemented in winter 2009-2010). The area immediately west of the tunnel has not been restored, as a proposed oil facility has been proposed at this location, as well as other locations to the west in Arroyo Pescadero and the Core Habitat. An understanding of current wildlife activity in this area, as well as the effects to wildlife from increased recreation and other activities, may help to predict possible future impacts to wildlife activity from additional human activity, such as oil drilling activities. In addition, this study conforms to recommendations made in the Preserve's Resource Management Plan (RMP), which suggests that wildlife movement studies be conducted every five years to confirm the movement of animals across or through the Preserve, the results of which will allow Preserve managers to redirect or focus additional studies or actions (2007).

Figure 1. Regional Map of the Puente Hill Preserve

This study was conducted to determine the change in wildlife activity in the area over the past eight years and to evaluate the effectiveness of the Colima Service Tunnel for wildlife movement, considering the increase in recreational use and past and current management activities. In addition, this study was conducted to collect baseline data in the area, in the event that the proposed oil project is implemented, to predict impacts to wildlife movement, to make recommendations for resource management, and to compare against any future data to evaluate changes in wildlife activity from the oil project.

METHODS

For consistency and comparability with the previous USGS Colima Underpass study (USGS 2002), the methods used in that study were repeated in the current study. This study consisted of two major components, which are discussed separately below: Track Transects and Camera Stations.

Track Transects

This method involved the same three track transects used in 2001-02 (East, Central and West transects), located along the Arroyo San Miguel and Arroyo Pescadero trails (with one centered on the Colima tunnel) (Figure 2). This year, a fourth transect was added in the Core Habitat (Core transect). The track transects were 1,000 meters long with a track station placed at 250 meter intervals, for a total of 5 track stations per transect. Each track station consisted of a one square meter plot covered with white gypsum powder and a rock placed in the center baited with two artificial scent lures every other day (Carman's Pro Choice and Canine Call). Track stations were checked to five consecutive mornings, where each track was identified to species and then the station was cleared and reset. Some survey periods were less than five days due to rain (Appendix A). Track transects were surveyed monthly from November 2009 through October 2010.

To obtain an index of relative abundance, the number of visits by each species was divided by the total sampling effort. The track index for each month 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 track station in which the 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

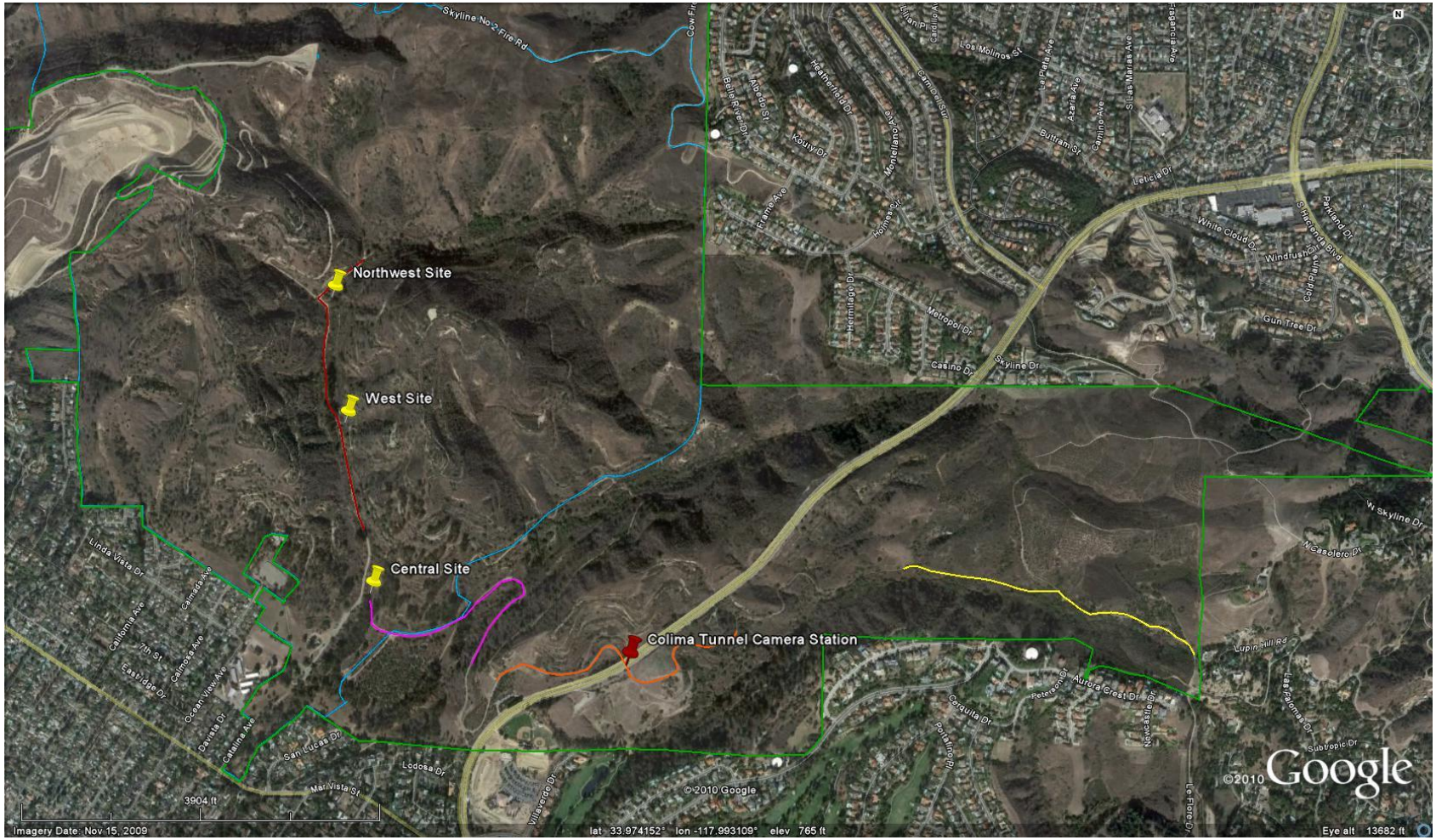


Figure 2. Locations of Track Transects and Camera Stations. *(Transects (lines): East – yellow, Central – Orange, West – Purple, Core – Red. Camera Stations (pins): Core Habitat – Yellow, Colima Service Tunnel – Red. Preserve Boundary – Green, Core Habitat area – Blue.)*

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.

For comparison between 2001-02 data and 2009-10 data, paired t-tests were used. For comparison between the Core transect and the three original transects (West, Central and East), unpaired t-tests of equal variance were used.

Camera Stations

Consistent with the previous USGS study, one motion-sensor digital infrared camera (Leaf River IR-3BU) was set at the entrance to the Colima Service Tunnel along the Arroyo San Miguel trail. However, an additional camera was also used in the Core Habitat area, and was rotated monthly between three different stations: the Central, West, and Northwest sites. The cameras captured photographs on a 24-hour cycle, and photographs were downloaded and batteries were checked and/or replaced weekly.

A camera index was determined per species per month by dividing the number of photos of each species (entering/exiting the tunnel or passing by the Core Habitat camera) by the number of nights the camera was active; see Appendix A for a summary of nights per month that the cameras were active. Consistent with the USGS study, camera indices for each species at the Colima Service Tunnel were divided by the average track index for the East and West track transects[1], resulting in a weighted camera index.

For comparison between 2001-02 data and 2009-10 data, paired t-tests of the weighted camera indices were used.

Roadkill Data

Observations of roadkill along Colima Road have been regularly reported by Habitat Authority Staff and Rangers since 2008, with the date of observation, detailed location (GPS coordinates as possible), species and age (if possible). Prior to that, California State University Fullerton conducted weekly roadkill surveys along Colima Road as part of a monitoring study for the Harbor Boulevard Wildlife Underpass (Elliott and Stapp 2008; Stapp and Cashin 2009), from July 2004 through June 2007, and then from July 2008 through June 2009.

RESULTS

Track Transects

Original Transect Data Compared with Current Data

Ten wildlife species were detected at track transects during the current study; see Appendix B for all transect data per month per species. Domestic dogs and humans were

[1] The average of the East and West track index per species was added to by 1.0 for normalization, as was done with the previous USGS study analysis (Chris Haas, personal communication).

also detected at all transects, even at the Core transect where public access is prohibited (although to a much smaller degree); however, due to the placement of warning signs at all track stations in 2009-10, dog and human activity was less than in 2001-02 and does not allow for an accurate comparison. Seven of the wildlife species were detected at all transects (coyote, bobcat, raccoon, striped skunk, rabbit, ground squirrel and gray fox). Deer activity was not detected at the East transect stations, opossum was not detected at the East or West transect stations, and spotted skunk was not detected at the West transect stations. Coyote was the most frequent visitor to all transects in both 2001-02 and 2009-10. The second most frequent visitor to all transects in 2001-02 was domestic dog, but in 2009-10 was rabbit; the decrease in dog visitation is likely due to signs that were placed at each track station in 2009-10 asking hikers to keep away from the stations, which may not have been used in 2001-02. The least frequent visitors to the track transects in 2009-10 (in order of least to most) were gray fox, deer, opossum, raccoon, and spotted skunk. These species were also the least frequent in 2001-02, except that gray fox was not observed, and instead bobcat was one of the least frequent visitors.

When testing for differences in track indices at individual transects in 2001-02 and 2009-10, only four species showed a significant change in activity: bobcat increased at the West transect ($t = 4.16$, $p = 0.002$, $df = 11$), striped skunk decreased at the East transect ($t = 2.58$, $p = 0.0256$, $df = 11$), rabbit increased at the Central transect ($t = 5.02$, $p = 0.0004$, $df = 11$) and East transect ($t = 4.75$, $p = 0.0006$, $df = 11$), and ground squirrel also increased at the Central transect ($t = 2.99$, $p = 0.0123$, $df = 11$) and East transect ($t = 3.74$, $p = 0.0033$, $df = 11$).

When all three of the original transects are combined (West, Central, East), five species showed a significant change in activity between 2001-02 and 2009-10 (Table 1): bobcat increased ($t = 3.97$, $p = 0.0033$, $df = 35$), coyote decreased ($t = 2.28$, $p = 0.086$, $df = 35$), rabbit increased ($t = 3.89$, $p = 0.0004$, $df = 35$), and ground squirrel increased ($t = 4.76$, $p = 0.0000$, $df = 35$). Although gray fox also showed a significant increase, it had such infrequent visitation (as reflected by the very low track indices) that further analysis is not useful, other than to note that it was not observed in 2001-02 but was observed in 2009-10. No other species exhibited large or significant changes.

The most significant trends are for coyotes and bobcats, as medium to large carnivores are the focus of this study, and the track stations were designed to attract them as opposed to small mammals and herbivores (such as rabbits and ground squirrels). As such, deer are also not the focus of the track transects; therefore, data regarding deer is addressed later under the Camera Data discussion.

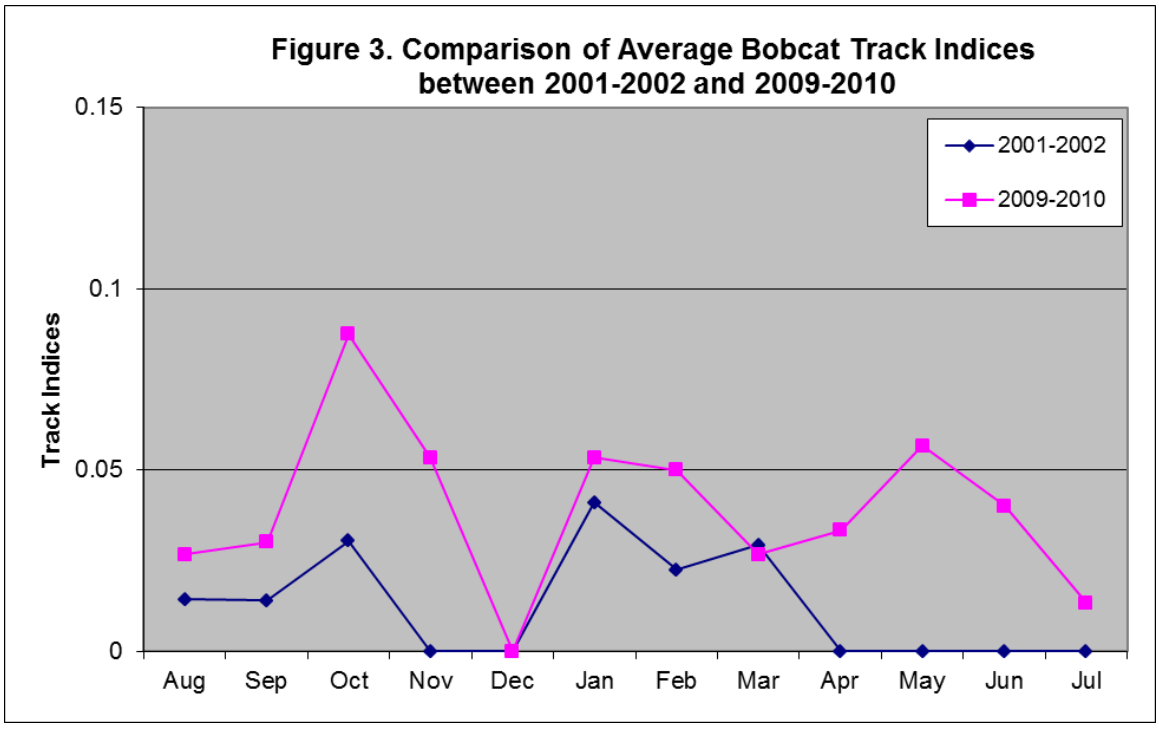
Table 1. Average Track Indices in Current Study Area for Three Original Transects (West, Central and East), 2001-02 and 2009-10

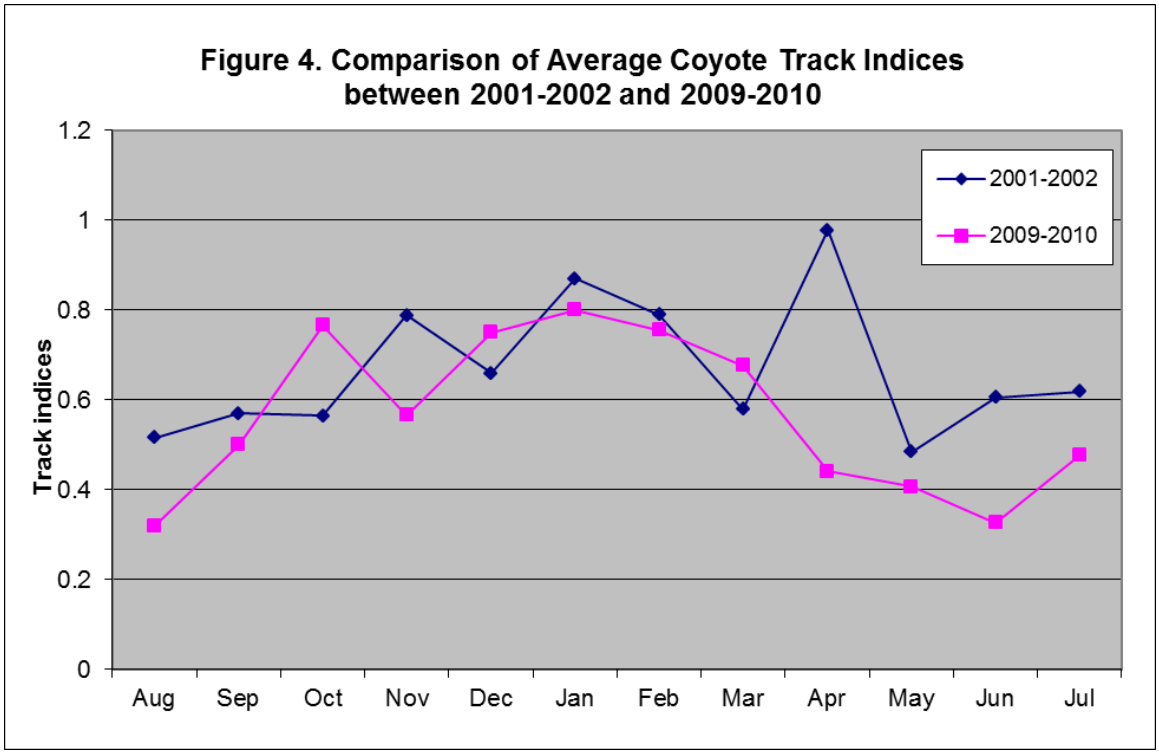
	Average Track Index			**Relative % Change**	***T-test***
Species	**2001-2002**	**2009-2010**	**Change**		***P value***
Bobcat	0.013	0.039	0.026	+200%	*0.0003**
Coyote	0.669	0.566	-0.103	-15%	*0.0286**
Mule Deer	0.011	0.007	-0.004	-36%	*0.5480*

Species	Average Track Index			Relative % Change	*T-test*
	2001-2002	2009-2010	Change		*P value*
Gray Fox	0.000	0.008	+0.008	--**	*0.0162**
Opossum	0.000	0.003	+0.003	--**	*0.1516*
Rabbit	0.172	0.380	0.208	+121%	*0.0004**
Raccoon	0.015	0.019	+0.004	+27%	*0.4048*
Spotted Skunk	0.017	0.020	0.003	+18%	*0.8050*
Ground Squirrel	0.027	0.144	0.117	+433%	*0.0000**
Striped Skunk	0.106	0.099	-0.007	-7%	*0.7366*

**Significant (<0.05)*
***Cannot be calculated because the change cannot be divided by the 2001-2002 value of zero.*

When the monthly track indices from 2001-02 and 2009-10 for bobcats and coyotes are depicted graphically (Figure 3 and 4, respectively), they appear to have very similar trends. For example, in Figure 3, bobcat activity appears to peak in October and again in January-February during both survey periods, and both show the lowest activity levels in December. However, the peaks are much higher in 2009-10 than in 2001-02, and there is another activity peak in May 2009-10 which is absent in 2001-02 (there is no activity in 2001-02 from April through July). There are more similarities between survey periods for coyote activity, which on Figure 4 shows a relatively gradual increase in activity from August through January, which then decreases to a lower point in May/June; however, there is a peak in activity in April 2001-02 which is absent in 2009-10.





The significant increase in bobcat activity in 2009-10 compared to 2001-02 appears to be primarily due to significant increases at the West Transect, but is also due to substantial increases at the Central and East transects (Table 2). The Core transect was not studied in 2001-02, but based on the increases observed at the other three transects, it is likely that similar increases have occurred there as well given its adjacency and lack of human activity in the Core Habitat.

Table 2. Bobcat Track Indices per Transect, 2001-02 and 2009-10

Transect	**Average Track Index**			***T-test***
	2001-2002	**2009-2010**	**Change**	***P value***
East (Arroyo San Miguel)	0.013	0.032	+0.019	*0.178*
Central (spanning Colima)	0.003	0.020	+0.017	*0.123*
West (Arroyo Pescadero)	0.022	0.066	+0.044	*0.002**
Core (La Canada Verde)	n/a	0.039	n/a	*n/a*

**Significant (<0.05)*

Core Transect Data Compared to Original Transect Data

When comparing data from the Core transect to the other three original transects (West, Central and East), bobcat activity is still highest at west transect, but second highest at

Core transect (which is directly adjacent to the West transect). Coyote activity is highest at the East transect and gradually decreases westward (over the Central and West transects) until reaching the Core transect where it is lowest (Table 3). However, none of these differences are significant. Although relative differences in track indices between the Core transect and other transects are larger for bobcats than coyotes. For example, bobcat activity at the Core transect is 95 percent higher than at the Central transect and 63 percent higher than at the East transect, whereas for coyotes these relative percent differences are only 10 and 21 percent, respectively.

Table 3. Comparison of Core Transect Bobcat Track Indices to Other Transects

Transect	**Track Index**	**Difference Compared to Core**	**Relative % Difference**	***T-test P-value****
Bobcat				
Core	0.039	n/a	n/a	*n/a*
West	0.066	+0.027	41%	*0.1162*
Central	0.020	-0.019	95%	*0.1807*
East	0.024	-0.015	63%	*0.4660*
Coyote				
Core	0.495	n/a	n/a	*n/a*
West	0.519	+0.024	5%	*0.7906*
Central	0.548	+0.053	10%	*0.6120*
East	0.630	+0.135	21%	*0.1706*

**Significant (<0.05)*

An additional track transect was conducted in October 2010 in the Core Habitat along an old road leading to the City's Savage Canyon Landfill, north of the Core transect. Although the data covered only one study period, and therefore is not enough to provide a valid comparison with other transect data, it did show higher bobcat activity levels than any other transect in October 2010, further supporting the high activity observed on the Core transect. That month, the bobcat track index along the Landfill Road transect was 0.2, whereas indices from the other transects ranged from 0.05 to 0.15. Coyote track indices from the Landfill Road transect were similar to, but slightly lower than, the other transects.

Camera Stations

Colima Service Tunnel Station – Original Data Compared to Current Data

The camera at the Colima Service Tunnel was active for 245 nights from December 1, 2009 through October 31, 2010; see Appendix A for the number of nights per month the cameras were active, and Appendix C for monthly camera indices per species and per station. Six species were observed using the tunnel: deer, coyote, bobcat, striped skunk, rabbit and ground squirrel; however, it is likely that rabbit and ground squirrel were only present at the entrance to the tunnel and did not move through the entire tunnel. In 2001, four species were observed using the tunnel: deer, coyote, bobcat and raccoon. Humans, dogs and horses were also observed using the tunnel, and based on unweighted camera

indices, total human activity (any photos with people, dogs, horses or bikes), has increased nearly five times since the trailhead opened in March 2002 (the human activity camera index in 2002 following the trailhead opening was 2.268 and the current camera index in 2009-10 is 10.05). In 2001-02, bobcats were the most frequent species using the tunnel, followed by coyote and deer; however, in 2009-10, coyotes are the most frequent, followed by deer and then bobcats (Table 4). Interestingly, while the bobcat camera index at the Colima tunnel has decreased significantly, the bobcat track indices have increased significant since the 2001-02 study as discussed previously.

Table 4. Colima Tunnel Camera Indices

Species	**2001-2002**	**2009-2010**	**Change**	**Relative % Change**	***T-test P value***
Bobcat	0.356	0.153	-0.203	-57%	*0.0405**
Coyote	0.308	0.345	0.037	+12%	*0.4209*
Deer	0.141	0.286	0.145	+103%	*0.0771*

**Significant (<0.05)*

Similar to the track index comparisons shown in Figures 3 and 4 for bobcats and coyotes, the comparison on monthly camera indices for bobcats, coyotes and deer are very similar between the two study periods. In Figure 5, bobcat activity at the Colima Service Tunnel shows a peak in January and a lower stable level of activity from May through July; however, in 2001-02 there is an additional peak in March, and the peaks are much higher than those in 2009-10. Both the track index graph (Figure 1) and the camera index graph (Figure 5) for bobcats indicate a relative peak in January with reduced activity periods in the Summer, but both show additional activity peaks in March of 2001-02. Figure 6 also shows a similar peak in coyote activity at the tunnel in both years during the winter (January-March) and a relative lull in the summer, which is reflected in the track index graph as well (Figure 4). However, Figure 7 shows that the deer activity at the tunnel is lowest in the winter during both years (November through February), with higher activity levels in the summer, although there is a very large spike in activity in April 2009-10 which is absent in April 2001-02.

Figure 5. Colima Tunnel Monthly Bobcat Use Comparison between 2001-02 and 2009-10

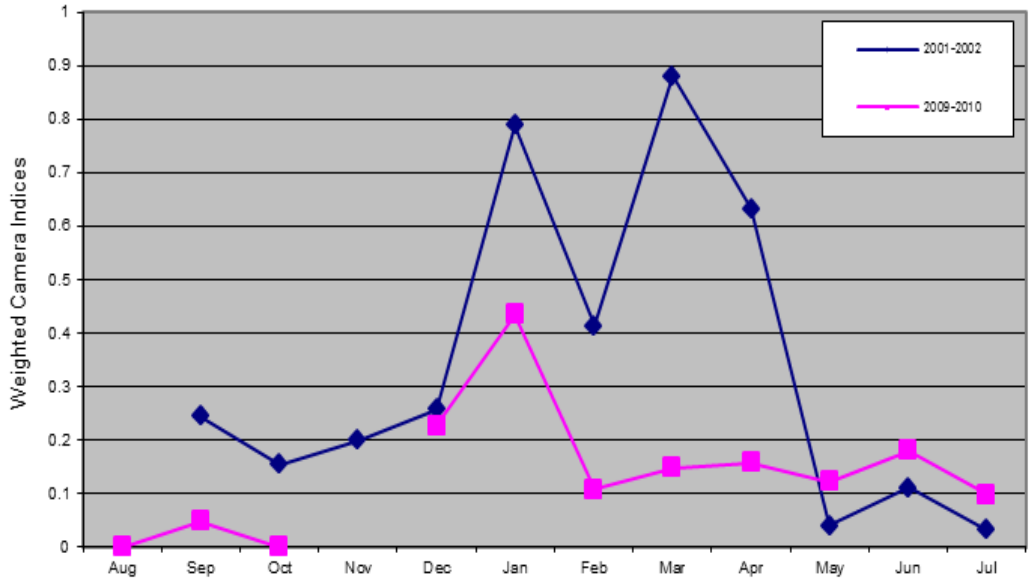
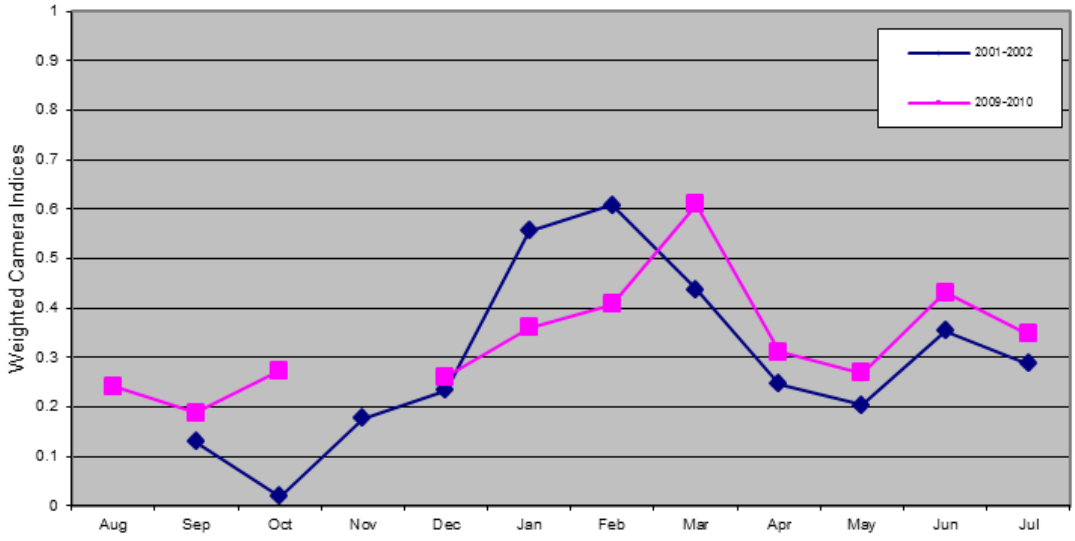
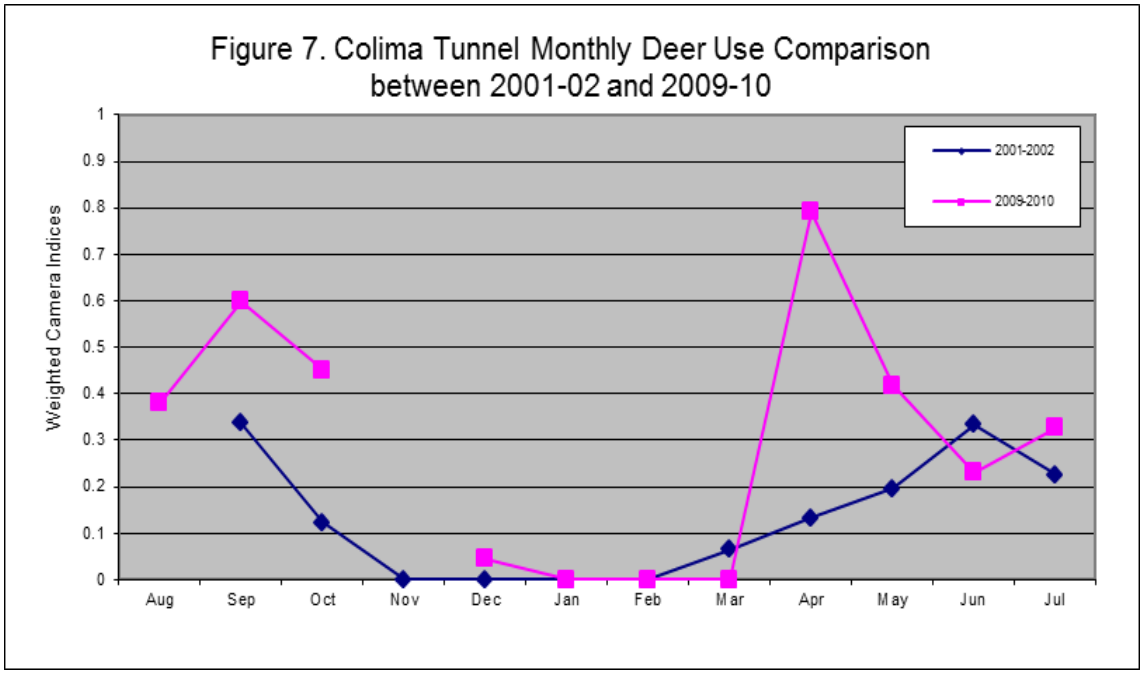
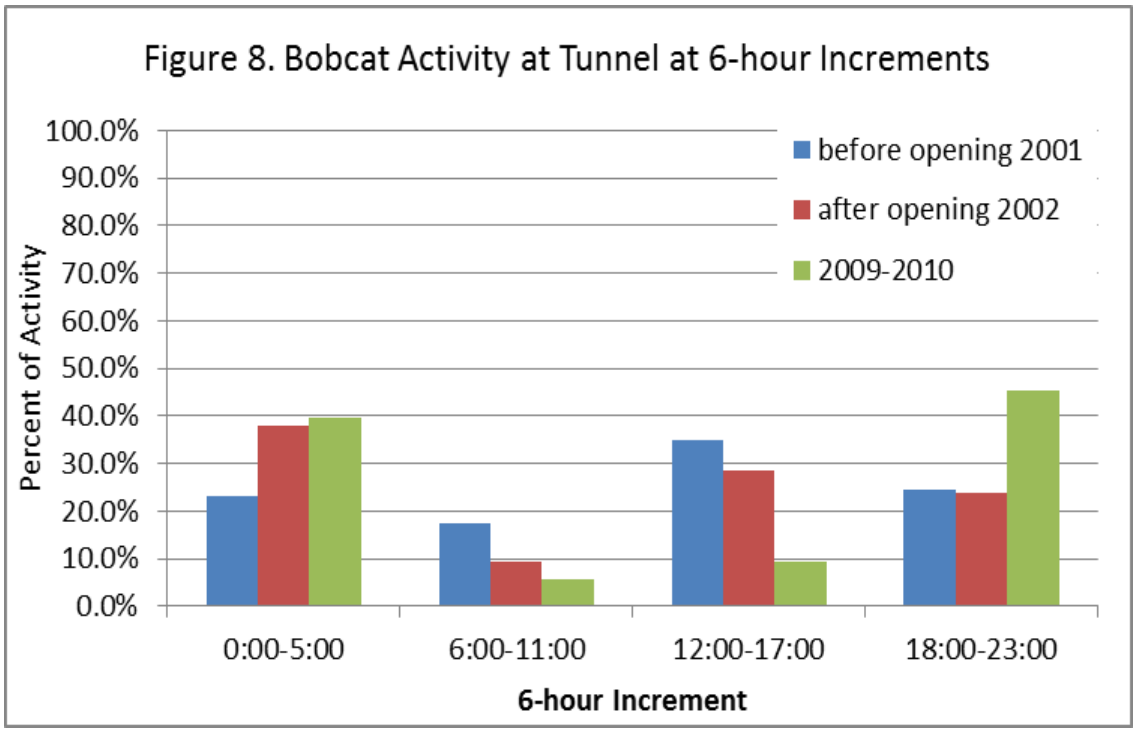


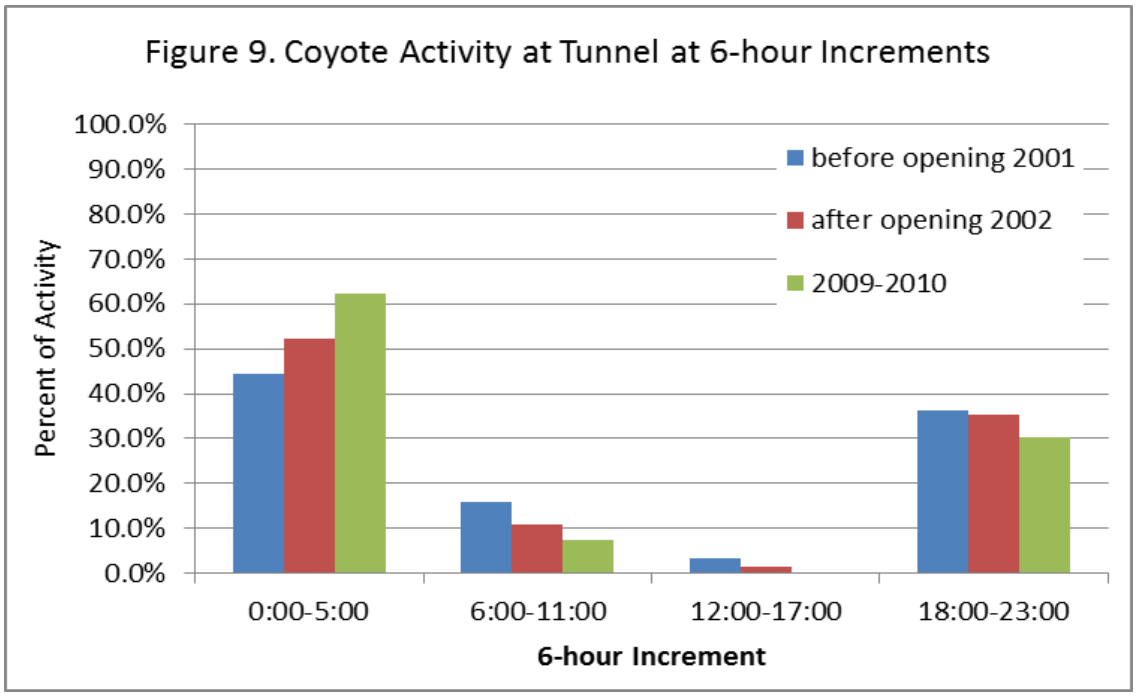
Figure 6. Colima Tunnel Monthly Coyote Use Comparison between 2001-02 and 2009-10

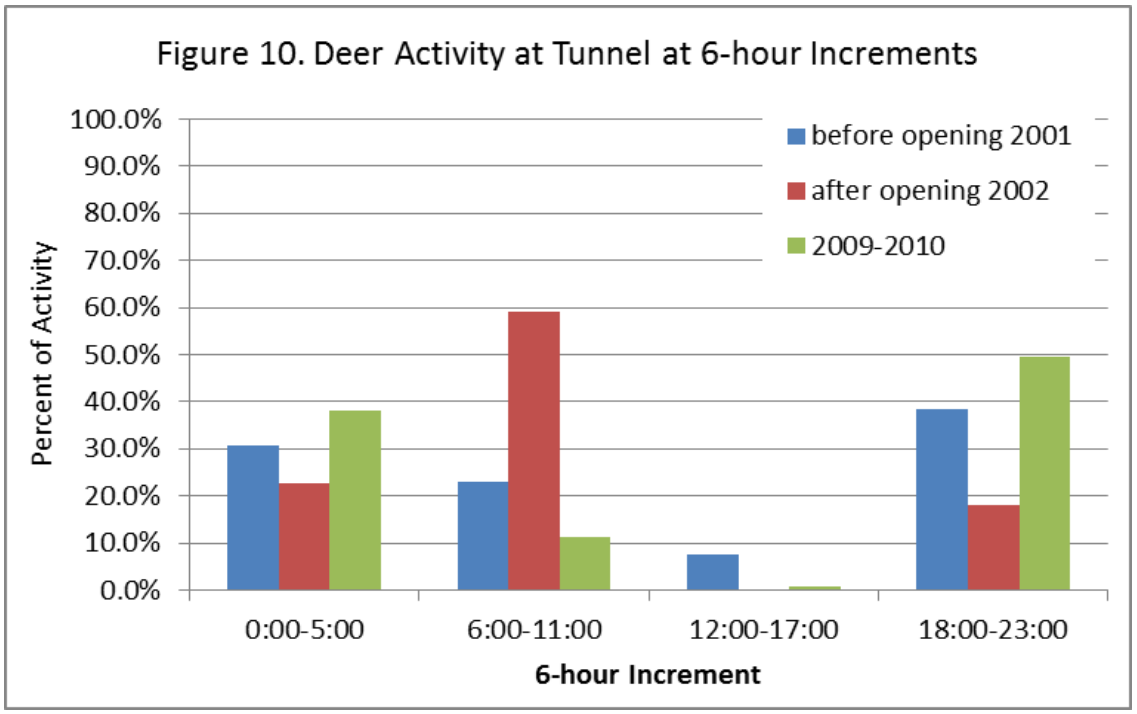




An analysis of the camera data also shows distinctive daily activity patterns. At the Colima Service Tunnel, activity for bobcats, coyotes and deer have all decreased during the day and increased at night since the opening of the trailhead (Figures 8, 9 and 10, respectively). This trend is most apparent for bobcats and coyotes. The previous study noted that after the tunnel was opened to public use, only coyote and deer showed differences in hourly underpass use; however, based on current data, it appears that bobcats are also now exhibiting dramatic differences in hourly underpass use.







Core Habitat Stations

Comparison between camera indices at the Colima Servie Tunnel and the Core Habitat is challenging, as the Tunnel acts as a funnel which concentrates wildlife activity to one single point, whereas there are currently no similar restrictions to movement at any of the

Core Habitat stations. Therefore, it would be expected that activity levels of all species would be higher at the Colima Service Tunnel than in the Core Habitat, and comparing the two would not yield any useful information. As such, the fact that coyote and bobcat activity are higher at the Tunnel than in the Core Habitat is expected (Table 5). However, what is unexpected is that deer activity is actually higher in the Core Habitat than at the Tunnel.

Table 5. Core Habitat Camera Indices compared to Colima Service Tunnel

Species	Central Station	West Station	Northwest Station	*Average all Core Stations*	*Colima Service Tunnel**
Bobcat	0.018	0.036	0.033	*0.029*	0.146
Coyote	0.342	0.107	0.180	*0.210*	0.528
Deer	0.387	0.232	0.533	*0.384*	0.297

**Unweighted Camera Indices used for comparison to Core Habitat Camera Stations*

Comparing camera indices between the three different Core Habitat stations shows some differences in wildlife usage, such as bobcat activity at the West and Northwest sites are almost double the activity level at the Central site, whereas coyote activity is much higher at the Central site, and deer activity is much higher at the Northwest site.

Colima Service Tunnel and Core Habitat Hourly Activity Comparison

As discussed previously, wildlife use at the Colima Service Tunnel has decreased during the daytime following the opening of the Tunnel to the public. As such, it would be expected that wildlife use in the Core Habitat, where public access is prohibited, would occur more evenly throughout the day. A comparison of daily wildlife activity at the Tunnel and the Core Habitat supports this hypothesis, as shown in Figures 11, 12 and 13. Figure 11 shows that in the Core Habitat, bobcat activity occurs during the day and night with relative evenness, whereas their activity at the Tunnel is much more reduced during the daylight hours. The same trend is true for coyotes, shown in Figure 12. This trend is also observed for deer, although not as dramatically, as deer activity levels are very low from 12:00 to 16:00 at both the Tunnel and Core Habitat (Figure 13).

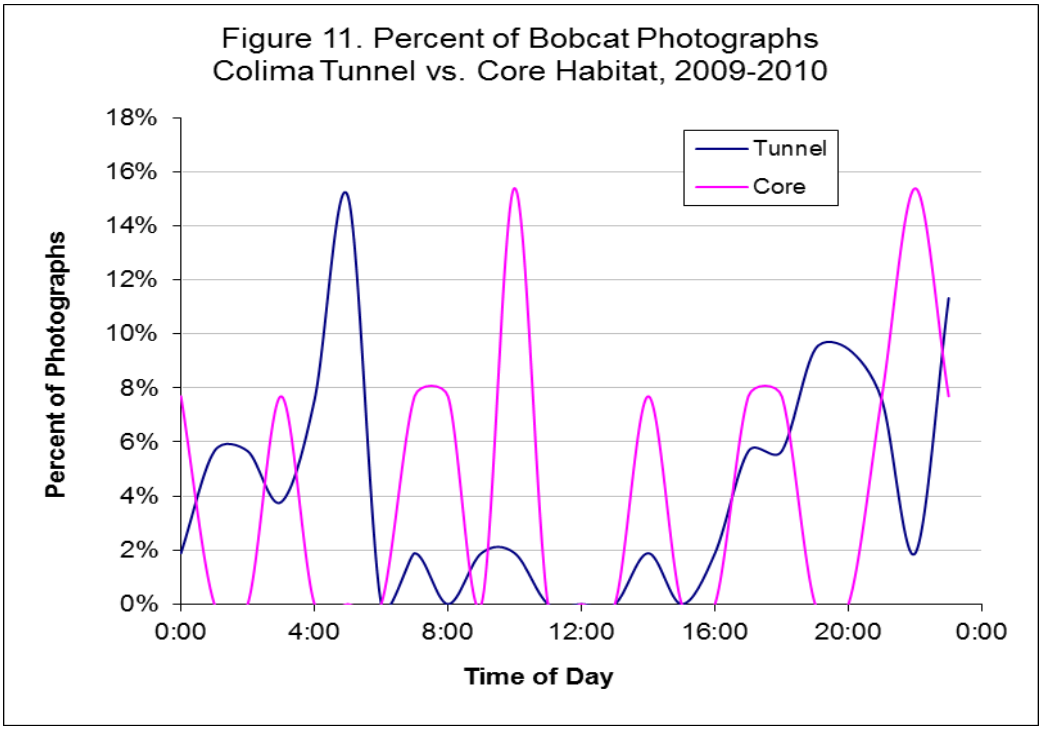


Figure 11. Percent of Bobcat Photographs
Colima Tunnel vs. Core Habitat, 2009-2010
Tunnel
Core
Percent of Photographs
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time of Day

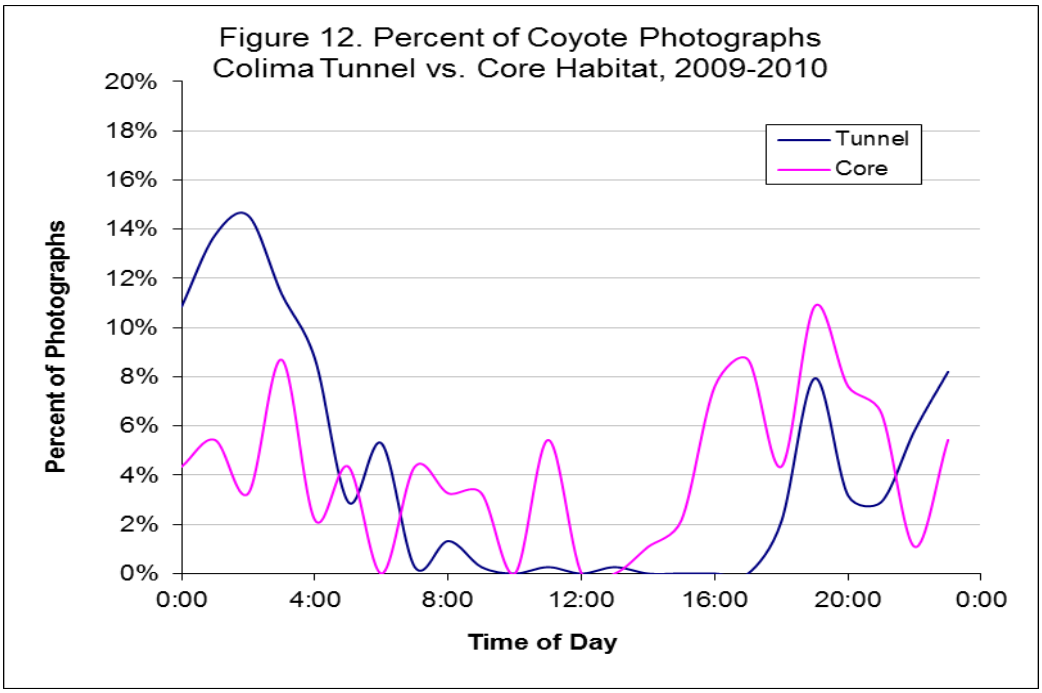


Figure 12. Percent of Coyote Photographs
Colima Tunnel vs. Core Habitat, 2009-2010
Tunnel
Core
Percent of Photographs
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
0:00
4:00
8:00
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16:00
20:00
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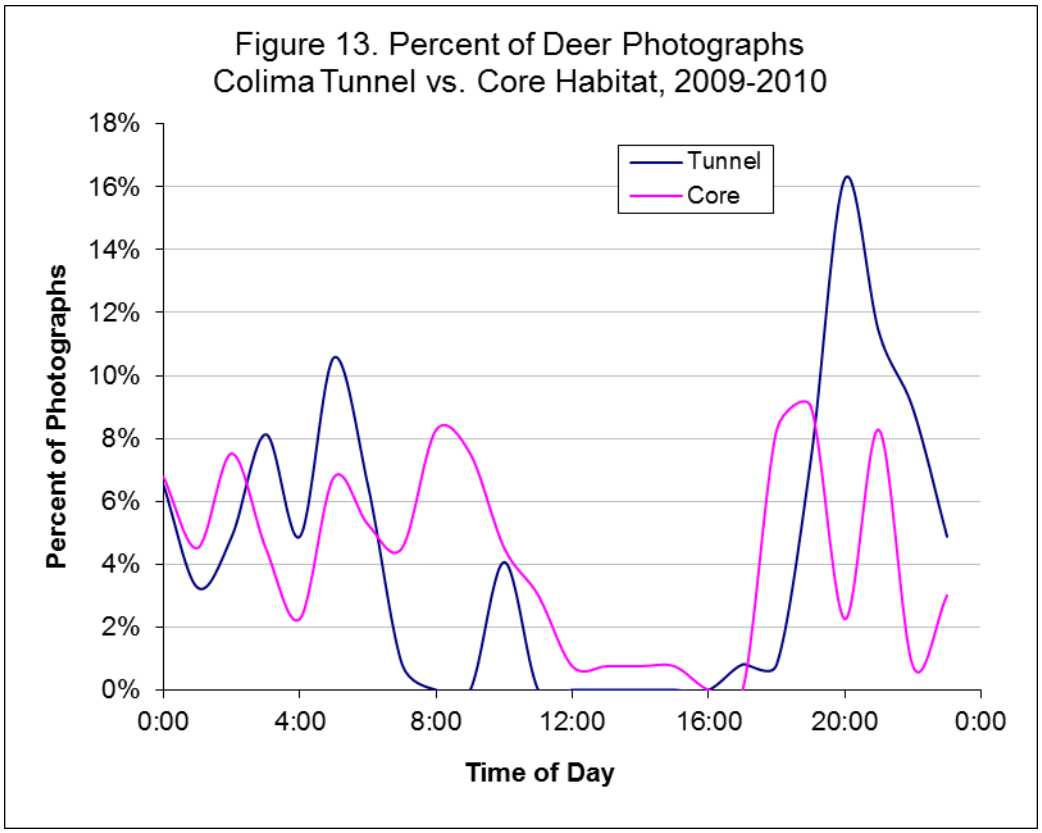
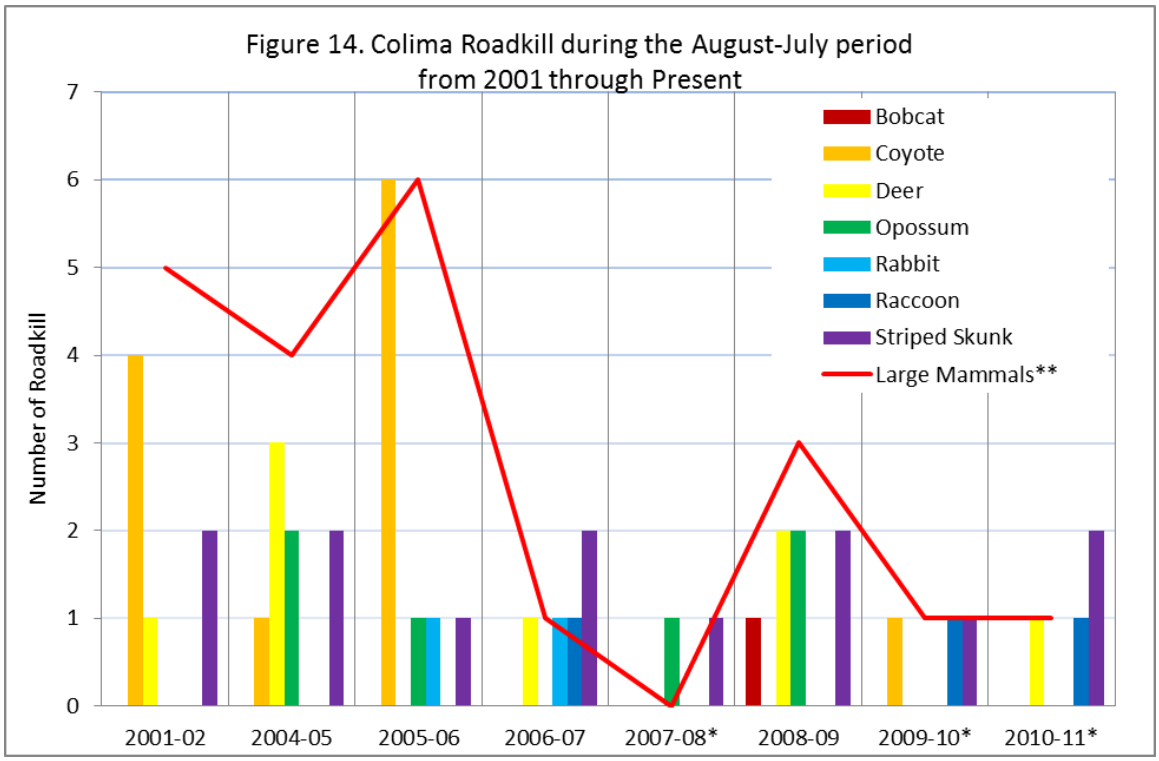
Time of Day



Colima Road Roadkill

The previous study noted that seven road-killed animals were observed along Colima Road during the August 2001 to July 2002 survey period (four coyotes, two striped skunk and one mule deer), and that all were observed in the southbound lane. During the same time period in 2009-10 (August through July), three road-killed animals were observed (one skunks, one raccoon, and one coyote), one each in the south- and northbound lanes[2]. The graph in Figure 14 of roadkill along Colima Road from 2001 to present indicates that overall roadkill levels have decreased over time, especially for large mammals (bobcat, coyote and deer combined). A map of these roadkill indicate that most of the large mammal roadkill occur north of the Colima Service Tunnel (Figure 15).

[2] It is unknown in which lane the third roadkill (coyote) was found.



*Roadkill based on incidental observations by Rangers and Staff; 2010-11 period data through November 2010 only.

**Large mammals include bobcat, coyote and deer.

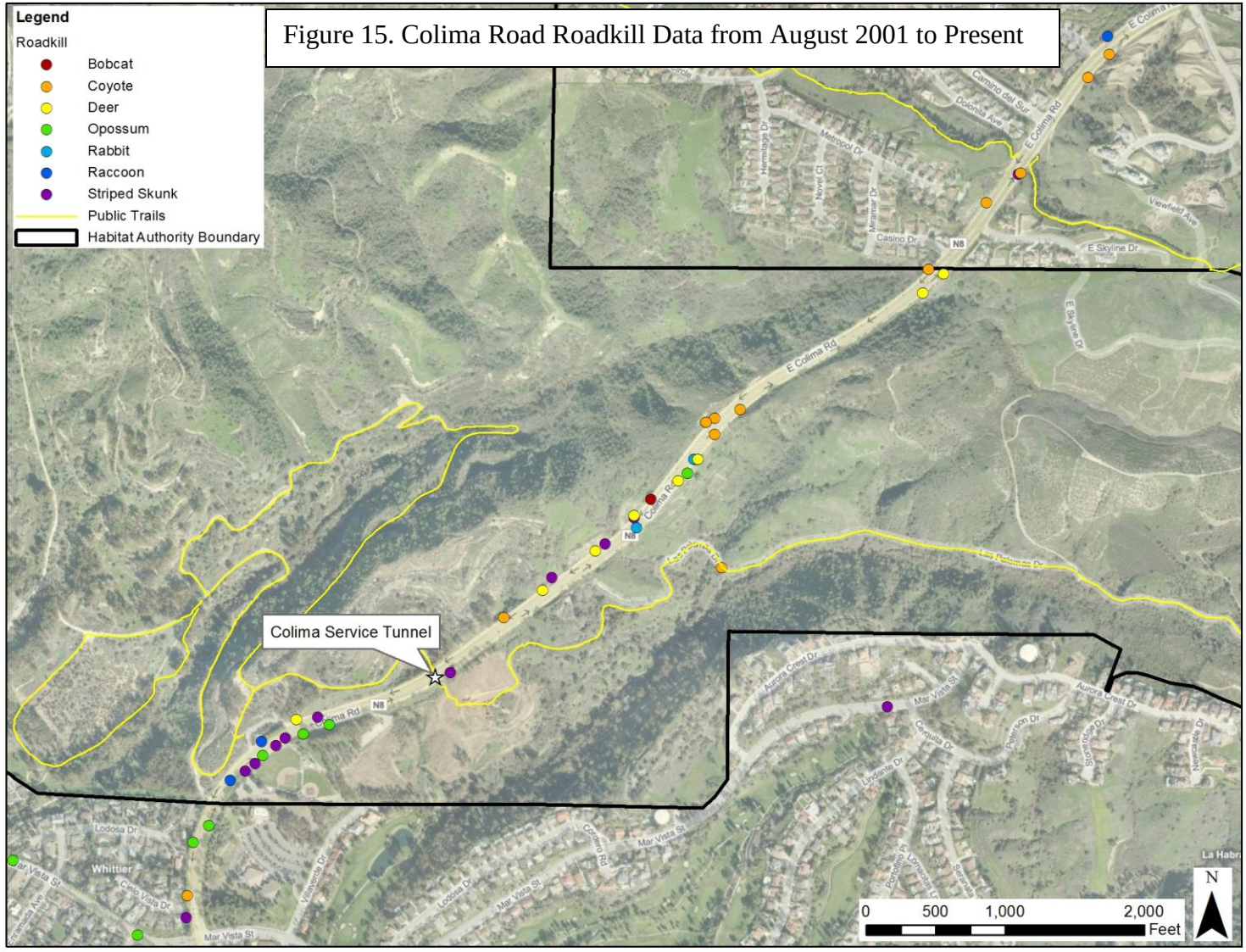


Figure 15. Colima Road Roadkill Data from August 2001 to Present

DISCUSSION

Although the previous USGS study determined that the opening of this area to public recreation did not have any effect on wildlife, a long-term view eight years later indicates some effects. As noted in the Results section, bobcat activity on the transects increased significantly and substantially, and coyote activity decreased significantly but not substantially. Although coyote activity has decreased significantly, it has only decreased by 15 percent. Given that they are they exhibited the highest activity levels of any species, and given their adaptability, this decrease is not considered to be of concern at this time; however, should conditions change in the area another study should be conducted to assess additional changes. However, the significant and substantial increase in bobcat activity is notable and worthy of further analysis.

The East, Central and West transects were also studied in an earlier study by Haas and Crooks (1999), which actually showed much higher bobcat indices at that time. The 1997-1998 study showed the highest bobcat track indices in the area around and west of Colima Road (the Central and West transects, respectively), which was several years after Chevron's oil activities ceased in the early 1990's and after the City bought the property in 1995 (Table 6). Only four years later, the 2001-2002 study showed a substantial decrease in bobcat track indices, which is unexpected considering the cessation of oil activity disturbance. However, the area was already being used for recreational activity prior to its official opening to the public in March 2002 (Haas and Turschak 2002). The increase in hikers and domestic dogs from 1997-98 to 2001-02 documented by these studies may be one the reason that bobcat track indices dropped in that area, as bobcat activity has been shown to be reduced by increased recreational activity, including dogs (George and Crooks 2006). Increased recreational activity following the opening of the trailhead in March 2002 may be one reason that, as noted in Figure 3, there was no bobcat activity on any transects from April through July of 2002, compared to a relative peak of bobcat activity during this same time period in 2010. However, given that overall bobcat activity has increased since 2001-02 despite a nearly five times increase in recreational use, there may be other factors involved.

Table 6. Bobcat Track Indices in Current Study Area, 1997-98, 2001-02 and 2009-10

Transect	Track Indices		
	1997-1998	2001-2002	2009-2010
East (Arroyo San Miguel)	0.039	0.013	0.032
Central (spanning Colima)	0.113	0.003	0.020
West (Arroyo Pescadero)	0.152	0.022	0.066
Core (La Canada Verde)	n/a	n/a	0.039

The low bobcat track indices in 2001-02 may have been due to the fact that several large-scale habitat restoration projects were being implemented in 2001 and 2002 in the immediate vicinity of the West, Central and East transects. From 2000 through 2002, an eight acre stand of eucalyptus trees was removed and native plants were installed at a site adjacent to the West transect. At the Arroyo Pescadero trailhead, adjacent to the Central

transect, a smaller stand of eucalyptus were removed and native plants were installed, an ADA-compliant interpretive trail was constructed, and parking lot improvements were implemented in 2001-02. And an approximately 15-acre habitat mitigation project was being implemented adjacent to the East transect during this time period. These restoration projects would likely have been most active in the fall, when the site is prepared and seeded/planted, and in the spring, when the site is weeded and maintained; these are also the periods of largest difference between the 2001-02 and 2009-10 bobcat track indices as shown in Figure 3. The reduction of habitat restoration activities in these areas since 2001-02 and the maturation of the restored habitat, plus the recovery of the vegetation in areas formerly used by oil activities, may be responsible for the increase in bobcat indices observed in 2009-10.

Bobcat activity levels have almost returned to 1997-1998 levels along the East Transect. However, this increase is not to the level observed in 1997-98 for the Central and West transects. The bobcat activity along the Central Transect is higher than it was in 2001-2002, but is still not nearly as high as it was in 1997-1998; some of this may be due to the lack of woody vegetative cover from eucalyptus tree removal conducted by the Fire Department in 2008, and from habitat restoration activities implemented on both sides of the Colima Tunnel in late 2009 and early 2010. The bobcat activity along the West Transect is higher than in 2001-2002, but still nearly half of what was observed in 1997-1998. Given that no large-scale restoration or other major management activities have occurred recently in the vicinity of that transect, the most likely reason for the lower activity level is from increased recreational use, which has increased by nearly five times according to recent motion-sensor camera data. Similar reductions in bobcat, and overall wildlife activity, from increased recreational use have been observed in other studies (George and Crooks 2006).

This supports the importance of maintaining an area that is free from regular human disturbance, such as the Core Habitat. The Core Habitat shows high bobcat activity as well as high deer activity. In fact, the deer camera index for the Core Habitat is actually higher than the unweighted camera index at the Colima Service Tunnel. This may indicate the importance of the Core Habitat for deer use and movement, since it would be expected that wildlife activity would be lower in the Core Habitat than the Tunnel, since the tunnel acts as a funnel which concentrates wildlife activity to one single point, whereas there are currently no similar restrictions to movement at any of the Core Habitat Stations. This further supports observation from a previous study that this area contains the highest bobcat indices in the Preseve and the highest levels of deer activity in the entire Puente-Chino Hills (Haas and Crooks 1999). This is further supported by comparing the current data to data from other track studies conducted on the Preserve. Bobcat track indices from the current study are as high, or higher, than the highest bobcat track indices from transects at other areas on the Preserve.

Of the 17 transects studied by Haas and Crooks in 1997-98, only five showed bobcat activity[3], three of which are the same as those in the current study (East, Central and

[3] A single track station located at Skyline Drive also showed bobcat activity, but only consisted of one track station instead of the five stations that compose most of the other study transects.

West). Many transects did not show any bobcat activity, including several in the Powder Canyon and Turnbull Canyon areas. The other two transects showing bobcat activity were in Powder Canyon and along Hacienda Boulevard, with track indices of 0.033 and 0.016, respectively. Given that the bobcat indices from the current study transects are 0.020, 0.032, 0.039, and 0.066, they would still be higher than nearly all of the transects in other areas of the Preserve during the 1997-98 study.

Also, in a study by Elliott and Stapp (2008) which conducted track studies along 13 transects throughout the Preserve from 2005 to 2007, only eight transects showed bobcat activity. Several transects did not show any bobcat activity, including along Harbor Boulevard and in Sycamore Canyon near the trailhead (Stapp and Elliott 2008, unpublished data). Although this study did not include any in the Arroyo Pescadero or Core Habitat area, it does show that the track indices of the current study are also higher than nearly all the transects in the 2005-07 study, which range from 0.008 to 0.029. In the 2005-07 study, the transect with one of the highest indices is located at the top of the La Canada Verde (Core Habitat) watershed[4], which currently shows a relatively high bobcat index of 0.039, which is the second highest of all of the currently studied transects.

All of these studies indicate that the area between Colima and Turnbull Canyon has historically had, and continues to have, high bobcat usage compared to most other areas of the Preserve. This is further evidenced by comparing bobcat activity at the Harbor Blvd. Underpass in the Powder Canyon area to activity at the Colima tunnel, as only a handful of bobcat photos were taken over four years of study in the Harbor Underpass (Elliott and Stapp 2008; Stapp and Cashin 2009), compared to over 100 photos in 2001-2002 (Haas and Turschak 2002) and over 30 photos in 2009-2010 in the Colima Service Tunnel.

However, despite the fact that bobcat activity in the area has increased since 2001-02 based on track indices, bobcat activity at the Colima Service Tunnel has still decreased substantially and significantly. There are several possible reasons for this decrease. The most likely is due to the substantial increase in recreational activity, which has increased at the Tunnel by five times since it was opened in March 2002.

Another possible reason for the decrease in tunnel activity by bobcats may be the habitat mitigation activities immediately adjacent to the south entrance of the tunnel, which began in summer 2009 and continue to present. The Central transect still shows the lowest bobcat indices, which may also be related to these restoration activities as well as the 2008 removal of large stands of eucalyptus trees adjacent to this transect. However, the peak period of mitigation installation activity (January 2010) also showed the highest bobcat camera index. Haas and Turschak (2002) speculated that the reason for high bobcat indices in the tunnel but low track indices on the central transect (which spans both sides of the tunnel) could be because bobcats may move through the tunnel quickly, not taking any time to linger on the trail to visit the track stations; it is possible that such behavior was occurring at this time as well. But if the decrease in bobcat is due to

[4] This transect was located along the Skyline Trail near Frame Street in Hacienda Heights.

restoration activities, the maturation of the mitigation habitat over time (assuming no additional major disturbances, such as the proposed oil exploration project) may result in another increase in bobcat indices, although not likely to 1997-98 levels due to the current heavy recreational activity.

Another possible factor contributing to the decreased bobcat activity at the Tunnel is the increase in coyote activity. Coyotes were strangely absent in the Colima tunnel in 1997-1998, but showed a camera index of 0.308 in 2001-02, and an index of 0.345 in 2009-10. In 1997-98, deer showed the highest use of the Colima tunnel followed second by bobcats. By 2001-02 bobcats showed the highest use, followed second by coyotes and third by deer. Currently, coyotes show the highest use, followed second by deer and third by bobcats. With the large increase in daytime recreational activity over the past eight years, bobcats have shifted their activity to be predominantly nocturnal, as shown in Figure 8; however, this is also the time period when coyotes are most active in the Tunnel, which may further reduce bobcat activity at night, possibly contributing to the observed overall lower bobcat activity levels. It is unclear why coyotes were not using the tunnel in 1997-98, but it is possible that it took several years for coyotes to learn of its presence following its disuse by oil companies in the early 1990's; in a study of the Harbor Blvd. underpass, it took almost six months for coyotes to begin heavily using the underpass and several years for roadkills to decrease as a result (Elliott and Stapp 2008; Stapp and Cashin 2009). Coyotes may cause bobcats to avoid areas and may also compete for food resources (Fedriani 2000). This effect may be evidenced by the fact that coyotes have also been shown to cause gray foxes to avoid areas, and while gray foxes were found using the Colima tunnel in 1997-1998, no foxes were found using the Tunnel in either 2001-2002 or the current 2009-2010 study. Interestingly, there was also no dog use of the Colima Tunnel in 1997-98, which has since increased despite signs warning that dogs are not allowed along the Arroyo San Miguel trail which goes through the Colima Service Tunnel. In a study of recreational impacts to wildlife at the Nature Reserve of Orange County, daytime activity of bobcats was found to be significantly and negatively affected by high levels of human activity, particularly when with dogs or on bikes (George and Crooks 2006).

There are several other possible reasons for the decrease in bobcat activity at the tunnel between 2001-02 and 2009-10. One reason may be due to differences in camera sensitivity and/or position between the two study periods. However, this difference is unlikely to be significant, as the number of coyotes entering/exiting was very similar between the study periods, and the number of deer entering/exiting increased. Another possible reason for the decrease in activity may simply be due to changes in a particular bobcat individual's movement pattern or home range. If most of the photos were generated by one individual, and if it decided to shift its home range away from the tunnel, or if it chose to use another route to cross Colima Road, this could have strongly affected the bobcat activity. However, the reduced bobcat activity is not likely due to an individual being killed on Colima Road, as no bobcat roadkill have been observed here during the current 2009-10 study period, and only one has been observed here over the last nine years (in January 2009, almost one year prior to the current study).

In another study in the Chino Hills area, bobcat activity showed seasonal variation between two different study years (1998 and 1999), similar to some of the variability shown in this study between 2001-02 and 2009-10 (Lyren 2001); in that study, and in this study, bobcat activity at tunnels was highest in the winter (December through February), except for in 2001-02 where another activity peak occurred in March. So, it is possible that some of the differences in seasonal use between 2001-02 and 2009-10 can be explained by natural variations in bobcat activity; however, the overall activity level is still significantly lower.

Despite the decrease in bobcat use of the Colima Service Tunnel, it is still regularly used by bobcats, coyotes and deer for movement under busy Colima Road. And despite the increase in recreational use of the Tunnel, the Tunnel has remained effective as a wildlife crossing, as roadkill along Colima Road does not appear to have increased as a result of this increased recreational use of the Tunnel, and there are almost no large mammal roadkill in the vicinity of the Tunnel further indicating their use of the Tunnel for movement under Colima Road. However, since roadkill data is not available prior to 2001, it is unknown whether the cluster of large mammal roadkill further north along Colima Road and north of the Tunnel was present prior to recreational use of the area, or even during previous oil activities in the area. Therefore, it remains possible that these activities have caused this roadkill cluster, possibly due to avoidance of the Tunnel by some individuals.

IMPLICATIONS AND RECOMMENDATIONS

The results of this study indicate that while increases in recreational use have affected some wildlife activity since the area was opened to public use in 2002, the area still exhibits the highest bobcat activity in the entire Preserve and has not substantially reduced the effectiveness of the Colima Service Tunnel as a major movement path under busy Colima Road, although bobcat use of the Tunnel has decreased. However, further increases in human activity in the area could adversely affect wildlife activity in the area, particularly use of the Colima Service Tunnel.

Although the entire study area exhibits high bobcat activity, the highest levels are along the West and Core transects, east of Colima Road and in or near the Core Habitat. The reason for these high activity levels may be due to the fact that the Core Habitat is the largest area within the Preserve that is the most buffered from human development and where public access is prohibited. Bobcats are sensitive to human disturbance and tend to make their home ranges further from human development, particularly female bobcats (Riley 2006). In addition, these areas support riparian habitat, which is associated with female bobcat home ranges (Lawhead 1984; Markovchick-Nicholls, et al. 2008; Preuss and Gehring 2007; Riley 2006). Additional human development in this area, such as from the proposed oil project, could affect bobcat activity in this area, possibly causing them to shift their home ranges or movement paths further north into the remaining habitat. Avoidance of oil drilling activities may be one reason why bobcats were not observed along a transect in Sycamore Canyon in a previous study (Stapp and Elliott

2008, unpublished data)[5]. Avoidance of proposed oil activities in the Core Habitat and vicinity could shift bobcat and other wildlife movement to the another possible primary movement route along the Skyline Ridge at the top of the La Canada Verde watershed (Core Habitat), which may cause them to cross Colima Road north of the tunnel. However, this is the location where most large mammal roadkills have historically occurred. This could significantly affect wildlife movement through the corridor by either causing more roadkills at this location or by causing the animals to avoid crossing Colima Road at this location in order to avoid collisions.

With the potential implementation of the oil project in the Core Habitat, daytime wildlife activity would be expected to decrease and shift more to nighttime activity, as has been shown at the Colima Service Tunnel in response to daytime recreational use. Since the Core Habitat is the only area of the Preserve where public access is prohibited, it is valuable for uninterrupted daytime wildlife use, particularly considering the amount of human disturbance that the Preserve is subjected to due to surrounding urban and suburban development and heavy recreational activity. Potential impacts from proposed oil activities in this area could occur during the day and night, given that drilling activities occur 24 hours per day, and crews would likely need to be present in the area at all times during normal operations.

If increased recreational activity or other development is occurs in the area, several actions should be considered to mitigate for possible adverse impacts to wildlife activity, particularly for bobcats. These may include:

- Closing the Arroyo Pescadero and Arroyo San Miguel trails to recreational activity

- Constructing an underpass or overpass further north on Colima Road.

- Further study of bobcat population dynamics and movement to determine functionality of the area for population maintenance and movement, particularly in the Core Habitat.

Continued monitoring of the Colima Service Tunnel is recommended to determine whether the decrease in bobcat activity is a consistent trend or is due to natural variability. If such a consistent trend is observed, seasonal closure of the Tunnel should be considered even in the absence of increased recreation or other development, possibly during the peak use periods exhibited prior to public recreational access (January through April). Continued monitoring of roadkill along Colima Road should also continue to further gauge the effectiveness of the Tunnel for successful wildlife movement.

[5] However, four other transects out of a total 13 in the study also showed no bobcat activity.

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Appendix A. Track Transect Survey Dates and Camera Station Monthly Activity Summary

Track Station Survey Dates

Month	**Dates**
November 2009	11/3 – 11/7
December 2009	12/9 – 12/10
January 2010	1/5 – 1/9
February 2010	2/9, 2/12 – 2/13
March 2010	3/9 – 3/13
April 2010	4/7 – 4/10
May 2010	5/4 – 5/8
June 2010	6/15 – 6/19
July 2010	7/13 – 7/17
August 2010	8/10 – 8/14
September 2010	9/8 – 9/12
October 2010	10/24, 10/27 – 10/29

Camera Station Monthly Summary of Nights Active

Month	**Colima Service Tunnel**	**Core Habitat**		
		Central	***West***	***Northwest***
November 2009	0	0	4	23
December 2009	22	2	27	0
January 2010	17	25	0	6
February 2010	18	0	0	25
March 2010	13	0	30	0
April 2010	24	27	0	3
May 2010	23	0	4	25
June 2010	26	8	30	0
July 2010	30	20	0	8
August 2010	21	0	13	15
September 2010	20	15	4	0
October 2010	31	14	0	17

Appendix B. Monthly Track Indices Per Species Per Transect, 2009-2010

Transect	*Month*	*Deer*	*Coyote*	*Bobcat*	*Raccoon*	*Opossum*	*Striped Skunk*	*Spotted Skunk*	*Rabbit*	*Squirrel*	*Gray fox*	*Dog*	*Hiker/ Runner*
Central	Nov-09	0.050	0.500	0.000	0.000	0.050	0.050	0.000	0.450	0.050	0.050	0.200	0.050
Central	Dec-09	0.000	0.750	0.000	0.125	0.000	0.000	0.000	0.125	0.000	0.000	0.250	0.000
Central	Jan-10	0.000	0.800	0.000	0.000	0.000	0.250	0.100	0.500	0.000	0.000	0.250	0.000
Central	Feb-10	0.000	1.000	0.083	0.083	0.000	0.000	0.083	0.083	0.000	0.000	0.083	0.000
Central	Mar-10	0.000	0.750	0.000	0.000	0.000	0.100	0.050	0.250	0.300	0.000	0.300	0.000
Central	Apr-10	0.000	0.375	0.000	0.000	0.000	0.188	0.000	0.625	0.125	0.000	0.063	0.000
Central	May-10	0.000	0.300	0.050	0.000	0.000	0.100	0.000	0.700	0.150	0.050	0.100	0.000
Central	Jun-10	0.000	0.300	0.000	0.000	0.000	0.300	0.100	0.700	0.350	0.000	0.000	0.000
Central	Jul-10	0.000	0.550	0.000	0.000	0.050	0.300	0.000	0.550	0.550	0.000	0.000	0.000
Central	Aug-10	0.000	0.200	0.000	0.000	0.000	0.050	0.000	0.650	0.350	0.000	0.000	0.050
Central	Sep-10	0.050	0.300	0.050	0.000	0.000	0.050	0.100	0.650	0.250	0.000	0.000	0.050
Central	Oct-10	0.000	0.750	0.063	0.000	0.000	0.125	0.000	0.125	0.125	0.000	0.000	0.000
East	Nov-09	0.000	0.480	0.120	0.120	0.000	0.040	0.000	0.440	0.000	0.000	0.320	0.040
East	Dec-09	0.000	0.900	0.000	0.000	0.000	0.200	0.000	0.100	0.000	0.000	0.100	0.000
East	Jan-10	0.000	0.760	0.040	0.000	0.000	0.200	0.120	0.240	0.000	0.000	0.040	0.040
East	Feb-10	0.000	0.800	0.000	0.000	0.000	0.067	0.000	0.200	0.133	0.000	0.267	0.000
East	Mar-10	0.000	0.680	0.040	0.000	0.000	0.080	0.000	0.400	0.040	0.000	0.400	0.000
East	Apr-10	0.000	0.600	0.050	0.000	0.000	0.000	0.000	0.350	0.150	0.000	0.300	0.000
East	May-10	0.000	0.680	0.040	0.000	0.000	0.040	0.040	0.640	0.200	0.040	0.040	0.000
East	Jun-10	0.000	0.160	0.000	0.040	0.000	0.040	0.040	0.920	0.480	0.000	0.000	0.000
East	Jul-10	0.000	0.360	0.000	0.040	0.000	0.080	0.040	0.680	0.400	0.000	0.000	0.000
East	Aug-10	0.000	0.560	0.040	0.000	0.000	0.040	0.040	0.680	0.360	0.000	0.000	0.080
East	Sep-10	0.000	0.680	0.000	0.000	0.000	0.120	0.000	0.720	0.360	0.000	0.000	0.000
East	Oct-10	0.000	0.900	0.050	0.000	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000
West	Nov-09	0.040	0.720	0.040	0.080	0.000	0.160	0.000	0.080	0.040	0.000	0.160	0.000
West	Dec-09	0.000	0.600	0.000	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000
West	Jan-10	0.000	0.840	0.120	0.000	0.000	0.240	0.000	0.120	0.000	0.000	0.400	0.000
West	Feb-10	0.000	0.467	0.067	0.067	0.000	0.133	0.000	0.267	0.000	0.000	0.333	0.000
West	Mar-10	0.000	0.600	0.040	0.000	0.000	0.080	0.000	0.320	0.040	0.000	0.440	0.000
West	Apr-10	0.000	0.350	0.050	0.000	0.000	0.150	0.000	0.250	0.000	0.000	0.100	0.050
West	May-10	0.080	0.240	0.080	0.040	0.000	0.040	0.000	0.320	0.000	0.040	0.240	0.000
West	Jun-10	0.000	0.520	0.120	0.000	0.000	0.240	0.000	0.480	0.080	0.080	0.320	0.040
West	Jul-10	0.040	0.520	0.040	0.000	0.000	0.000	0.000	0.320	0.280	0.040	0.000	0.000
West	Aug-10	0.000	0.200	0.040	0.000	0.000	0.040	0.000	0.280	0.040	0.000	0.000	0.000
West	Sep-10	0.000	0.520	0.040	0.000	0.000	0.000	0.000	0.320	0.120	0.000	0.000	0.000
West	Oct-10	0.000	0.650	0.150	0.000	0.000	0.050	0.000	0.150	0.100	0.000	0.000	0.100
Core	Nov-09	0.000	1.000	0.040	0.000	0.000	0.000	0.000	0.080	0.000	0.000	0.040	0.000
Core	Dec-09	0.000	0.400	0.000	0.000	0.000	0.100	0.100	0.000	0.000	0.000	0.000	0.000
Core	Jan-10	0.000	0.680	0.080	0.000	0.000	0.240	0.000	0.160	0.000	0.000	0.000	0.000
Core	Feb-10	0.000	0.467	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000
Core	Mar-10	0.000	0.760	0.080	0.000	0.000	0.080	0.000	0.120	0.000	0.040	0.000	0.000
Core	Apr-10	0.050	0.600	0.050	0.000	0.000	0.000	0.000	0.050	0.050	0.000	0.000	0.000
Core	May-10	0.000	0.080	0.040	0.000	0.000	0.040	0.000	0.200	0.040	0.000	0.000	0.000
Core	Jun-10	0.000	0.480	0.000	0.000	0.000	0.040	0.000	0.440	0.000	0.000	0.040	0.000
Core	Jul-10	0.040	0.320	0.000	0.040	0.000	0.040	0.040	0.440	0.000	0.000	0.000	0.000
Core	Aug-10	0.000	0.400	0.040	0.000	0.040	0.120	0.080	0.560	0.160	0.000	0.000	0.000
Core	Sep-10	0.040	0.200	0.040	0.000	0.000	0.080	0.040	0.440	0.120	0.000	0.000	0.000
Core	Oct-10	0.000	0.550	0.100	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.050

Appendix C. Monthly Camera Indices Per Species 2009-2010

Colima Service Tunnel Station (weighted)

Month	Coyote	Deer	Bobcat
Dec-09	0.260	0.045	0.227
Jan-10	0.359	0.000	0.436
Feb-10	0.408	0.000	0.108
Mar-10	0.610	0.000	0.148
Apr-10	0.311	0.792	0.159
May-10	0.268	0.418	0.123
Jun-10	0.431	0.231	0.181
Jul-10	0.347	0.327	0.098
Aug-10	0.242	0.381	0.000
Sep-10	0.188	0.600	0.049
Oct-10	0.273	0.452	0.000

Core Habitat Stations (unweighted)

Central Station

Month	Coyote	Deer	Bobcat
Nov-09	--	--	--
Dec-09	0.000	0.000	0.000
Jan-10	0.320	0.000	0.000
Feb-10	--	--	--
Mar-10	--	--	--
Apr-10	0.148	0.333	0.000
May-10	--	--	--
Jun-10	0.125	0.125	0.000
Jul-10	0.300	0.500	0.050
Aug-10	--	--	--
Sep-10	0.867	0.867	0.000
Oct-10	0.429	0.714	0.000

West Station

Month	Coyote	Deer	Bobcat
Nov-09	0.000	0.000	0.000
Dec-09	0.000	0.074	0.000
Jan-10	--	--	--
Feb-10	--	--	--
Mar-10	0.233	0.500	0.067
Apr-10	--	--	--
May-10	0.250	0.000	0.250
Jun-10	0.033	0.000	0.000
Jul-10	--	--	--
Aug-10	0.231	0.615	0.077
Sep-10	0.000	0.250	0.000
Oct-10	--	--	--

Northwest Station

Month	Coyote	Deer	Bobcat
Nov-09	0.348	0.217	0.043
Dec-09	--	--	--
Jan-10	0.167	0.167	0.000
Feb-10	0.160	0.680	0.000
Mar-10	--	--	--
Apr-10	0.000	2.000	0.000
May-10	0.080	0.680	0.080
Jun-10	--	--	--
Jul-10	0.125	1.250	0.000
Aug-10	0.000	0.333	0.000
Sep-10	--	--	--
Oct-10	0.353	0.235	0.000

All Core Stations Combined

Month	Coyote	Deer	Bobcat
Nov-09	0.276	0.172	0.034
Dec-09	0.000	0.065	0.000
Jan-10	0.259	0.037	0.000
Feb-10	0.160	0.680	0.000
Mar-10	0.194	0.419	0.065
Apr-10	0.133	0.500	0.000
May-10	0.097	0.516	0.097
Jun-10	0.067	0.033	0.000
Jul-10	0.200	0.333	0.033
Aug-10	0.100	0.367	0.033
Sep-10	0.483	0.517	0.000
Oct-10	0.387	0.452	0.000