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Data Summary

Prepared for:

San Diego Association of Governments

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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Abstract

We investigated the role of large-scale wildfires on the relative abundance of carnivores at two study areas within San Diego County of southern California, 1) Santa Ysabel Open Space Preserve and 2) Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area. In October and November of 2003, large-scale fires burned approximately 130,000 ha of San Diego County. To assess fire impacts on local carnivore communities, we collected data using two sampling techniques, 1) track surveys with baited scent stations and 2) remotely triggered camera stations. Sampling prior to the fires was conducted between May 2001 and June 2003, while post-burn sampling was conducted between August 2006 and September 2007. We calculated the relative abundance of carnivore species for each track transect and camera station, comparing pre-burn and post-burn abundance indices.

Fifteen medium to large mammal species were detected across Santa Ysabel and Rancho Jamul at track transects and camera stations. We detected 11 native species including mountain lion (*Puma concolor*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), bobcat (*Felis rufus*), badger (*Taxidea taxus*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), spotted skunk (*Spilogale gracilis*), opossum (*Didelphis virginiana*), and long-tailed weasel (*Mustela frenata*). We also detected four species typically associated with humans including, domestic cow (*Bos taurus*), domestic horse (*Equus caballus*), domestic dog (*Canis familiaris*), and domestic cat (*Felis catus*). Ten of the native species (badger excluded) and two human-associated species (domestic horse and domestic dog) were documented within both study sites.

Within Santa Ysabel and Rancho Jamul, we found little evidence that the 2003 wildfires affected the relative abundance of the carnivore species for which we gathered sufficient data. Most of the species we studied seemed capable of persisting in the patchwork of unburned and burned habitats resulting from these wildfires. In addition, the effects of the fires were likely short term for most carnivore species. We did not begin post-burn monitoring until nearly three years after the wildfires of 2003, by which time we likely missed the more dramatic immediate responses to wildfire. Overall, we suspect the indirect effects of wildfires, such as changes in habitat suitability and predator-prey dynamics, were largely responsible for the minor changes we observed in the abundance and distribution of carnivore species. Our surveys indicate that Santa Ysabel and Rancho Jamul currently support resident populations of a variety of carnivore species, including coyotes and

bobcats. The continued protection and careful fire management of these sites and adjacent refugia should help to protect the resident mammalian carnivore communities and provide landscape connectivity far into the future.

Introduction

Wildfires have long been a part of the natural and human-altered environments of southern California. Keeley et al. (1999, 2004) state that large landscape level fires occurred in the past and will likely persist as long as southern California continues to experience episodes of severe fire weather (e.g., fast, dry winds). Despite fire suppression efforts and management plans, large and small wildfires continue to occur from both natural ignition sources and those associated with an increasing human population (Keeley et al. 2004).

Fire can have both negative and positive impacts on the local flora and fauna. Carnivore populations and their responses to wildfire are of interest to researchers and land managers for a variety of reasons. They represent an excellent group of species for conservation in that they are wide-ranging, exhibit low population densities, and are large patch or interior dwelling species (Meffe et al. 1997). Further, the disappearance of top predators from fragmented systems may have community-wide implications (Robinson 1953, 1961; Linhart and Robinson 1972, Sargeant et al. 1983, Voight and Earle 1983, Schmidt 1986, Johnson et al. 1989, Ralls and White 1995, Sovada et al. 1995). Top predators often function as keystone species in wildlife communities and shifts in keystone species can have cascading impacts affecting the dynamics of the ecosystem as a whole, resulting in increases in some species and declines in others (Mills et al. 1993).

The effect of large-scale wildfire on carnivore abundance has not been widely evaluated. In fact, Fisher and Wilkinson (2005) report “substantial gaps in data exist for carnivores” and recommend further research into species responses to wildfire. Some fire research related to carnivore behavior immediately following wildfire has been done in Yellowstone National Park. Singer et al. (1989) and Blanchard and Knight (1990) report grizzly bears (*Ursus arctos horribilis*) feeding on fire-killed ungulates immediately after the 1988 wildfires. With regard to longer term community response, Cunningham et al. (2006) studied gray fox and coyote abundance in burned and unburned areas of the Mazatzal Mountains of Arizona following a major wildfire. Locally, Schuette (2007) evaluated the prevalence of carnivore species in chaparral habitat approximately two years after the Cedar Fire in San Diego County. However, the relationship between carnivore communities and wildfire has not been explored extensively in southern California. We believe these communities to be useful in assessing ecosystem health and change following catastrophic fire. In the short term, fire may cause direct mortality, loss of habitat, and changes in prey availability (Whelan 1995). Fire may also have positive impacts on some species, especially those preferring open or disturbed habitat for den sites, movement, foraging, or reproduction.

In October and November of 2003, monumental fires swept across southern California, consuming over 300,000 ha of wild lands. This area included over 130,000 ha of San Diego County which burned in the Cedar and Otay Fires. In addition to the loss of nearly 5,000 structures and 15 human fatalities (CDF 2005), these large fires potentially impacted the local communities of carnivores in a region already recognized as being at great risk for biodiversity loss (Mittermeier et al. 1997). Of particular concern was the fact that half of San Diego County's large network of protected habitat reserves, the Multiple Species Conservation Plan, was directly affected by the fires. Some of the reserves were entirely within the fire footprints. Concern over the recovery of these wildlands and the covered species within them (e.g., the mountain lion (*Puma concolor*), a keystone species, and the badger (*Taxidea taxus*), a state mammal species of special concern (CDFG 2008)) motivated our research.

In this study, we investigated the effect of the 2003 wildfires on carnivores by comparing data on relative abundance collected approximately three years after the fires to existing data collected in the two years prior to the fires. Our primary objective was to examine the short term response of carnivores to large-scale patchy wildland fire and determine whether the fire affected the relative abundance of individual species.

Study Area

This research was conducted within San Diego County, California at two separate study areas, 1) Santa Ysabel Open Space Preserve and 2) Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area (Figure 1).

Santa Ysabel Open Space Preserve (Santa Ysabel) is located near the small town of Santa Ysabel in the northern portion of San Diego County. At an average elevation of 1,078 m, the area supports oak and pine woodlands, native and non-native grasslands, chaparral, coastal sage scrub, and riparian woodlands. Dominating the various vegetation communities are coast live oak (*Quercus* *agrifolia*), annual, non-native grasses (*Avena* and *Bromus*), chamise (*Adenostoma fasciculatum*), Engelmann oak (*Quercus engelmannii*), and white sage (*Salvia apiana*). This 1,500 ha site is managed by the Parks and Recreation Department of the County of San Diego. The average July high temperature is 33°C, while the average January daily low temperature is 1°C. The average annual rainfall is 53 cm. Santa Ysabel represents the northeastern extent of the Cedar Fire, which consumed a large portion of the eastern property in 2003.

Rancho Jamul Ecological Reserve - Hollenbeck Canyon Wildlife Area (collectively referred to as Rancho Jamul) is located near the international border between the United States and Mexico, between the towns of Jamul and Dulzura in southern San Diego County. The combined property is managed by the California Department of Fish and Game. Rancho Jamul Ecological Reserve covers approximately 1,500 ha, and its southern portion burned during the Otay Fire of 2003. Hollenbeck Canyon Wildlife Area covers 1,450 ha and was untouched by the 2003 wildfires. The average elevation across Rancho Jamul Ecological Reserve - Hollenbeck Canyon Wildlife Area is 250 m. The area encompasses a diversity of vegetation communities including native and non-native grasslands, coastal sage scrub, and upland and riparian woodlands dominated by oaks, sycamores, and willows. In addition to natural vegetation communities, there are extensive, fallow agricultural fields. Dominant plant species at the site include annual, non-native grasses, California buckwheat (*Eriogonum fasciculatum*), California sagebrush (*Artemisia californica*), coast live oak, western sycamore (*Platanus racemosa*), laurel sumac (*Malosma laurina*), and San Diego sunflower (*Viguiera laciniata*). Rancho Jamul's average July maximum temperature is 29°C, while the average January low temperature is 5°C. Annual precipitation averages 31 cm.

All temperature and precipitation values reported here are 30 yr averages (1966-1995; Franklin et al. 2001). We used geographic information system (GIS) application to extract these values for each point.

Methods

We inventoried carnivore populations within San Diego County, as part of a large multi-taxa project conducted by the U.S. Geological Survey. Although native carnivores were the target species for this study, we include other large mammals and human-associated species for which we obtained substantial data. Two sampling techniques were used to document the relative abundance of mammal species across the study areas, 1) track surveys with baited scent stations and 2) remotely triggered camera stations.

Track Surveys with Baited Scent Stations

Track surveys, utilizing baited scent stations, have been used widely as a means to monitor trends in carnivore populations. Following methods developed by Linhart and Knowlton (1975), track surveys have been shown to be effective measures of distribution and relative abundance of mammalian species (Conner et al. 1983, Sargeant et al. 1998, Crooks 2002).

We established track transects along roads and trails throughout the Santa Ysabel and Rancho Jamul study areas. Each 1,000 m transect was made up of five scent stations spaced at approximately 250 m intervals. Distances between stations were approximate, as we tried to place baited scent stations in the most optimal locations, usually at trail or road crossings. Each scent station was composed of a 1 m^2 plot of finely sifted gypsum powder and a rock (See cover photo, top center). The rock was placed in the middle of the station and baited with two artificial scent lures (Russ Carman's Pro Choice and Canine Call) every other day during sampling. Stations were checked for tracks on five consecutive mornings during pre-burn sampling and four consecutive mornings during post-burn sampling. The tracks left behind by animals as they visited the stations were identified to species. Afterwards, the station was cleared and the gypsum powder was resifted.

To obtain an index of relative abundance, we divided the number of times each species was detected along a transect by the total sampling effort at that transect. This index was calculated using the equation $\mathbf{I_j = [v_j/(s_j n_j)]}$, where I_j = index of species activity at transect j, v_j = number of visits to stations along transect j by a particular species, s_j = number of stations in transect j, and n_j = number of nights that stations were active in transect j. We omitted any scent stations where tracks were too difficult to read from the sampling nights. Thus, the true sampling effort was $\mathbf{[s_j n_j] - o_j}$, where o_j = number of omitted sampling nights in transect j. This index does not provide data on the absolute number of individuals. Instead, the index compares relative abundance of species across space and time. We compared track indices to determine changes in relative activity levels from pre-burn to post-burn sampling.

Santa Ysabel

We established ten track transects at Santa Ysabel (Figure 2, 3; Appendix 1). Transects 1 through 9 were located along dirt roads throughout the property. To further assess the movement of medium and large bodied mammals along and across roadways bordering and bisecting the preserve, additional scent stations were placed at potential movement points along state routes CA-78 and CA-79. Although not a true transect (it did not contain five scent stations 250 m apart in a linear configuration), the three scent stations established at varying intervals along these two roads were collectively referred to as Transect 10. Track transects were surveyed quarterly from June 2002 to June 2003 for a total of five sample periods before the wildfires of 2003. Following the fires, we re-surveyed the same track transects quarterly between July 2006 and June 2007 for a total of four sample periods (Table 1).

Rancho Jamul

We established a total of twelve track transects throughout Rancho Jamul (Figure 4, Appendix 2). Of the eight transects sampled pre-burn, five transects (referred to as Transects 1-5) were located along dirt roads within Rancho Jamul Ecological Reserve. As at Santa Ysabel, additional scent stations were placed along and across roadways bordering the property, at potential movement points along state route CA-94 and Otay Lakes Road. Again, though not true transects, three track transects (referred to as CA-94, Otay Lakes Road, and Underpasses) consisting of five to six scent stations were established to monitor these roads and the associated underpasses. The eight pre-burn transects were surveyed between May 2001 and February 2002 for a total of four sample periods before the fires of 2003. Following the fires, we surveyed the eight established track transects, as well as four additional transects (referred to as Transects 6-9) established along dirt roads within Hollenbeck Canyon Wildlife Area (Figure 4). We surveyed all 12 transects quarterly between July 2006 and June 2007 for a total of four sample periods (Table 1).

Camera Surveys

Remotely triggered camera stations have become an increasingly useful tool in recording the activity of various wildlife species (Griffiths and Van Schaik 1993, Jacobson et al. 1997, Karanth and Nichols 1998). Cameras provide a relatively low-maintenance means of surveying wildlife populations; researchers only visit the units to collect and replace spent film and batteries. We established camera stations along dirt roads, wildlife trails, and cattle paths throughout both study sites. Whenever the infra-red motion sensor attached to a camera detected movement, the camera would document the event with a photograph. All cameras were programmed to record the date and time of the activity on the resulting image.

To obtain an index of relative abundance, we divided the number of camera visits (photographs) of each species by the total sampling effort for that camera. This index was calculated using the equation $\mathbf{I_j = [v_j/n_j]}$, where, I_j = index of activity at camera j, v_j = number of visits to camera j by a particular species, and n_j = number of nights that camera j was active. The sampling effort (number of nights the camera was active) is variable among camera stations and is based on the number of days each roll of film lasted in the field (from initial placement until full exposure or removal). This activity index does not provide data on the absolute number of individuals. Instead, the index compares the relative abundance of species across space and time. We compared camera indices to determine changes in the relative activity levels from pre-burn to post-burn sampling.

Santa Ysabel

Nine Camtrak cameras (CamTrakker, 1050 Industrial Drive, Watkinsville, GA 30677) were placed throughout Santa Ysabel in 2002, as part of a multi-taxa monitoring study (Figure 2, 3; Appendix 1). These cameras operated between April 2002 and June 2003, and were removed from the field prior to the 2003 Cedar Fire. Following the wildfire, we reestablished all nine camera stations at the exact locations of the pre-burn efforts. They operated continuously in the field for one year, September 2006 through September 2007. The exact number of operational days (sampling effort) for each camera varied depending on the level of activity at the station (Table 1). Camera 9 was established in early September 2006 and removed in late September 2007 for a sampling effort of 384 days (Table 1).

Rancho Jamul

We established five Camtrak cameras throughout Rancho Jamul in 2001 (Figure 4, Appendix 2). These cameras operated between May 2001 and March 2002 to create our pre-burn dataset. The cameras were removed from the field in March 2002 and reinstalled after the 2003 Otay Fire to conduct post-burn sampling. In August 2006, we resumed sampling at the five pre-burn camera stations within Rancho Jamul Ecological Reserve. We also added four additional camera stations in the Hollenbeck Canyon Wildlife Area and one additional station in the Rancho Jamul Ecological Reserve (Figure 4, Appendix 2). A total of ten cameras operated continuously from August 2006 to September 2007. Due to the variability in activity levels, the exact number of operational days for each camera differed, ranging from as few as 45 to as many as 410 sample days (Table 1), a factor that is taken into account in the calculation of the relative abundance.

Results

Fifteen medium to large mammal species, including several domestic species, were detected across Santa Ysabel and Rancho Jamul at track transects and camera stations. We detected 11 native species including, mountain lion, mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), bobcat (*Felis rufus*), badger, gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), spotted skunk (*Spilogale gracilis*), opossum (*Didelphis virginiana*), and long-tailed weasel (*Mustela frenata*). We also detected four species typically associated with humans including, domestic cow (*Bos taurus*), domestic horse (*Equus caballus*), domestic dog (*Canis familiari*s), and domestic cat (*Felis catus*). Ten of the native species (badger excluded) and two human-associated species (domestic horse and domestic dog) were documented within both study sites. For this report, we primarily discuss the responses of native species to wildfire, although we also report detections of human-associated species. Many additional animals, including several small mammals, birds, lizards, and snakes, were recorded at track transects and camera stations, but are not discussed in this report.

Track Surveys with Baited Scent Stations

Santa Ysabel

Overall, we detected twelve species at baited scent stations throughout Santa Ysabel. These species included ten native species (mule deer, coyote, bobcat, badger, gray fox, raccoon, striped skunk, spotted skunk, opossum, and long-tailed weasel) and two non-native species (domestic cow and domestic dog) (Table 2). A total of 599 species detections were obtained during pre-burn sampling, while 772 species detections were obtained during post-burn sampling. Coyotes and striped skunks were detected on all ten transects within the reserve during both pre-burn and post-burn sampling. Similarly, bobcats were detected on the same nine track transects before and after the wildfires. Gray foxes were detected on eight transects (although not the same eight transects) both pre-burn and post-burn. We did not detect raccoons prior to the wildfires, but we detected them at seven transects during post-burn sampling. Likewise, we did not detect badgers or long-tailed weasels before the wildfires, but we detected both species in low numbers during post-burn sampling.

Four transects (Transects 5-8) were burned completely in the wildfires, while six transects remained untouched (Transects 1-4, 9, 10) (Table 2). In general, we detected one to three more species at all track transects during post-burn sampling than were detected during pre-burn sampling. Transect 10 was the exception. We detected four species on this transect during pre-burn sampling and only three species during post-burn sampling. Transect 7 was visited by the most species both before (8 species) and after (10 species) the fires, despite the fact that the entire transect burned. Badgers were detected only on Transect 7, which we documented and have confirmed with a photograph (Appendix 3).

Coyote activity was highest at Transect 1 both before and after the wildfires. Overall, coyote activity was much higher during post-burn sampling than pre-burn sampling. Mule deer, bobcat, raccoon, striped skunk, and opossum activity were also somewhat higher during post-burn sampling. Gray fox activity remained steady during pre-burn and post-burn sampling, while spotted skunk activity declined during post-burn sampling (Table 2).

Rancho Jamul

Overall, we detected twelve species at baited scent stations throughout Rancho Jamul. These species included ten native species (mountain lion, mule deer, coyote, bobcat, gray fox, raccoon, striped skunk, spotted skunk, opossum, and long-tailed weasel) and two non-native species (domestic dog and domestic cat) (Table 3). A total of 484 species detections were obtained during pre-burn sampling, while 680 species detections were obtained during post-burn sampling. Coyotes and domestic dogs were detected on all transects within Rancho Jamul both before and after the fires. We detected no mountain lions or long-tailed weasels during the pre-burn sampling, but after the fires we detected one of each.

Seven of the eight original track transects at Rancho Jamul were burned in the wildfires of 2003. For this reason, four new (unburned) transects in Hollenbeck Canyon Wildlife Area were added during the post-burn sampling. The Underpasses transect and Transect 3 were visited by the most species during pre-burn sampling (eight and seven species, respectively). After the fires, Transects 9, 8, and 7 within Hollenbeck Canyon Wildlife Area were visited by the most species (nine, seven, and seven species, respectively) (Table 3).

Overall, coyote activity was much higher during post-burn sampling as compared to pre-burn sampling. In contrast, mule deer, bobcat, raccoon, and striped skunk activity declined from pre-burn to post-burn sampling. There was minimal change in gray fox activity between pre-burn and post-burn sampling (Table 3).

Camera Surveys

Santa Ysabel

Eleven species were detected at camera stations, including eight native species (mountain lion, mule deer, coyote, bobcat, gray fox, raccoon, striped skunk, and opossum) and three non-native species (domestic cow, domestic horse, and domestic dog) (Table 4). A total of 584 species detections were obtained during pre-burn sampling, while 1,920 species detections were obtained during post-burn sampling. Representative photos from the camera stations are included in Appendix 4.

Four camera stations (Cameras 5-8) burned in the Cedar Fire, while the other five camera stations (Cameras 1-4, 9) remained relatively untouched. Cameras 5 and 9 were visited by the most species during pre-burn sampling (7 species). During post-burn sampling, Camera 5 was again visited by the most species (10 species). Mule deer were detected at all nine camera stations both before and after the wildfires (Table 4).

Bobcat activity was highest at Cameras 3 and 8 during both pre-burn and post-burn sampling, but overall, bobcat activity fell slightly from pre-burn to post-burn sampling. As was the case with track transects, coyote activity was much higher during post-burn sampling than pre-burn sampling. Mule deer, gray fox, and striped skunk activity changed very little from pre-burn to post-burn sampling (Table 4).

Rancho Jamul

Overall, we detected eight species at camera stations throughout Rancho Jamul. These species included six native species (mountain lion, mule deer, coyote, bobcat, raccoon, and striped skunk) and two non-native species (domestic horse and domestic dog) (Table 5). A total of 231 species detections were obtained during pre-burn sampling, while 879 species detections were obtained during post-burn sampling. Coyotes were detected at all camera stations within Rancho Jamul during both pre-burn and post-burn sampling. We did not detect raccoons prior to the wildfires, but we detected them at three cameras during post-burn sampling. We detected one mountain lion prior to the wildfires, but did not detect any mountain lions at camera stations during post-burn sampling. Representative photos from the camera stations are included in Appendix 4.

All five original camera sites (Camera 2-6) burned in the 2003 wildfires, so five additional cameras (Cameras 7-11) were placed in unburned areas for post-burn sampling. The five original camera stations each detected the same number or fewer species from pre-burn to post-burn sampling. Overall, the five new camera stations detected more species per camera than the original cameras during post-burn sampling (Table 5).

Coyote activity was highest at Camera 2 both before and after the wildfires, but overall, coyote activity fell from pre-burn to post-burn sampling. Bobcat activity also fell from pre-burn to post-burn sampling. Mule deer activity remained the same between pre-burn and post-burn sampling (Table 5).

Discussion

Species Responses

In this study, we looked at species abundance indices for track transects and camera stations throughout Santa Ysabel and Rancho Jamul. During the surveys, the most commonly detected species were mule deer, coyotes, bobcats, gray foxes, and striped skunks. For the most part, we found little evidence that fire affected the relative abundance of the carnivore species for which we had gathered sufficient data. Most of the species we studied seemed capable of persisting in both unburned and burned habitats. In addition, the effects of the fires were likely short term for most of the carnivore species. We did not begin post-burn monitoring until nearly three years after the fires of 2003, so we may have missed any immediate carnivore response. Overall, we suspect the indirect effects of the fire, such as changes in habitat suitability and predator-prey dynamics, were largely responsible for the minor changes we observed in the abundance and distribution of carnivore species.

The 2003 wildfires removed downed wood and leaf litter cover in our study areas, leaving behind sparse shrubs and large amounts of open ground. These conditions are most suitable for habitat generalists and open habitat specialist species. As such, it follows that we saw the most noticeable changes in coyote abundance from pre-burn to post-burn sampling. Overall, we found higher abundance indices for coyotes during post-burn sampling as compared to the pre-burn sampling indices. They increased in 3 out of 4 measured indices at Rancho Jamul and Santa Ysabel. Coyotes are widespread and relatively abundant throughout the region. They are known to occupy open habitats (Gese et al. 1995, Koehler and Hornocker 1991), as well as some fragmented areas (Haas 2000). By creating open habitat, the 2003 fires likely improved the foraging opportunities and prey base of coyotes. Wirtz (1977) found greater consumption of birds and deer by coyotes after a chaparral fire in the San Dimas Experimental Forest, California. It is probable that prey species become vulnerable with the reduction of vegetative cover, and coyotes were able to capitalize on that vulnerability. Converse et al. (2006) found that small mammals generally increase following burn events, and Kaufman et al. (1988) postulated that small mammal populations rose following wildfire in direct response to increased food availability. The increased availability of prey combined with favorable hunting conditions undoubtedly accounts for much of the higher relative abundance of coyotes during post-burn sampling.

Because mule deer are linked to edge habitats and prefer open vegetation to dense forest (Ingles 1965), we expected mule deer populations to increase after the wildfire. Instead, mule deer detections remained relatively stable between pre-burn and post-burn sampling at both study sites. In looking at mule deer abundance indices, we give more weight to the camera indices than track indices. Unlike carnivores, mule deer are not attracted to the scent lure used at the track stations, and therefore, may be underrepresented by this survey method. They do however regularly use wildlife trails, including those monitored by our remote cameras. While we did not see an increase in mule deer abundance during post-burn sampling, Fisher and Wilkinson (2005) found that ungulate abundance was greatest immediately following fire and other disturbance events. Our results can be attributed in part to the fact that much of the vegetation had already recovered by the time we began post-burn sampling.

While coyotes and mule deer generally prefer early successional or disturbed communities, the conditions were probably less favorable for species dependent on dense cover for hunting or safety. As such, we expected bobcats and gray foxes to exhibit a negative response to the wildfires. Bobcats prefer areas with abundant vegetative cover (Litvaitis and Harrison 1989, Sunquist and Sunquist 2002), and will frequently avoid areas with open understories (Litvaitis et al. 1986). This aversion to open habitats is likely due to the lack of sufficient cover for hunting. As expected, we saw minor decreases in bobcat abundance at Rancho Jamul from pre-burn to post-burn sampling. There were also decreases in bobcat abundance at camera stations comparing pre-burn to post-burn sampling at Santa Ysabel. On the other hand, we found little change in the relative abundance indices for gray foxes between pre-burn and post-burn sampling. Gray foxes are known to prefer brush and fairly dense vegetation (Nowak 2005), so we expected gray fox abundance to decrease following the wildfires. In Arizona, Cunningham et al. (2006) found that relative abundance indices for gray foxes decreased immediately following a major wildfire, but returned to pre-fire levels over the subsequent two to three years. In San Diego County, Schuette (2007) observed gray foxes most often in interior burn areas compared to burn edges and unburned chaparral approximately two years after the Cedar Fire. These findings suggest that while gray foxes were likely affected by wildfire, they recovered relatively quickly. Therefore, our survey efforts may have missed the initial response of gray foxes to the open habitats generated by the wildfires. We suspect the immediate changes in vegetation and loss of cover from the wildfires probably affected bobcats and gray foxes adversely. While gray foxes and bobcats likely ventured into burned areas soon after the wildfires to hunt for small vertebrate prey, they probably did not recolonize the burned areas until sufficient cover had been restored.

Aside from the more commonly detected species, we obtained a small amount of data on several rare or cryptic species. Interestingly, we obtained badger and long-tailed weasel observations only during post-burn sampling. Typically considered to be nocturnal, fossorial creatures (Nowak 2005), badgers may be difficult to detect using track transects and camera stations. They prefer open, grassy habitat (Nowak 2005) and likely benefitted from the reduced cover and increased small mammal prey base following the wildfires. Badgers are known to occur in San Diego County, and at least two animals were reported as dead on roads near Lake Henshaw in 2006 (Scott Tremor personal communication). To our knowledge, these 2007 tracks represent the most current badger observation in eastern San Diego County.

Long-tailed weasels are nearly ubiquitous across the entire United States. Despite this large distribution, they are detected only infrequently using track transects and cameras. They occupy a wide variety of habitat types, but seem to prefer open areas with grass or low vegetation near water sources (Nowak 2005). Their preference for these open areas and the ability to successfully exploit a variety of habitat types may confer an advantage in recently burned or disturbed habitats. Although we found no literature documenting the interactions of long-tailed weasels and fire, the short-tail weasel (*Mustela erminea*) prefers early successional communities over more mature forests (Sims and Buckner 1973).

Mountain lions were another infrequently detected species. In large part, this rarity is due to the considerable size of their home-ranges and the uncertainty of sampling the right place at the right time. We recorded very few mountain lions within Rancho Jamul either before or after the wildfires. However, we obtained more detections within Santa Ysabel, particularly during pre-burn sampling. Mountain lion activity appeared to fall slightly at the Santa Ysabel camera stations between pre-burn and post-burn sampling. Aside from large home-range size, mountain lions are the most sensitive predator species to fragmentation effects (Beier 1993, Crooks 2002). The disturbances associated with wildfires, combined with the pressures imposed by urban encroachment, could prove to be unfavorable for mountain lion populations. In Idaho, Seidensticker et al. (1973) found that mountain lions avoid crossing large open areas with minimal cover. In southern Utah, mountain lions showed a preference for dense vegetation with limited horizontal visibility (Laing and Lindsey 1991). However, mountain lions could also benefit from fires that enhance mule deer habitat through the reduction of vegetative cover and new growth. In southern California, mule deer comprise the majority of the mountain lion's diet (Beier 1995). Mountain lion numbers increased following a wildfire in British Columbia, possibly due to a fire related increase in the mule deer population (Edwards 1954). Overall, both mountain lion and mule deer populations could potentially benefit from a patchwork of unburned and burned habitat, provided that urban encroachment and fragmentation are kept in check.

Limitations

Although track and camera surveys are useful in documenting the presence and activities of wildlife in a study area, inferences are limited by the inability to distinguish multiple visits by a single individual from many single visits by multiple individuals. While some studies have shown that indirect surveys for carnivores are proportional to actual abundance (Stander 1998, Carbone et al. 2001), most studies (like ours) have only reported visitation data as indices of distribution or relative abundance. Such indices cannot yield accurate estimates of population size and have been criticized on these grounds (Anderson 2001). Therefore, changes in track or camera indices across time do not necessarily reflect actual changes in population densities.

In addition, track and camera surveys are not always effective in documenting the entire suite of carnivore species. Santa Ysabel and Rancho Jamul both lie within the range of the ringtail (*Bassariscus astutus*) (Ingles 1965), but it remained undetected through pre-burn and post-burn sampling. More intensive, species specific survey efforts, such as hair snares or scat surveys, may be necessary to determine whether ringtails and other secretive species are present in the study areas. Additionally, non-invasive sampling of hair or scat has the potential to generate samples for subsequent genetic analysis. These analyses could help determine important population parameters and behavior patterns of carnivores, including population sizes, dispersal rates, genetic structure, and relatedness between and among populations (Snow and Parker 1998, Taberlet et al. 2001, Taberlet et al. 1999). These techniques, when conducted in concert with the methods used in our study, may provide for more complete monitoring of carnivore species.

Conservation Implications

Under scenarios of more frequent or severe wildfires, we may see more pronounced effects of wildfire on medium and large mammals. Although the Cedar and Otay Fires were massive in size, they burned through the landscape quickly, leaving behind some intact patches of vegetation (personal observations). A more severe fire, burning more slowly and completely across the landscape, could cause greater direct mortality, as seen with elk populations in Yellowstone National Park during the 1988 wildfires (Singer et al. 1989). A severe loss of vegetation could also cause local extinctions of carnivores dependent upon relatively dense, brushy habitat for hunting or safety. Finally, under repeated short return interval fire events, vegetation communities could transition to mostly grassland communities, rather than returning to native shrublands, such as coastal sage scrub (Zedler et al. 1983, Keeley 2005). According to Shaffer and Laudenslayer (2006), large fires can create expansive areas of similar vegetation, which can negatively impact many species. Any permanent loss of cover could cause population reductions in those species most sensitive to disturbance and habitat fragmentation.

Aside from the previously listed concerns, Santa Ysabel and Rancho Jamul are thought to be critical areas in maintaining landscape connectivity in southern California. Santa Ysabel lies at the nexus of two critical connectivity zones, the Cuyamaca-Palomar corridor and the Santa Ysabel Valley riparian corridor (Penrod 2000). Rancho Jamul and the surrounding area have been identified as a critical connectivity zone between Otay Mesa and the southern Laguna Mountains (Cleveland National Forest) (Penrod 2000). Large mammals, mainly carnivore species, have been identified as a key group indicative of the connection. In the face of more frequent and severe wildfires, it may be difficult to maintain the functional corridors necessary to promote juvenile dispersal and genetic diversity. Degradation of habitat and loss of vegetative cover are major concerns when considering functional corridors.

Conclusion

Our surveys indicate that Santa Ysabel and Rancho Jamul currently support resident populations of a variety of carnivore species, including coyotes and bobcats. The continued protection of these sites along with refugia on adjacent properties and careful fire management should help protect the mammalian carnivore community and provide landscape connectivity into the future. Accordingly, changes in management or land use should be closely monitored to determine their effects on local carnivore communities.

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Table 1. Total sampling effort for track transects and camera stations at Santa Ysabel Open Space Preserve and Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area during pre-burn and post-burn sampling. The track transect sampling effort is defined as $[s_j n_j] - o_j$, where s_j = number of stations in transect j, and n_j = number of nights that stations were active in transect j, and o_j = number of omitted sampling nights in transect j. The camera sampling effort is defined as the number of days the camera was active. Abbreviations of transect names within the table are as follows: OL = Otay Lakes Road and UP = Underpasses.

Santa Ysabel	*Sampling Dates*	*Track Transect*									
		1	2	3	4	5	6	7	8	9	10
Pre-burn	Jun 4-8, Sep 17-21, Dec 4-7, 2002 Mar 11-15, Jun 10-14, 2003	117	117	120	116	116	115	112	119	119	69
Post-burn	Jul 18-21, Oct 31-Nov 3, 2006 Mar 13-16, Jun 26-29, 2007	80	80	80	78	78	79	79	73	80	48
		Camera Station									
		1	2	3	4	5	6	7	8	9	
Pre-burn	Apr 2002 - Jun 2003	250	216	184	204	230	136	136	190	326	
Post-burn	Sep 2006 - Sep 2007	265	172	346	260	292	367	307	147	384	

Rancho Jamul	*Sampling Dates*	*Track Transect*											
		1	2	3	4	5	6	7	8	9	CA-94	OL	UP
Pre-burn	May 15-19, Jul 31-Aug 4, Oct 30-Nov 3, 2001 Feb 5-9, 2002	98	99	98	97	100	-	-	-	-	99	119	118
Post-burn	Jul 31-Aug 3, Nov 7-10, 2006 Feb 6-9, Jun 12-15, 2007	74	74	74	78	77	79	76	76	76	76	91	95
		Camera Station											
		2	3	4	5	6	7	8	9	10	11		
Pre-burn	May 2001 - Mar 2002	133	198	164	45	141	-	-	-	-	-		
Post-burn	Aug 2006 - Sep 2007	410	334	407	397	332	263	236	298	334	278		

Table 2. Mammal species detected at track transects within Santa Ysabel Open Space Preserve during pre-burn (Pre) and post-burn (Post) sampling, relative to the wildfires of October 2003. Track indices are listed for each species. Track index is calculatedas $I_j = \{v_j/(s_j n_j)-o_j\}$, where I_j = index of species activity at transect j, v_j = number of visits to stations along transect j by a particular species, s_j = number of stations in transect j, n_j = number of nights that stations were active in transect j, and o_j = number of omitted sampling nights in transect j. Track transects outside of the fire perimeter are identified as "Unburn", and those within the fire perimeter are labeled "Burn".

		Transect Number and Burn Status										*Average*		*Total #*	*# Transects*
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Relative*	*Standard*	*Detections*	*Detecting*
Native Species		*Unburn*	*Unburn*	*Unburn*	*Unburn*	*Burn*	*Burn*	*Burn*	*Burn*	*Unburn*	*Unburn*	*Abundance*	*Deviation*	*by Species*	*Species*
Mountain lion	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Mule deer	*Pre*	0	0	0	0	0	0	0.009	0.017	0	0	**0.003**	**0.006**	**3**	**2**
	Post	0	0.013	0.050	0.013	0.038	0.063	0.063	0	0.013	0	**0.025**	**0.026**	**20**	**7**
Coyote	*Pre*	0.470	0.359	0.183	0.190	0.078	0.165	0.429	0.059	0.126	0.333	**0.239**	**0.147**	**262**	**10**
	Post	0.625	0.550	0.563	0.462	0.321	0.405	0.468	0.534	0.263	0.375	**0.456**	**0.115**	**347**	**10**
Bobcat	*Pre*	0.077	0.085	0.075	0.086	0.078	0.070	0.089	0.008	0.008	0	**0.058**	**0.036**	**67**	**9**
	Post	0.013	0.038	0.175	0.115	0.038	0.076	0.127	0.096	0.050	0	**0.073**	**0.055**	**57**	**9**
Badger	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0.025	0	0	0	**0.003**	**0.008**	**2**	**1**
Gray fox	*Pre*	0.068	0.103	0.025	0.147	0.052	0.078	0.054	0	0.042	0	**0.057**	**0.045**	**66**	**8**
	Post	0.025	0.175	0.100	0.026	0.064	0.025	0	0.027	0.075	0	**0.052**	**0.054**	**41**	**8**
Raccoon	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0.025	0.025	0	0.026	0	0.013	0.013	0.055	0.050	0	**0.021**	**0.020**	**16**	**7**
Striped skunk	*Pre*	0.043	0.060	0.092	0.043	0.224	0.122	0.205	0.076	0.168	0.014	**0.105**	**0.073**	**121**	**10**
	Post	0.125	0.250	0.275	0.179	0.167	0.165	0.253	0.096	0.100	0.042	**0.165**	**0.077**	**129**	**10**
Spotted skunk	*Pre*	0	0.017	0	0.009	0.129	0.096	0.036	0.025	0.017	0	**0.033**	**0.044**	**38**	**7**
	Post	0	0.013	0	0	0.013	0.025	0.013	0	0.013	0	**0.008**	**0.009**	**6**	**5**
Opossum	*Pre*	0	0.043	0	0.009	0	0.026	0.009	0	0	0.014	**0.010**	**0.014**	**11**	**5**
	Post	0	0	0.063	0.103	0.077	0.177	0.025	0	0.213	0	**0.066**	**0.078**	**52**	**6**
Long-tailed weasel	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0.025	0.013	0	0	0	0	0	0.014	0	0	**0.005**	**0.009**	**4**	**3**
Human Associated Species															
Domestic cow	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0.150	0.238	0.013	0.154	0.192	0.051	0.089	0.137	0.150	0	**0.117**	**0.077**	**92**	**9**
Domestic horse	*Pre*	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Domestic dog	*Pre*	0.043	0.026	0.008	0.034	0	0	0.027	0.067	0.025	0.058	**0.029**	**0.023**	**31**	**8**
	Post	0	0	0	0	0	0	0.013	0.055	0	0.021	**0.009**	**0.018**	**6**	**3**
Total # Detections by Transect	***Pre***	**82**	**81**	**46**	**60**	**65**	**64**	**96**	**30**	**46**	**29**			599	
	Post	**79**	**105**	**99**	**84**	**71**	**79**	**86**	**74**	**74**	**21**			772	
# Species Detected at Transect	***Pre***	**5**	**7**	**5**	**7**	**5**	**6**	**8**	**6**	**6**	**4**				
	Post	**7**	**9**	**7**	**8**	**8**	**9**	**10**	**8**	**9**	**3**				

Table 3. Mammal species detected at track transects within Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area during pre-burn (Pre) and post-burn (Post) sampling, relative to the wildfires of October 2003. Track indices are listed for each species. Track index is calculated as $I_j = \{v_j/(s_j n_j)-o_j\}$, where I_j = index of species activity at transect j, v_j = number of visits to stations along transect j by a particular species, s_j = number of stations in transect j, n_j = number of nights that stations were active in transect j, and o_j = number of omitted sampling nights in transect j. Track transects outside of the fire perimeter are identified as "Unburn", and those within the fire perimeter are labeled "Burn".

		Transect Number and Burn Status															
Native Species		*1 Unburn*	*2 Burn*	*3 Burn*	*4 Burn*	*5 Burn*	*6 Unburn*	*7 Unburn*	*8 Unburn*	*9 Unburn*	*CA-94 Burn*	*Otay Lakes Road Burn*	*Under-passes Burn*	*Average Relative Abundance*	*Standard Deviation*	*Total # Detections by Species*	*# Transects Detecting Species*
Mountain lion	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0.013	0	0	0	0	**0.001**	**0.004**	**1**	**1**
Mule deer	*Pre*	0.031	0.030	0.122	0.103	0.030	-	-	-	-	0	0	0	**0.040**	**0.048**	**31**	**5**
	Post	0	0	0.027	0.038	0.013	0.013	0.013	0	0.039	0	0.011	0	**0.013**	**0.015**	**12**	**7**
Coyote	*Pre*	0.449	0.556	0.429	0.320	0.340	-	-	-	-	0.111	0.151	0.025	**0.298**	**0.185**	**238**	**8**
	Post	0.743	0.622	0.878	0.410	0.545	0.772	0.763	0.500	0.645	0.171	0.462	0.095	**0.551**	**0.240**	**510**	**12**
Bobcat	*Pre*	0	0.030	0.051	0.093	0.030	-	-	-	-	0	0	0.067	**0.034**	**0.035**	**28**	**5**
	Post	0	0.014	0	0	0	0.013	0.039	0.013	0.066	0	0.022	0.053	**0.018**	**0.023**	**18**	**7**
Gray fox	*Pre*	0	0	0.010	0	0	-	-	-	-	0	0.008	0	**0.002**	**0.004**	**2**	**2**
	Post	0	0	0.014	0	0	0	0.013	0	0.013	0.013	0	0	**0.004**	**0.007**	**4**	**4**
Raccoon	*Pre*	0.010	0	0.010	0	0.020	-	-	-	-	0	0.034	0.202	**0.034**	**0.069**	**32**	**5**
	Post	0	0	0	0	0	0	0	0.013	0.026	0	0.011	0.021	**0.006**	**0.010**	**6**	**4**
Striped skunk	*Pre*	0.020	0	0.061	0.031	0	-	-	-	-	0	0.017	0.059	**0.024**	**0.025**	**20**	**5**
	Post	0.014	0	0	0.038	0.013	0.013	0.053	0.066	0.026	0	0.011	0	**0.019**	**0.022**	**18**	**8**
Spotted skunk	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0.076	**0.009**	**0.027**	**9**	**1**
	Post	0	0	0	0	0	0	0	0.013	0.013	0	0	0.074	**0.008**	**0.021**	**9**	**3**
Opossum	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0.008	**0.001**	**0.003**	**1**	**1**
	Post	0	0	0	0	0	0	0.013	0	0.026	0	0	0	**0.003**	**0.008**	**3**	**2**
Long-tailed weasel	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	0	0.011	**0.001**	**0.003**	**1**	**1**
Human Associated Species																	
Domestic horse	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Domestic dog	*Pre*	0.214	0.182	0.224	0.155	0.130	-	-	-	-	0.071	0.143	0.059	**0.147**	**0.061**	**120**	**8**
	Post	0.081	0.014	0.027	0.038	0.104	0.203	0.092	0.145	0.263	0.105	0.121	0.042	**0.103**	**0.074**	**97**	**12**
Domestic cat	*Pre*	0	0	0	0	0	-	-	-	-	0	0	0.025	**0.003**	**0.009**	**3**	**1**
	Post	0	0.014	0	0	0	0	0	0	0	0	0	0	**0.001**	**0.004**	**1**	**1**
Total # Detections by Transect	***Pre***	**71**	**79**	**89**	**68**	**55**	**-**	**-**	**-**	**-**	**18**	**42**	**62**			**484**	
	Post	**62**	**49**	**70**	**41**	**52**	**80**	**75**	**58**	**85**	**22**	**28**	**58**			**680**	
# Species Detected at Transect	***Pre***	**5**	**4**	**7**	**5**	**5**	**-**	**-**	**-**	**-**	**2**	**5**	**8**				
	Post	**3**	**4**	**4**	**4**	**4**	**5**	**7**	**7**	**9**	**3**	**6**	**6**				

Table 4. Mammal species detected at camera stations within Santa Ysabel Open Space Preserve during pre-burn (Pre) and post-burn (Post) sampling, relative to the wildfires of October 2003. Camera indices are listed for each species and are calculated as $I_j = \{v_j/n_j\}$, where I_j = index of activity at camera j, v_j = number of visits to camera j by a particular species, and n_j = number of nights that camera j was active. Camera stations outside of the fire perimeter are identified as "Unburn", and those within the fire perimeter are labeled "Burn".

		Camera Number and Burn Status									*Average*		*Total #*	*# Cameras*
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Relative*	*Standard*	*Detections*	*Detecting*
Native Species		*Unburn*	*Unburn*	*Unburn*	*Unburn*	*Burn*	*Burn*	*Burn*	*Burn*	*Unburn*	*Abundance*	*Deviation*	*by Species*	*Species*
Mountain lion	*Pre*	0.004	0	0	0	0.035	0	0	0.011	0.006	**0.006**	**0.011**	**13**	**4**
	Post	0	0	0.003	0.008	0	0	0	0	0	**0.001**	**0.003**	**3**	**2**
Mule deer	*Pre*	0.048	0.296	0.027	0.113	0.017	0.029	0.257	0.068	0.034	**0.099**	**0.105**	**171**	**9**
	Post	0.030	0.006	0.072	0.192	0.130	0.117	0.319	0.027	0.013	**0.101**	**0.103**	**272**	**9**
Coyote	*Pre*	0.008	0	0.022	0	0	0.007	0	0	0.003	**0.004**	**0.007**	**8**	**4**
	Post	0.109	0.029	0.066	0.031	0.110	0.003	0.029	0.061	0	**0.049**	**0.041**	**116**	**8**
Bobcat	*Pre*	0.152	0.005	0.348	0.039	0.091	0.074	0.007	0.289	0.049	**0.117**	**0.124**	**214**	**9**
	Post	0.045	0	0.191	0.027	0.147	0	0.016	0.374	0.023	**0.092**	**0.126**	**197**	**7**
Badger	*Pre*	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Gray fox	*Pre*	0.084	0	0.027	0.015	0.017	0	0	0	0.006	**0.017**	**0.027**	**35**	**5**
	Post	0.060	0	0.066	0	0.017	0	0	0.007	0.003	**0.017**	**0.027**	**46**	**5**
Raccoon	*Pre*	0	0	0	0	0	0	0	0.032	0	**0.004**	**0.011**	**6**	**1**
	Post	0.004	0	0.006	0	0.021	0	0	0.007	0	**0.004**	**0.007**	**10**	**4**
Striped skunk	*Pre*	0.024	0	0.033	0.015	0.091	0.022	0.007	0	0	**0.021**	**0.029**	**40**	**6**
	Post	0.045	0	0.052	0	0.010	0	0	0.041	0.005	**0.017**	**0.022**	**41**	**5**
Spotted skunk	*Pre*	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Opossum	*Pre*	0	0.005	0	0.005	0	0	0	0	0	**0.001**	**0.002**	**2**	**2**
	Post	0	0	0.006	0	0.003	0	0	0.014	0	**0.003**	**0.005**	**5**	**3**
Long-tailed weasel	*Pre*	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Human Associated Species														
Domestic cow	*Pre*	0	0.181	0.011	0.103	0.004	0	0	0.074	0.046	**0.046**	**0.063**	**92**	**6**
	Post	0.868	2.610	0.023	0.685	0.366	0.068	0.313	0.408	0.135	**0.609**	**0.800**	**1205**	**9**
Domestic horse	*Pre*	0	0	0	0	0.004	0	0	0	0.006	**0.001**	**0.002**	**3**	**2**
	Post	0	0	0	0	0.062	0	0	0	0	**0.007**	**0.021**	**18**	**1**
Domestic dog	*Pre*	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0.024	0	0	0	0	**0.003**	**0.008**	**7**	**1**
Total # Detections by Camera	***Pre***	**80**	**105**	**86**	**59**	**60**	**18**	**37**	**90**	**49**			**584**	
	Post	**308**	**455**	**168**	**245**	**260**	**69**	**208**	**138**	**69**			**1920**	
# Species Detected at Camera	***Pre***	**6**	**4**	**6**	**6**	**7**	**4**	**3**	**5**	**7**				
	Post	**7**	**3**	**9**	**5**	**10**	**3**	**4**	**8**	**5**				

Table 5. Mammal species detected at camera stations within Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area during pre-burn (Pre) and post-burn (Post) sampling, relative to the wildfires of October 2003. Camera indices are listed for each species. Camera index is calculated as $I_j = \{v_j/n_j\}$, where I_j = index of activity at camera j, v_j = number of visits to camera j by a particular species, and n_j = number of nights that camera j was active. Camera stations outside of the fire perimeter are identified as "Unburn", and those within the fire perimeter are labeled "Burn".

		Camera Number and Burn Status													
Native Species		*2 Burn*	*3 Burn*	*4 Burn*	*5 Burn*	*6 Burn*	*7 Unburn*	*8 Unburn*	*9 Unburn*	*10 Unburn*	*11 Unburn*	*Average Relative Abundance*	*Standard Deviation*	*Total # Detections by Species*	*# Cameras Detecting Species*
Mountain lion	*Pre*	0	0	0.006	0	0	-	-	-	-	-	**0.001**	**0.003**	**1**	**1**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Mule deer	*Pre*	0.030	0.106	0.244	0.089	0.043	-	-	-	-	-	**0.102**	**0.085**	**75**	**5**
	Post	0	0.108	0.305	0.521	0.051	0.004	0	0.007	0.033	0.004	**0.103**	**0.174**	**399**	**8**
Coyote	*Pre*	0.556	0.106	0.079	0.044	0.014	-	-	-	-	-	**0.160**	**0.224**	**112**	**5**
	Post	0.263	0.135	0.103	0.008	0.063	0.144	0.064	0.037	0.078	0.122	**0.102**	**0.072**	**343**	**10**
Bobcat	*Pre*	0.008	0.172	0.006	0.044	0.014	-	-	-	-	-	**0.049**	**0.070**	**40**	**5**
	Post	0	0.003	0.005	0	0	0	0.025	0.104	0.015	0.018	**0.017**	**0.032**	**50**	**6**
Gray fox	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Raccoon	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**	**0**	**0**
	Post	0	0.003	0.005	0	0	0.004	0	0	0	0	**0.001**	**0.002**	**4**	**3**
Striped skunk	*Pre*	0	0.005	0	0	0	-	-	-	-	-	**0.001**	**0.002**	**1**	**1**
	Post	0	0	0	0	0	0	0	0.003	0	0	**0.000**	**0.001**	**1**	**1**
Spotted skunk	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Opossum	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Long-tailed weasel	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**	**0**	**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Human Associated Species															
Domestic horse	*Pre*	0	0	0.006	0	0	-	-	-	-	-	**0.001**	**0.003**	**1**	**1**
	Post	0.012	0	0	0	0	0	0.017	0.007	0.051	0.004	**0.009**	**0.016**	**29**	**5**
Domestic dog	*Pre*	0	0.005	0	0	0	-	-	-	-	-	**0.001**	**0.002**	**1**	**1**
	Post	0.002	0	0	0	0	0	0.008	0.017	0.132	0.004	**0.016**	**0.041**	**53**	**5**
Domestic cat	*Pre*	0	0	0	0	0	-	-	-	-	-	**0**	**0.000**		**0**
	Post	0	0	0	0	0	0	0	0	0	0	**0**	**0.000**	**0**	**0**
Total # Detections by Camera	***Pre***	**79**	**78**	**56**	**8**	**10**	-	-	-	-	-			**231**	
	Post	**114**	**83**	**170**	**210**	**38**	**40**	**27**	**52**	**103**	**42**			**879**	
# Species Detected at Camera	***Pre***	**3**	**5**	**5**	**3**	**3**	-	-	-	-	-				
	Post	**3**	**4**	**4**	**2**	**2**	**3**	**4**	**6**	**5**	**5**				

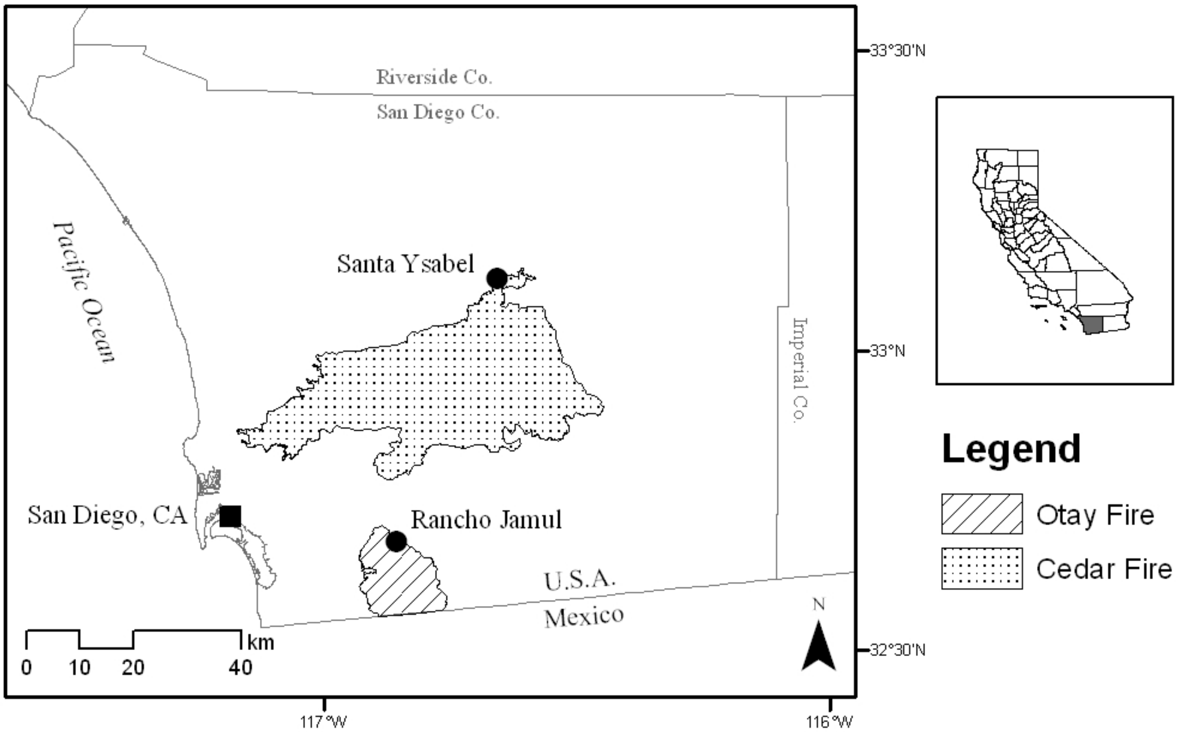


Figure 1. Map of study sites within San Diego County, California, showing the extent of the Cedar and Otay Fires of 2003.

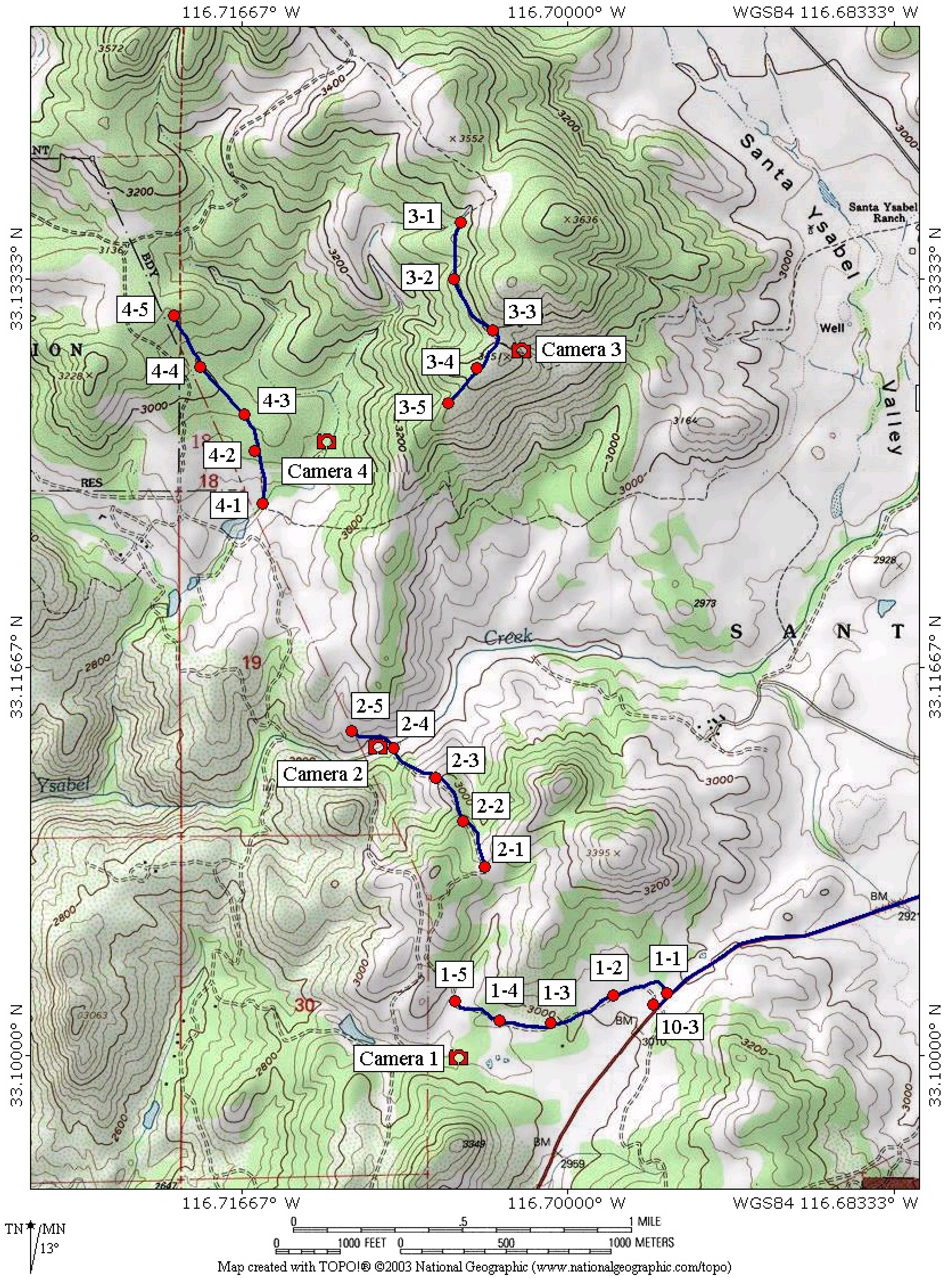


Figure 2. Locations of track transects (blue lines) with baited scent stations (red circles) and camera stations (camera icons) within the western section of Santa Ysabel Open Space Preserve. Only one of the three baited scent stations comprising Transect 10 is included here; the others are in Figure 3.

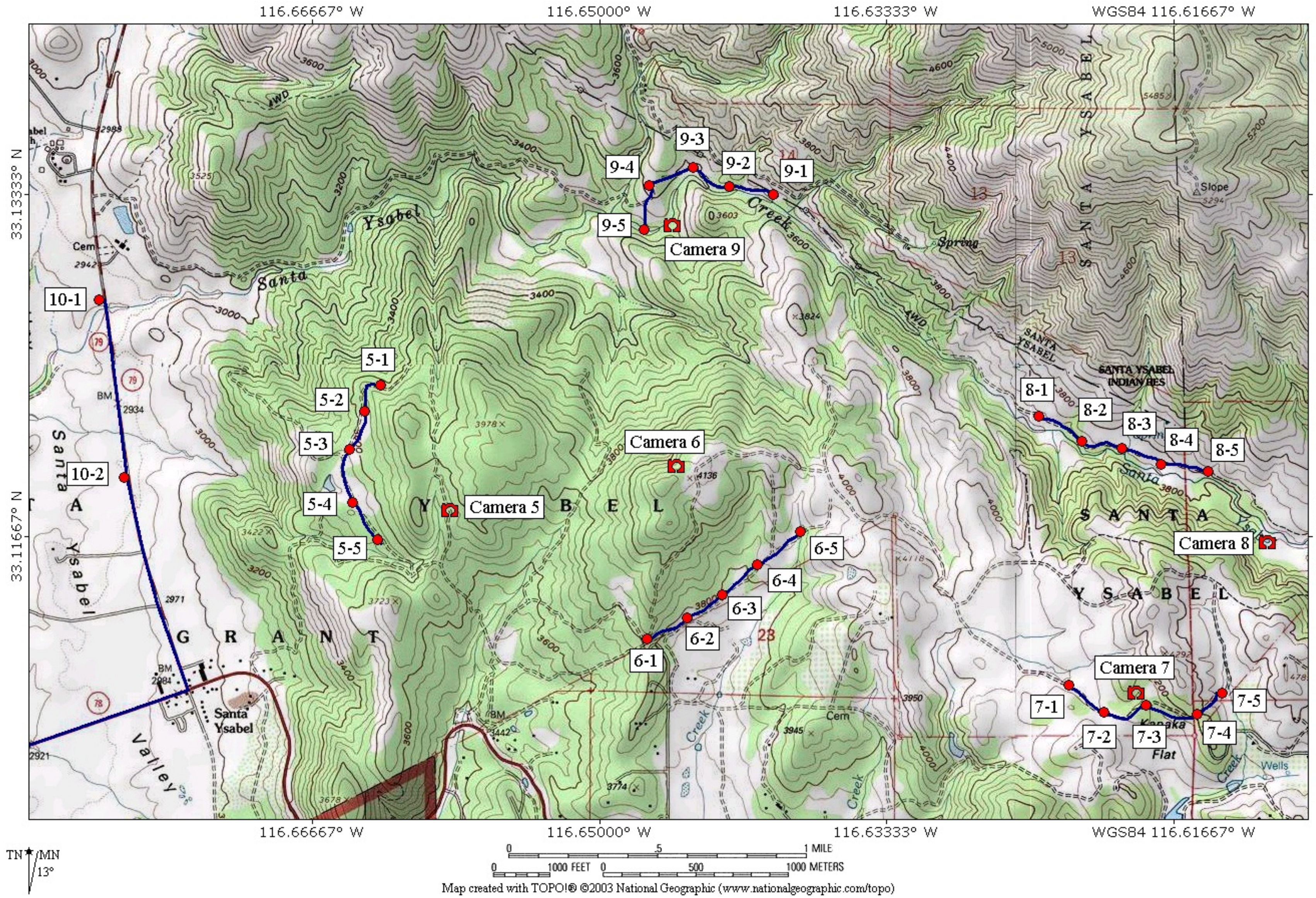


Figure 3. Locations of track transects (blue lines) with baited scent stations (red circles) and camera stations (camera icons) within the eastern section of Santa Ysabel Open Space Preserve. Transect 10 is divided between Figure 2 and Figure 3.

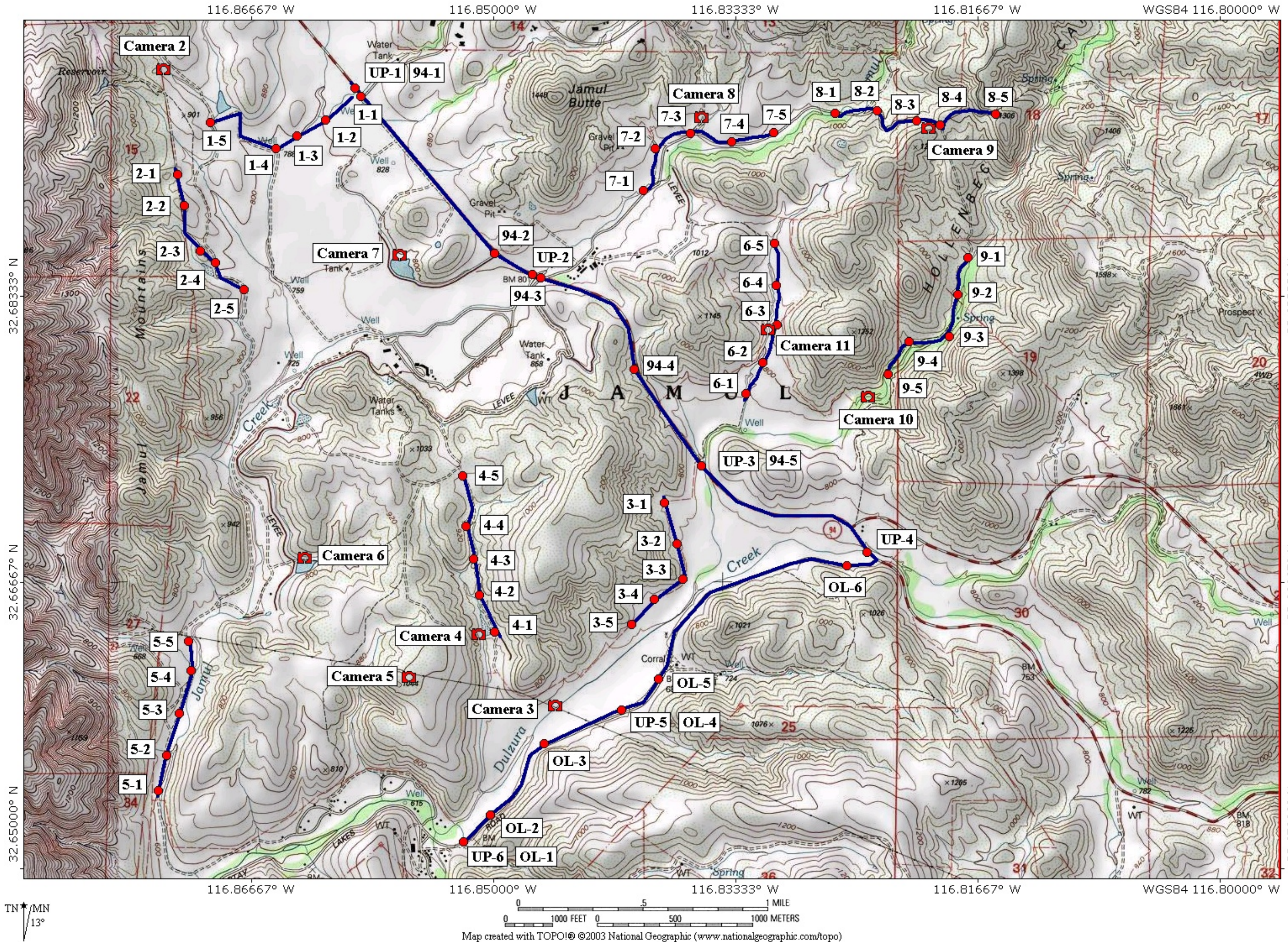


Figure 4. Locations of track transects (blue lines) with baited scent stations (red circles) and camera stations (camera icons) within the Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area. Baited scent stations along state route CA-94 and Otay Lakes Road were frequently paired with one scent station at the road surface and another in the associated culvert. Scent stations in the associated culverts make up the Underpasses transect.

Appendix 1. GPS coordinates of camera stations and baited scent stations within each track transect at Santa Ysabel Open Space Preserve. Locations were obtained in WGS 84 datum.

Survey Location	*Degrees N*	*Degrees W*	*Survey Location*	*Degrees N*	*Degrees W*
Transect 1			Transect 7		
1-1	33.10263	116.69563	7-1	33.10942	116.62272
1-2	33.10222	116.69834	7-2	33.10804	116.62069
1-3	33.10134	116.70084	7-3	33.10841	116.61818
1-4	33.10148	116.70344	7-4	33.10793	116.61525
1-5	33.10228	116.70574	7-5	33.10890	116.61378
Transect 2			Transect 8		
2-1	33.10810	116.70414	8-1	33.12243	116.62439
2-2	33.11000	116.70528	8-2	33.12119	116.62195
2-3	33.11183	116.70667	8-3	33.12090	116.61959
2-4	33.11313	116.70891	8-4	33.12013	116.61733
2-5	33.11386	116.71092	8-5	33.11983	116.61454
Transect 3			Transect 9		
3-1	33.13561	116.70512	9-1	33.13331	116.63991
3-2	33.13330	116.70577	9-2	33.13371	116.64246
3-3	33.13110	116.70384	9-3	33.13463	116.64452
3-4	33.12951	116.70457	9-4	33.13375	116.64709
3-5	33.12796	116.70599	9-5	33.13158	116.64740
Transect 4			Transect 10		
4-1	33.12367	116.71553	10-1	33.12826	116.67901
4-2	33.12591	116.71592	10-2	33.11944	116.67752
4-3	33.12750	116.71646	10-3	33.10217	116.69558
4-4	33.12956	116.71871			
4-5	33.13166	116.72006			
Transect 5			Cameras		
5-1	33.12393	116.66278	Camera 1	33.09987	116.70552
5-2	33.12263	116.66394	Camera 2	33.11316	116.70965
5-3	33.12047	116.66498	Camera 3	33.13027	116.70235
5-4	33.11825	116.66423	Camera 4	33.12623	116.71221
5-5	33.11638	116.66275	Camera 5	33.11793	116.65867
			Camera 6	33.11971	116.64575
Transect 6			Camera 7	33.10907	116.61882
6-1	33.11155	116.64718	Camera 8	33.11630	116.61117
6-2	33.11263	116.64486	Camera 9	33.13150	116.64649
6-3	33.11376	116.64278			
6-4	33.11526	116.64077			
6-5	33.11684	116.63828			

Appendix 2. GPS coordinates of camera stations and baited scent stations within each track transect at Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area. Locations were obtained in WGS 84 datum.

Survey Location	*Degrees N*	*Degrees W*	*Survey Location*	*Degrees N*	*Degrees W*
Transect 1			Transect 6		
1-1	32.69496	116.85907	6-1	32.67769	116.83249
1-2	32.69360	116.86148	6-2	32.67948	116.83132
1-3	32.69259	116.86335	6-3	32.68167	116.83030
1-4	32.69187	116.86485	6-4	32.68397	116.83039
1-5	32.69345	116.86943	6-5	32.68634	116.83059
Transect 2			Transect 7		
2-1	32.69043	116.87170	7-1	32.68951	116.83954
2-2	32.68860	116.87124	7-2	32.69198	116.83878
2-3	32.68597	116.87007	7-3	32.69279	116.83645
2-4	32.68529	116.86911	7-4	32.69233	116.83356
2-5	32.68371	116.86710	7-5	32.69287	116.83057
Transect 3			Transect 8		
3-1	32.67132	116.83816	8-1	32.69399	116.82633
3-2	32.66898	116.83722	8-2	32.69414	116.82342
3-3	32.66686	116.83683	8-3	32.69360	116.82071
3-4	32.66577	116.83887	8-4	32.69334	116.81914
3-5	32.66426	116.84044	8-5	32.69394	116.81529
Transect 4			Transect 9		
4-1	32.66379	116.84986	9-1	32.68553	116.81720
4-2	32.66594	116.85083	9-2	32.68338	116.81788
4-3	32.66801	116.85122	9-3	32.68098	116.81851
4-4	32.66990	116.85173	9-4	32.68074	116.82123
4-5	32.67281	116.85196	9-5	32.67882	116.82274
Transect 5			CA-94		
5-1	32.65459	116.87299	94-1	32.69545	116.85946
5-2	32.65666	116.87245	94-2	32.68587	116.84980
5-3	32.65910	116.87159	94-3	32.68440	116.84666
5-4	32.66153	116.87070	94-4	32.67905	116.84022
5-5	32.66326	116.87095	94-5	32.67343	116.83555

Appendix 2 (continued). GPS coordinates of camera stations and baited scent stations within each track transect at Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area. Locations were obtained in WGS 84 datum.

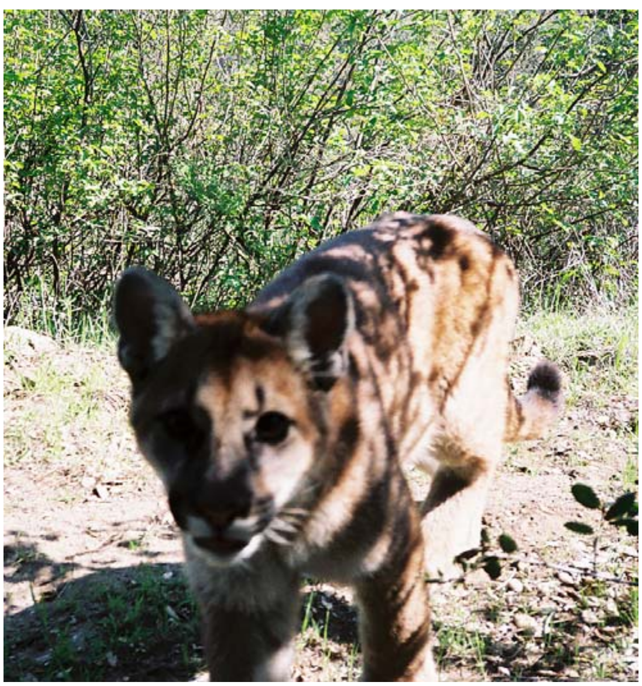
Survey Location	*Degrees N*	*Degrees W*	*Survey Location*	*Degrees N*	*Degrees W*
Otay Lakes Road			Cameras		
OL-1	32.65150	116.85193	Camera 2	32.69655	116.87271
OL-2	32.65316	116.85014	Camera 3	32.65943	116.84560
OL-3	32.65731	116.84637	Camera 4	32.66359	116.85081
OL-4	32.65917	116.84106	Camera 5	32.66114	116.85574
OL-5	32.66111	116.83855	Camera 6	32.66813	116.86294
OL-6	32.66758	116.82552	Camera 7	32.68570	116.85640
			Camera 8	32.69362	116.83562
Underpasses			Camera 9	32.69300	116.81996
UP-1	32.69545	116.85946	Camera 10	32.67734	116.82413
UP-2	32.68456	116.84721	Camera 11	32.68136	116.83097
UP-3	32.67343	116.83555			
UP-4	32.66843	116.82410			
UP-5	32.65917	116.84106			
UP-6	32.65150	116.85193			

Appendix 3. Badger tracks photographed at a baited scent station along Transect 7 within Santa Ysabel Open Space Preserve.

Appendix 4. Representative photos of species detected at camera stations within Santa Ysabel Open Space Preserve and Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area.

Gray fox, Santa Ysabel – Camera 1

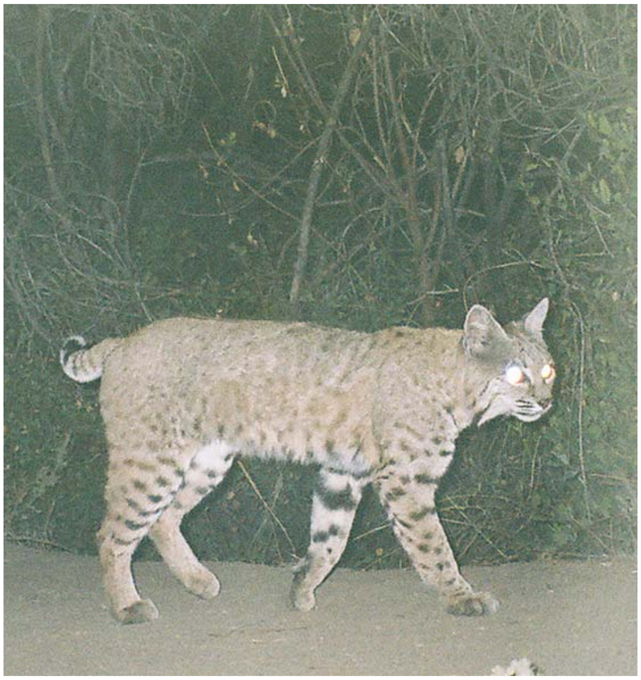
Coyote, Rancho Jamul – Camera 2



Mountain lion, SantaYsabel – Camera 3

Raccoon, Rancho Jamul – Camera 4

Appendix 4 (Continued). Representative photos of species detected at camera stations within Santa Ysabel Open Space Preserve and Rancho Jamul Ecological Reserve-Hollenbeck Canyon Wildlife Area.



Bobcat, SantaYsabel – Camera 5

Mule deer, Rancho Jamul – Camera 5

Opossum, SantaYsabel – Camera 8

Striped skunk, Rancho Jamul – Camera 9