A PRELIMINARY LARGE MAMMAL AND HERPTILE SURVEY OF GRIFFITH PARK, LOS ANGELES, CALIFORNIA

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1. INTRODUCTION

Griffith Park, the nation's largest municipally-owned park, is a natural oasis for both the human and wildlife populations of Los Angeles. Despite being surrounded by urban development, Griffith Park has remained in large part a natural environment. The park lies within the California Floristic Province, a biome considered one of 34 biodiversity hotspots for conservation worldwide due to its high levels of diversity, endemism, and the degree to which it is threatened (Myers et al. 2000). Griffith Park itself has become increasingly isolated from other nearby open areas and core wildlife habitat due to human activity and development. Two major roadways (US 101 and Interstate 405) separate the park from the rest of the Santa Monica mountains—which contain large areas of protected land (i.e., the Santa Monica Mountains National Recreation Area and the Santa Monica State Park)—and it is separated from the Verdugo Mountains and the Angeles Crest National Forest by continuous development. In spite of its location within this highly urbanized landscape, there are regular wildlife sightings and reports, indicating permanent habitation within the park by at least some large mammal species. However, to date, no formal studies of wildlife presence and/or distribution have been conducted, prohibiting the park's natural ecosystem from being properly managed.

This study reports on the first survey of Griffith Park's large mammals and herptiles. This study targeted mammalian carnivore species, particularly medium-sized carnivores, or mesocarnivores. These mesocarnivores are much more generalized than their larger counterparts and are less likely to be extirpated from areas of high human density and fragmentation (Park & Harcourt 2002, Crooks 2000). Carnivores that have been reported in the park and were targets of this study include large carnivores—mountain lion (*Puma concolor*) and coyote (*Canis latrans*)—as well as mesocarnivores—bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*). Although it is a marsupial, the Virginia opossum (*Didelphis virginiana*) is included as a target species because its generalist ecology is similar to that of mesocarnivores and can be detected by the same methods employed for carnivores in this study.

Carnivores serve as excellent indicators of the park's overall ecological health since their survival is contingent upon the health of the food chain below them. Given their low densities and large home ranges, they are also considered "umbrella" species, as management and conservation efforts targeted at carnivores encompass many other species in the process (e.g., Wilcox 1984, Fleishman et al. 2001). The purpose of this study is to provide baseline information on the presence of large mammalian and herptile species and their distribution and habitat needs throughout Griffith Park. This preliminary study should be used as a foundation from which further studies are based, and serves as a first step in developing a more complete ecological understanding of the park.

2. METHODS

2.1 Study area

Griffith Park is a 4,210-acre public park located entirely within the City of Los Angeles. It is part of the eastern end of the Santa Monica mountain chain, and elevations within the park range from 400 feet to 1625 feet a.s.l. An area of undeveloped, privately-owned land—hereafter referred to as the Barham property—abuts the northwestern portion of the park. The rest of the park is separated from other open areas by dense urban development: the average housing density to the west towards the rest of the Santa Monica mountains is 999 houses per square mile and 3496 houses per square mile northeast to the Angeles Crest mountains (US Census 2000). Griffith Park itself contains several golf courses and museums, an observatory, a zoo, picnic areas, and ballfields. These are contained in the outer edges of the park, and the interior has remained largely undisturbed except for a network of trails and fire roads. The park's landscape consists of both native vegetation types (mixed chaparral, mixed scrub, oak sycamore riparian, oak walnut, and oak) and introduced or altered vegetation (pine, ornamental/landscaped, disturbed) (Melendrez 2004). A wildfire burned approximately 800 acres of the park's southeastern portion in May 2007.

2.2 Mammal detection

2.2.1 *Carnivores*

We assembled and monitored 42 carnivore detection stations from June 6-24, 2007. These detection stations were placed along sampling lines, which consisted of 3-10 stations set at least 150 meters apart along existing access roads and hiking trails. These sampling lines were set up in seven representative areas of the park: Aberdeen (A), Brush Canyon (BC), Headworks (HW), Hollywood Ridge (HR), Old Zoo (OZ), Royce's Canyon (RC), and Skyline (SL) (Figs. 2a, 2b). Along each sampling line we alternated between two types of detection stations: tracking stations and hair snares (See Appendix A). Tracking stations consisted of a tracking substrate placed in a 1.5 m diameter circle that had been cleared of vegetation. An attractant was placed in the center of the circle to entice animals to enter the station and leave tracks. We initially used sifted sand mixed with mineral oil in a 32:1 ratio as our substrate (Bischof 2001, Harrison 2006) with a punctured cat food can (Boydston 2005, LSA 2003) staked in the center as an attractant. We noticed the sand began drying out after one to two days, rendering tracks difficult to read, and coyotes dug up several cat food cans, obliterating the station. After two days we began using powdered gypsum as the substrate and baited the stations with Gusto, a commercial trapping lure (Minnesota Trapline Products). Reflective aluminum takeout containers and carpet squares scented with trapping lure were hung with fishing line above the tracking stations to further attract target species (McDonald et al. 2000).

Hair snares consisted of a 10cm x 10cm square of commercial carpeting with 12 10mm long staples driven through the back. The carpet squares were scented with approximately 15 ml of either Gusto or a mixture of ground beaver castorum with several drops of imitation catnip oil and sprinkled with crushed dried catnip (Harrison 2006). We nailed the carpet squares to trees at least 10 cm dbh, and placed carpet squares approximately 16 inches off the ground, ensuring they were at a proper rubbing height for our target species (bobcat, fox, and coyote). The ground below the hair snares was cleared and tracking substrate was spread to help aid in species identification, and reflective tins were hung nearby with fishing line.

All animal sign present in the immediate vicinity of each station was noted during assembly to ensure that subsequent detections during the study were new. Stations were checked each day for the first four days, and every other day for the following eight days (e.g., Conner et al. 1983, Schauster et al. 2002, Gese et al. 2004); all identifiable tracks were measured, noted, and photographed, and new scat and other animal sign in the vicinity of the stations were recorded. After each examination, the station substrate was smoothed, and additional substrate and lure were added as necessary. Heavy machinery work and access restrictions prohibited us from visiting stations in the burned area of the park on the second day of monitoring; those stations were monitored for an additional day. The sampling line along Hollywood Ridge was set up one day late, and was thus monitored for only 11 days; stations in the Headworks area were only monitored for four continuous days (following Gese et al. 2004).

2.2.1.1 Calculating relative abundance

Absolute population numbers cannot be ascertained from tracking stations, as we cannot identify individual tracks and there is no way to distinguish tracks of a repeat visitor to a station from multiple visitors; rather, we used a relative detection index for each target species as a means of analysis. The overall detection index was calculating by dividing the total number of times a species was identified at any detection station by the total sampling effort. The total sampling effort was calculated by summing the number of nights each station was operating (Appendix A). The detection index ranges from 0 (species not found at any station) to 1 (species found at every station every night), and can be used to compare the ease with which different species are detected; from this, relative abundance can be inferred (Crooks 2002). Similar calculations can be made when grouping stations by sampling area to compare relative abundance in different areas of the park.

It was at times difficult to distinguish between the tracks of domestic dogs and coyotes in areas where were both present. We assumed all ambiguous tracks were coyote only if we were also able to ascertain coyote presence at that station through other detection means such as scat, urination, or hair rubs. If we could not confirm coyote presence through other sign, ambiguous tracks were not included in any analyses or tables.

2.2.1.2 Diversity calculation

In order to quantify target species biodiversity more completely than simply looking at species richness (the total number of species found), we used the Shannon Index of diversity. This index takes into account the relative abundance of species within a sample, as well as how evenly they are distributed within that sample. It is not affected by sample size, so we can compare across unequally sampled areas. The Shannon Index (H) is calculated by taking the proportion of a given species (*i*) out of all species present and multiplying it by the natural log of this proportion. This is done for all species in the sample, and the values are summed and multiplied by -1:

$$H = -\sum(p_i \times \ln(p_i))$$

A greater H value indicates a higher level of species diversity. A species evenness value, which allows us to obtain a measure of how evenly study species are distributed in a given area, can then be calculated. The Shannon Index (H) is divided by the log of the total number of species in the sample (S):

$$E_H = H/\log(S)$$

Evenness (E_H) approaches 0 as a sample becomes dominated by a single species and approaches 1 as a sample has similar proportions of all species.

2.2.2 *Other mammals*

Domestic dog (*Canis familiaris*) tracks found at detection stations were recorded on a presence/absence basis only, as they were not target wildlife species. We also recorded tracks and noted other sign of the non-carnivorous mammals that we could identify sign to at least the genus level at the detection stations, and included the records of the sign in the report as documentation of presence or absence in a given area. These mammals were the mule deer (*Odocoileus hemionus)* and cottontail rabbit (*Sylvilagus* spp.) However, we did not include these species in any calculations of diversity and did not create a detection index. While cottontail rabbit tracks have been reported to be prevalent at detection stations targeting carnivores (Loukmas et al. 2003), there is no reason to believe herbivore species would be attracted to our stations; any tracks discovered would likely be purely coincidental, and may not represent the true density of animals in the area. Due to time and labor cost restraints we were unable to conduct any formal rodent or smaller mammal surveys

2.3 <u>Herptiles</u>

We constructed 3' by 3' coverboards out of ½" to ¾ " thick and 5.5" wide scrap lumber. Six pieces approximately 36" long were fastened together with two crosspieces. Six coverboards were placed in each of the hexagonal arrays (following Reading 1997, Grant 1992, Manley et al. 2005) located in five areas: Skyline, Royce's Canyon, Brush Canyon, Old Zoo and Aberdeen (Figs. 3a, 3b). All coverboards in Brush Canyon and two coverboards in Royce's Canyon were in riparian woodland vegetation, while the Aberdeen array was located entirely on recently burned land. All coverboards in the Old Zoo and Skyline sample areas were set in scrub/chaparral vegetation. No arrays were set in the Headworks or Hollywood Ridge sample areas due to cost constraints. The arrays were checked on the same schedule as the carnivore detection stations for the first 12 days and then checked once a week for the following two weeks. In addition to checking the coverboards, we noted all other herptiles encountered throughout the study.

2.4 GIS mapping

All GIS maps included in this report were made in ArcView 3.0a (ESRI 1995) using digital orthoquad images obtained from the California Spatial Information Library. The vegetation types were based from the maps in the current Griffith Park Master Plan (Melendrez 2004) and drawn from the digital orthoquads without a formal ground-truthing effort. Thus, park boundary lines and vegetation zones should be considered close approximations of reality. Public roads were defined as roads in the park accessible to the general public. Limited access roads were defined as paved roads in the park not accessible to the general public. Selected fire roads, natural features, and buildings were also included in the maps for reference purposes.

3. RESULTS

Our 42 stations were monitored for a combined total of 491 nights of survey effort (Appendix A). During this time we detected six of our seven target species; only mountain lion presence could not be confirmed. We did find likely mountain lion scat in Royce's Canyon, but it was deposited prior to this study. Coyote was the most easily detected and widespread species, with coyote tracks accounting for nearly 80% of all carnivore tracks detected (Table 1). Coyote easily had the highest detection index of all target species, as coyote presence was identified in all seven study areas and at all but three detection stations. While skunk and bobcat were both found in four of the seven sample areas, skunk were detected at nearly twice as many stations as bobcat and had a much higher detection index (Table 2, Figs. 4a, 4b). Opossum and fox had the lowest detection index of all target species as both species were only detected in a single area (Figs. 4a, 4b).

The Skyline and Old Zoo areas had the highest species richness with five carnivore species detected in both of these areas. The Aberdeen area exhibited the lowest species richness, as only two species were detected at stations in this area (Table 3). When carnivore diversity of an area was calculated using Shannon's Diversity Index, the Old Zoo sample area also had the highest level of biodiversity. The Headworks area had the second highest Diversity Index, despite the fact that only three species were detected there; this is likely because this was the only station not dominated by coyotes and detections were thus more evenly distributed among species (Table 3). While the Royce's Canyon and Brush Canyons areas had the same species richness (3), Royce's Canyon had a much higher Diversity Index, as coyote tracks were the only carnivore species detected at all but one detection station in Brush Canyon (Tables 2, 3).

3.1 Effect of Human Use

When we grouped stations by subjective levels of human use (those trails that were open to the general public at the time of the study and along which we regularly saw people were deemed to have high levels of human use; these included the Skyline, Brush Canyon, and Hollywood Ridge areas), we found that the areas of high human use had a much lower level of carnivore diversity even though an equal number of species were detected in both groups (Table 3).

3.2 Microhabitat preference

Habitat preference and the patterning of different types of vegetation, or microhabitats, within the park may dictate wildlife distribution patterns in the park. As the distribution of microhabitats was correlated with altitude, we used altitude as an index of microhabitat type for this study. Woodland habitats (e.g., oak sycamore riparian, oak) were normally found near canyon bottoms (below 900 ft a.s.l.), and were thus considered low altitude; scrub and chaparral habitats dominated ridgetops and slopes (above 900 ft a.s.l.), and were thus considered high altitude. When we grouped stations by altitude, lower altitude stations recorded much higher levels of carnivore diversity (Table 3), indicating that most carnivores may prefer the variety of microhabitats found at lower sections of the park. Coyote was the only species detected on more than one occasion at high altitude stations.

3.3 Use of Burned Areas

The Aberdeen detection stations were the only stations set entirely in a portion of the park that had burned during the May 2007 fire. Three stations in the Old Zoo sample area were also set in burned area, but were at the edge of the burn (Fig 2a). The Aberdeen sample area had the lowest carnivore detection rate, carnivore species richness, and biodiversity of all areas sampled. With the exception of one raccoon, all carnivore detections in this area were of coyote. However, deer were seen during monitoring activities and deer tracks were noted during several checks of Aberdeen stations. Groups of deer numbering up to seven individuals were seen along the Vista del Valle road northwest of the intersection with the Aberdeen Fire Road. The Old Zoo stations that were set at the edges of the burned area had much higher detection rates, species richness, and biodiversity, as we detected coyote, skunk, and bobcat in the burned sites in the Old Zoo sample area, as well as deer and rabbit on multiple occasions.

3.4 Herptiles

Three reptile species were found during coverboard surveys: the Western fence lizard (*Sceloporus occidentalis*), Western whiptail lizard (*Cnemidophorus tigris*), and California whipsnake (*Masticophis lateralis*). Opportunistic searches under logs and rocks by the authors during the study turned up three additional species: the Southern alligator lizard (*Elgaria multicarinata*), Western skink (*Eumeces skiltonianus*), and Western rattlesnake (*Crotalus viridis*). An unrelated nightwalk taken during the course of the study also found a California kingsnake (*Lampropeltis getula*) near the Old Zoo coverboard array (A. Torres, pers. comm.). Fence lizards were the most commonly encountered reptile, observed at all coverboard arrays and in the vicinity of nearly every carnivore detection station. Whiptail lizards were observed in four of the seven study areas, and whipsnakes were found near two detection stations in the Aberdeen study area. All other reptiles were observed once; see Figures 3a,b for locations of all reptile sightings other than the Western fence lizard. No amphibians were detected during the course of this study.

4. DISCUSSION

4.1 Carnivores

4.1.1 *Coyote*

Coyote was by far the easiest carnivore to detect, suggesting that it is the most abundant and widespread carnivore in the park. It was detected in all sample areas at similar detection rates, indicating that they use all areas of the park with equal frequency. Other studies have demonstrated that coyote home range size is quite elastic and highly variable depending on food abundance and development (Gehrt 2004), and a study of coyote home range size in and around the Santa Monica Mountains National Recreation Area immediately west of Griffith Park found that home range size varied between 125 ha to 324 ha (Tigas et al. 2002). Given home ranges of similar size, Griffith Park could support up to 10 pairs of breeding coyote, given overlapping territories of the males and females of a pair. It is also likely that additional coyote living in the urban areas surrounding the park regularly visit the park, adding to the park's coyote numbers.

4.1.2 *Fox*

Unlike coyote, the distribution of gray fox in Griffith Park appears to be restricted to a small area within the park. We found evidence of gray fox in only one localized area within the Old Zoo study area; fox tracks and possible scat were recorded in and along the canyon northeast of Bee Rock (Figs. 4a, 4b). This area supports a good amount of tree cover in the riparian areas at the base of the canyon, as well as open scrubland higher up the canyon; fox may be attracted to areas with more tree cover, as they climb and will even nest in trees. A telemetric gray fox ranging study found a mean home range size of approximately 100 ha (Trapp 1978) indicating that Griffith Park is certainly large enough to support more than one breeding pair of fox. However, fox may be limited by habitat considerations, human activity, and competition with coyote throughout much of the park.

4.1.3 *Bobcat*

Bobcat was found in four areas within the park (Figs. 4a, 4b). Two of these areas were areas of high human use (Hollywood Ridge and Skyline), but an area with low human activity, Royce's Canyon, had by far the highest detection index (tracks were noted on four separate occasions), suggesting more frequent use of this area by bobcat. Previous studies of bobcat in southern California have found both spatial and temporal displacement of bobcat in response to high levels of human activity (Tigas et al. 2002, George & Crooks 2006), which could explain why most bobcat observations were in areas of low human use. Tigas et al. (2002) found a mean home range size of 149.8 and 125.2 ha for male and female bobcat, respectively, in unfragmented southern California habitat, and reported that home range size did not increase with fragmentation. This suggests that Griffith Park is large enough to support up to 10 pairs of breeding bobcat, given similar home range sizes.

4.1.4 *Raccoon, Skunk, and Opossum*

Raccoon and skunk had similar detection indices and were both found at approximately a third of all detection stations (Table 2, Appendix 2). However, the distribution of the stations at which they were detected differed for the two species; skunk were only detected in four sample areas, while raccoon were found in all but one sample area. The one exception for raccoons was a high-altitude ridge (the Hollywood Ridge area); we only detected one raccoon at higher elevation stations. These findings suggest that although they are widely distributed within Griffith Park, raccoon seem to prefer areas with better access to water sources, such as canyon bottoms. A study of raccoon home range size in the Presidio, an urban park in San Francisco, reported a mean home range size of 24.8 ha, with a significant amount of overlap between individual home ranges (Boydson 2004). These home range sizes are much smaller than those reported in other, non-urban studies (e.g., Fritzell 1978, Gehrt 2004), but could be representative of home range sizes of raccoon in Griffith Park, especially given the likelihood of anthropogenic food sources supplementing raccoon diet in the park and reducing resource competition. The data reported by Boydston (2004) suggests that Griffith Park is more than large enough to support a self-sustaining raccoon population.

Like raccoon, skunk were generally found in lower elevation areas, and seemed to prefer habitat near riparian zones. However, it is unclear why skunk were not as widespread as raccoon, particularly in seemingly high-quality habitat areas such as Royce's Canyon. It is unlikely that raccoons are outcompeting skunk in the park; Gehrt (2004) reports that differential foraging habits allow skunk and raccoon coexist with minimal competition despite the two species being omnivorous and similarly sized. Human activities—in particular supplementary feeding (G. Randall, pers. comm..)—may influence the distribution of skunk in Griffith Park. Boydston (2004) found that skunk home ranges in an urban park are much smaller (mean = 21.6 ha) than ranges reported from less urbanized studies, indicating that Griffith Park is large enough to support a self-sustaining skunk population.

Surprisingly, opossum, which are frequently sighted in developed areas in Los Angeles, had the lowest detection index of any target species in Griffith Park. Raccoon have been reported to outcompete opossums (Ladine 1997, Ginger et al. 2003), which could explain the low detection of the species (Figs. 4a, 4b, Table 3). It is also possible that opossum have become so highly urbanized in this area that they prefer developed areas to the park due to ease of foraging. Boydston (2004) reported similar findings in San Francisco's Presidio Park.

4.2 <u>Other mammals</u>

Mule deer, rabbit and a variety of rodent track and sign were detected at the scent stations, but only mule deer and rabbit tracks could be identified to at least the genus level.

4.2.1 *Mule deer*

Mule deer was the second most frequently detected species at the scent stations despite the fact that they were not a target species and the scent lures were not designed to attract them. Like coyote, deer were widespread, found in all sample areas and at all elevations (Table 1). They do not appear to avoid human activity; in fact, they are commonly seen on the golf courses in the park (authors, personal observation). This is supported by findings from a reserve in Orange County, California, that reported no clear avoidance of human recreation by mule deer (George & Crooks 2006). The impact of human recreation on deer behavior has not been extensively studied, although some studies have focused on the response of deer to hikers (e.g., Taylor & Knight 2003) and have found especially strong responses when dogs were present (Miller et al. 2001). Other studies have reported an increased use of landscaped areas (i.e., lawns, gardens, golf courses) by ungulates that have become habituated to human presence (e.g., Lubow et al. 2002).

4.2.2 *Rabbits*

Desert cottontail (*Sylvilangus audubonii*) was observed and/or *Sylvilagus* spp. sign detected in all but one sample area, suggesting a widespread presence in the park (Table 1). There does not appear to be an avoidance of areas of human use or any habitat preference by rabbits. As a dietary staple of coyote, bobcat, and fox, the presence of healthy rabbit populations in the park is important for resident carnivores.

4.3 Microhabitat preference

Some microhabitats, particularly woodland habitats (oak sycamore riparian, oak, pine), may be preferable to the dominant vegetation (chaparral and scrub), which could explain the higher carnivore diversity found in the lower altitude stations. Woodland habitats indicate the presence of nearby water sources, and proximity to water sources may be especially important for species with small home ranges, especially during periods of seasonal water shortage. Only coyote were detected more than once at the ridgetop stations, which suggests that coyote is the only species that regularly used higher elevation habitat during this study. It is not surprising that skunk and raccoon were rarely found at higher elevations, as their ranges are relatively small and they are thus limited by access to water sources; during this study we observed that nearly all of the reliable water sources were found in the park's lower elevations. This study was conducted at a time of record drought, with only 3 inches of rainfall since July 2006 (Becerra & Blankstein 2007). Wildlife were likely attracted to artificial water sources such as the golf courses, horse drinkers, and springs at lower elevations. Further studies, particularly during the wet season, should be conducted to determine what, if any, seasonal movement shifts are found in Griffith Park's wildlife.

Low altitude stations also tended to fall within canyon bottoms and riparian zones, which usually consist of woodland vegetation and thus contain more trees. These areas may provide more cover to animals than high-altitude ridges, and can provide relief from the heat. The increased cover in these areas may also be attractive to prey species seeking protection, which in turn draws the predators. Therefore, animals that tend to prefer areas with more cover may not use high-altitude ridgetops as often, regardless of the presence or absence of water sources.

4.4 Human Use

Of the three sample areas considered to be areas of high human use (Skyline, Brush Canyon, and Hollywood Ridge), Brush Canyon appeared to be the most heavily used by hikers and horseback riders. It was also the study area that exhibited the lowest biodiversity, outside of the burned Aberdeen sample area. These results from Brush Canyon are surprising, given that the oak/sycamore woodland habitat found in the canyon bottom had much higher detection rates in other sample areas (i.e., Royce's Canyon, Old Zoo).

Numerous studies have documented the impact of human recreation on wildlife (e.g., George & Crooks 2006, Whittaker & Knight 1998, Magle et al. 2005, Fernandez-Juricic et al. 2005) and one study even concluded that outdoor recreation is the primary cause for decline of endangered species in the United States (Taylor & Knight 2003). Mammalian carnivores are particularly susceptible to human disturbance because of their low densities and large home ranges (e.g., Ray et al 2005, George & Crooks 2006), and multiple studies have found that carnivores shift distribution and change behavior in response to human recreation (Aaris-Sorensen 1987, White et al. 1999, Nevin et al. 2005, George & Crooks 2006).

Results from our study suggest that high levels of human activity may limit the distribution of at least some carnivores (e.g., bobcat and fox) within the park. The low carnivore diversity in the Brush Canyon area in particular may reflect an avoidance of an area heavily used by humans. The Skyline trail also has regular hikers and horseback riders, and although human usage numbers have never been quantified (A. Torres, pers. comm.) casual observation during this study indicated that while both areas had comparable equestrian use, Brush Canyon receives many more hikers than Skyline, especially hikers with dogs. A previous study in southern California reported that bobcat and coyote showed no displacement from equestrian use, but were displaced by hikers, especially hikers with dogs (George & Crooks 2006). The negative impact of dogs on wildlife is well-documented (see Sime 1999 for a comprehensive review) and includes barking, chasing, scent-marking, disruption of habitat use (i.e., burrowing mammals and ground nesting birds), and disease transmission (e.g., Yalden & Yalden 1990, Mainini et al. 1993, Sime 1999, Miller et al. 2001). While a leash law does exist (L.A.M.C. 53.02), it appears to be poorly understood or rarely obeyed; for example, a casual count by the authors while checking the scent stations in Brush Canyon and along the Hollywood Ridge on three occasions totaled 37 dogs off leash and 18 dogs on leash.

4.5 Herptiles

Overall, the detection of herptiles for this study using the coverboard technique was very low. This may be due to the time of year in which the study was conducted; coverboards are intended to provide a differential environment for herptiles, which theoretically use the boards to help regulate their body temperature. It may be that temperatures were not hot enough during the study for the boards to be effective or that the extremely dry conditions during the course of the study affected the behavior and movements of herptiles, especially amphibians. We suggest that studies of the herptiles in Griffith Park should also be conducted during other times of year, particularly during the rainy season, in order to obtain a comprehensive sense of the herptile status in the park.

4.5 Suggestions for future study

As this study was conducted only once and over a short period of time, it represents only a snapshot in time within the park. Similar studies of wildlife presence and distribution should be conducted several times a year to obtain a more complete understanding of wildlife distribution and account for any possible seasonal movement and dispersal by wildlife. Conducting more studies will also be useful for monitoring population trends, as detection indices can be compared over time to detect any changes in distribution and relative abundance. Furthermore, it is unclear what, if any, compression effects the May 2007 fire had on the mammalian carnivore distribution we found in this study. Similar studies in the future would also help to understand mammalian response to fire in an isolated open space such as Griffith Park and how they return to burned area.

4.5.1 *Mammals*

The techniques used in this study proved effective in determining relative carnivore densities; it is clear that carnivores such as coyote, bobcat, fox, raccoon, and skunk are present (and in some cases widespread) within the park. However, due to constraints on time and expense, our study was necessarily limited in scope and could not determine population numbers or density. More labor-intensive and costly studies could be undertaken to gain a better understanding of absolute numbers of species and their ranging behavior. The carpet pad hair traps were readily rubbed by coyote and bobcat, suggesting that population estimates obtained using mark-recapture methods with DNA extracted from hair samples are feasible for these species. Live trapping mark-recapture methods could be employed for abundant smaller carnivores such as raccoon and skunk. Furthermore, radio telemetry studies would greatly help understand range requirements and movement of wildlife in the park.

It would also be beneficial to partner with owners of land bordering the park (e.g., Forest Lawn Cemetery, Department of Transportation, golf courses), especially land with connection to other open space, to determine what routes wildlife are using to move in and out of the park. Juveniles of species such as bobcat, coyote, and fox all disperse upon reaching adulthood and identifying and protecting dispersal routes is essential to maintaining the genetic diversity and health of these populations in the park. The numerous studies on corridor use by wildlife have been conducted in surrounding areas should be reviewed (e.g., Haas 2001, Ng et al. 2004, Penrod et al. 2006) and GIS analyses such as a Landscape Permeability Analysis (e.g. Singleton 2002, Penrod et al. 2006) could be applied to the land between Griffith Park and nearby large open spaces (such as the Angeles Crest National Forest or the Santa Monica National Recreation Area) and would aid in identifying and protecting possible dispersal routes.

4.5.2 *Herptiles*

More labor-intensive methods may prove more effective than coverboards for documenting the presence of rare or more cryptic species. Coverboard arrays may document more species in the wet season, when they can provide a differential environment; however, we recommend that visual encounter surveys and pitfall traps be used to better document the herptiles in the park. Night walks might also prove effective in documenting snake species.

4.6 General recommendations

Communication between the different organizations operating within the park, such as the Park Rangers and the Department of Water and Power (DWP), should be encouraged. DWP employees spend a great deal of time in the park and are the only people allowed in the park during the evening/nighttime hours, when many wildlife species are most active and therefore most likely to be observed. Personal conversation with DWP employees met during the surveys indicates that some are quite vigilant and knowledgeable about wildlife in the park and could be an asset in documenting species presence and distribution.

Griffith Park provides a unique opportunity for outdoor recreation within the city Los Angeles, and is thus an invaluable resource for local residents. With this in mind, we recommend that studies on human usage in different areas of the park be conducted. With a better understanding of the location and distribution of high levels of human recreation, as well as what type of recreation is occurring and where (i.e., horseback riding, hiking, hiking with dogs, etc.) we can better study, understand, and mitigate the effects of human activity in the park on resident wildlife.

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Table 1. Large mammal species detections at all stations.

Station	Coyote	Fox	Bobcat	Raccoon	Skunk	Opossum	Deer[1]	Rabbit[1]	Domestic Dog[2]
Skyline 1	7	—	—	1	1	—	—	1	X
2	1	—	1	1	—	1	—	—	X
3	8	—	—	1	—	—	—	—	X
4	—	—	—	—	—	—	1	—	—
5	5	—	—	—	—	—	—	—	
6	8	—	—	—	—	1	—	—	X
7	6	—	—	—	—	—	—	—	—
8	3	—	—	1	1	—	1	—	—
9	1	—	—	—	—	—	—	—	—
10	6	—	—	1	2	—	3	1	X
Brush 1	—	—	—	—	—	—	—	—	—
2	4	—	—	—	—	—	—	—	X
3	5	—	—	—	—	—	—	—	X
4	8	—	—	—	—	—	—	2	—
5	4	—	—	—	—	—	—	1	—
6	3	—	—	—	—	—	—	—	X
7	7	—	—	—	—	—	—	—	X
8	7	—	—	1	1	—	1	2	—
Royce 1	4	—	1	1	—	—	—	—	—
2	4	—	—	2	—	—	1	—	—
3	3	—	2	—	—	—	1	—	—
4	—	—	—	—	—	—	2	—	—
Old Zoo 1	7	—	—	—	2	—	1	1	—
2	1	—	—	—	—	—	2	—	—
3	3	—	1	—	1	—	1	2	—
4	4	1	1	1	2	—	—	—	—
5	7	—	—	—	2	—	3	3	—
6	8	1	1	—	2	—	—	1	—
7	5	—	—	1	—	—	—	—	—
8	4	—	—	2	1	—	2	—	—
9	8	2	—	1	—	—	2	—	X
10	2	—	—	—	1	—	—	—	—
Aberdeen 1	5	—	—	—	—	—	4	—	X
2	4	—	—	1	—	—	—	—	—
3	5	—	—	—	—	—	—	2	X
4	5	—	—	—	—	—	—	—	X
Hollywood 1	6	—	—	—	—	—	3	1	X
2	2	—	—	—	—	—	1	—	—
3	5	—	1	—	—	—	—	—	X
Headworks 1	1	—	—	—	1	—	—	1	X
2	1	—	—	3	—	—	—	3	—
3	1	—	—	—	—	—	1	1	—
Total	**178**	**4**	**8**	**18**	**17**	**2**	**30**	**22**	**N/A**

1 Nontarget wildlife species. These are likely coincidental detections and are not used in analyses.
2 *Canis familiaris* tracks detected at scent stations. Only presence/absence recorded; an "X" indicates presence.

Table 2. Detection indices for mammalian carnivore species in different sample areas.

	Coyote	Fox	Bobcat	Raccoon	Skunk	Opossum
Skyline	0.375	—	0.008	0.042	0.033	0.017
Brush	0.396	—	—	0.010	0.010	—
Royce	0.229	—	0.063	0.063	—	—
Old Zoo	0.377	0.031	0.023	0.038	0.085	—
Aberdeen	0.365	—	—	0.019	—	—
Hollywood	0.394	—	0.030	—	—	—
Headworks	0.250	—	—	0.250	0.083	—
Total	**0.363**	**0.008**	**0.016**	**0.037**	**0.035**	**0.004**

Table 3. Carnivore richness, diversity, and evenness in different sample areas in Griffith Park.

Area (#stations)	Species Richness	Shannon Index (H)	Evenness (E_H)
Skyline (10)	5	0.78	0.16
Brush (8)	3	0.23	0.05
Royce (4)	3	0.89	0.18
Old Zoo (10)	5	1.03	0.21
Aberdeen (4)	2	0.20	0.04
Hollywood (3)	2	0.26	0.05
Headworks (3)	3	1.00	0.20
Total (42)	**6**	**0.82**	**0.14**
Human Use (21)	5	0.57	0.11
No Human Use (21)	5	0.98	0.20
Ridgetops (14)	4	0.42	0.10
Lower Altitude (28)	6	0.97	0.16

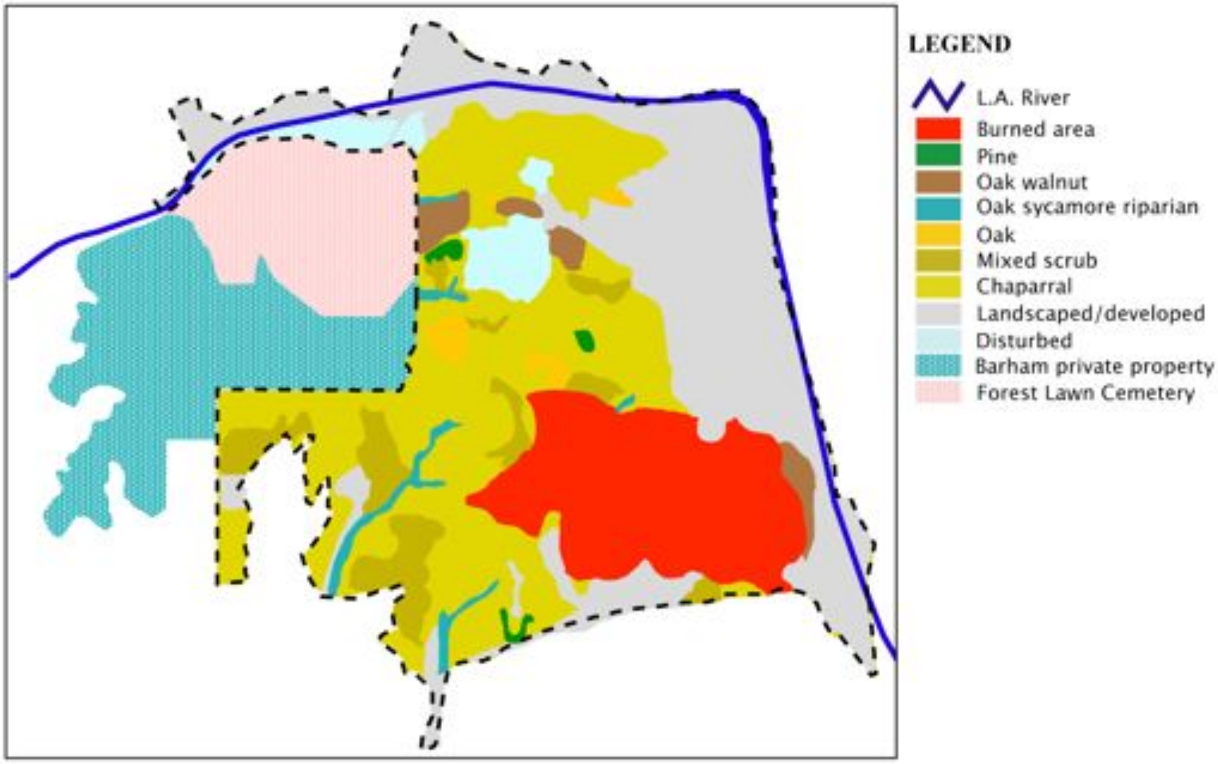


Figure 1. Griffith Park vegetation map. The burned area was a result of a fire immediately preceding this study in May 2007. Please see note in text about preparation of GIS images.

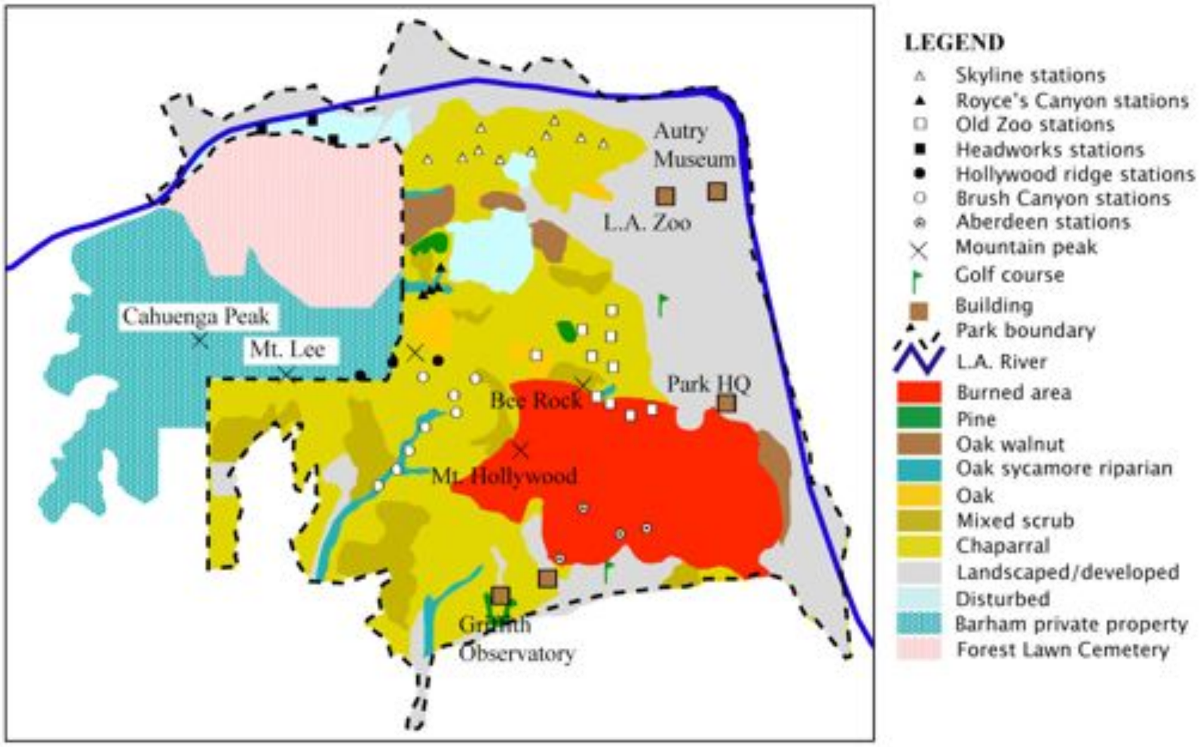


Figure 2a. Location of carnivore detection stations in different vegetation types in Griffith Park. Please see note in section 2.4 about GIS map construction.

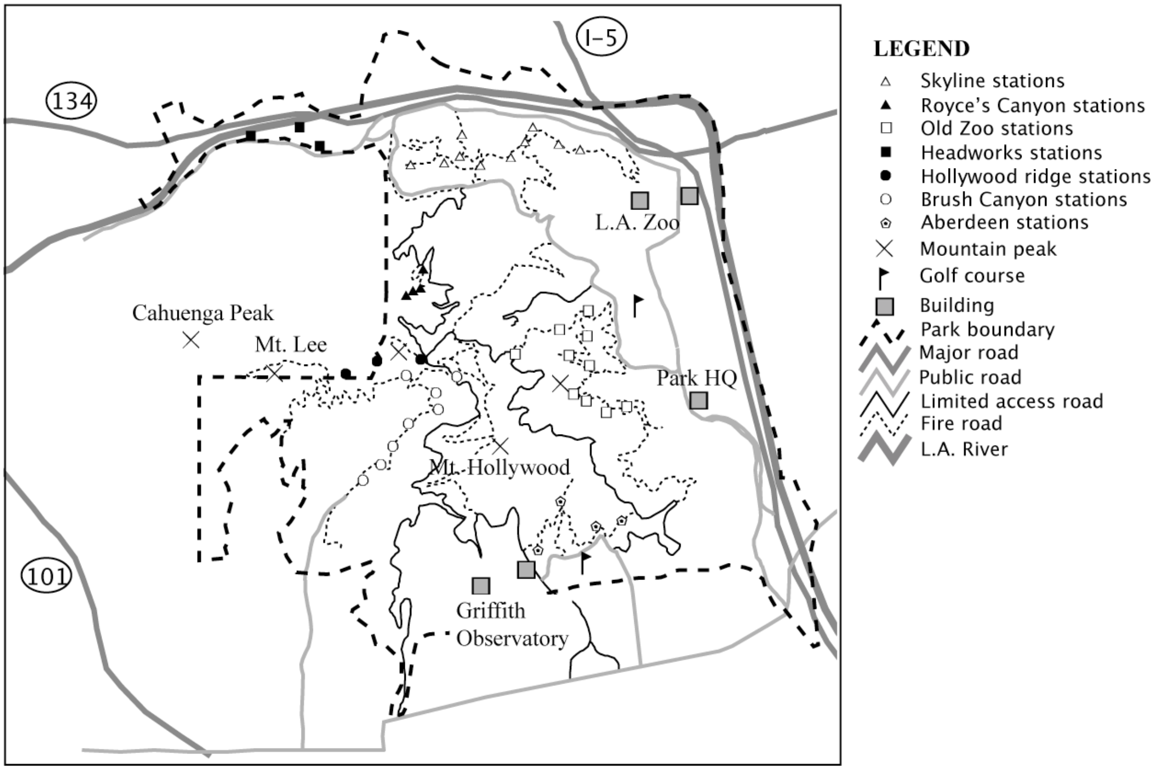


Figure 2b. Location of carnivore detection stations along selected existing roads and trails in Griffith Park.

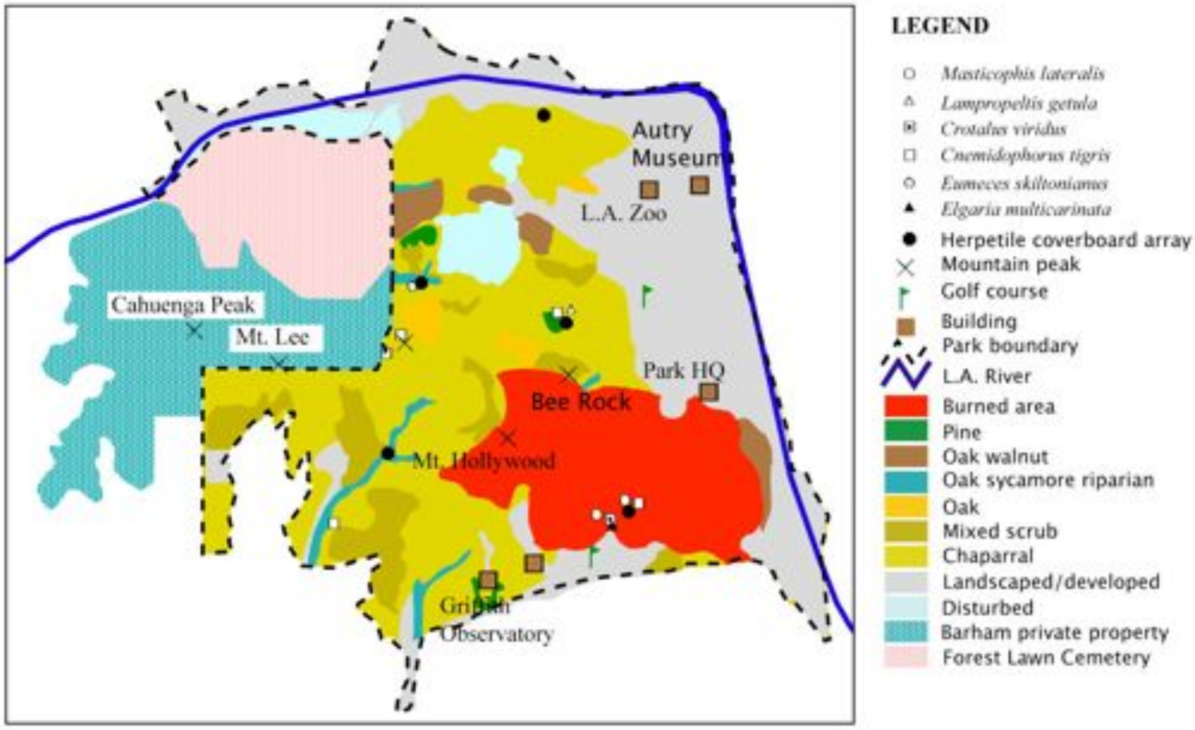


Figure 3a. Locations of herptile coverboard arrays in different vegetation types in Griffith Park. Please see section 2.4 for a note about GIS map development. Also shown are herptile species other than the Western Fence Lizard (*Sceloporus occidentalis*) encountered during the surveys. *S. occidentalis* was observed at nearly every detection station and coverboard array, and was seen frequently in other areas of the park.

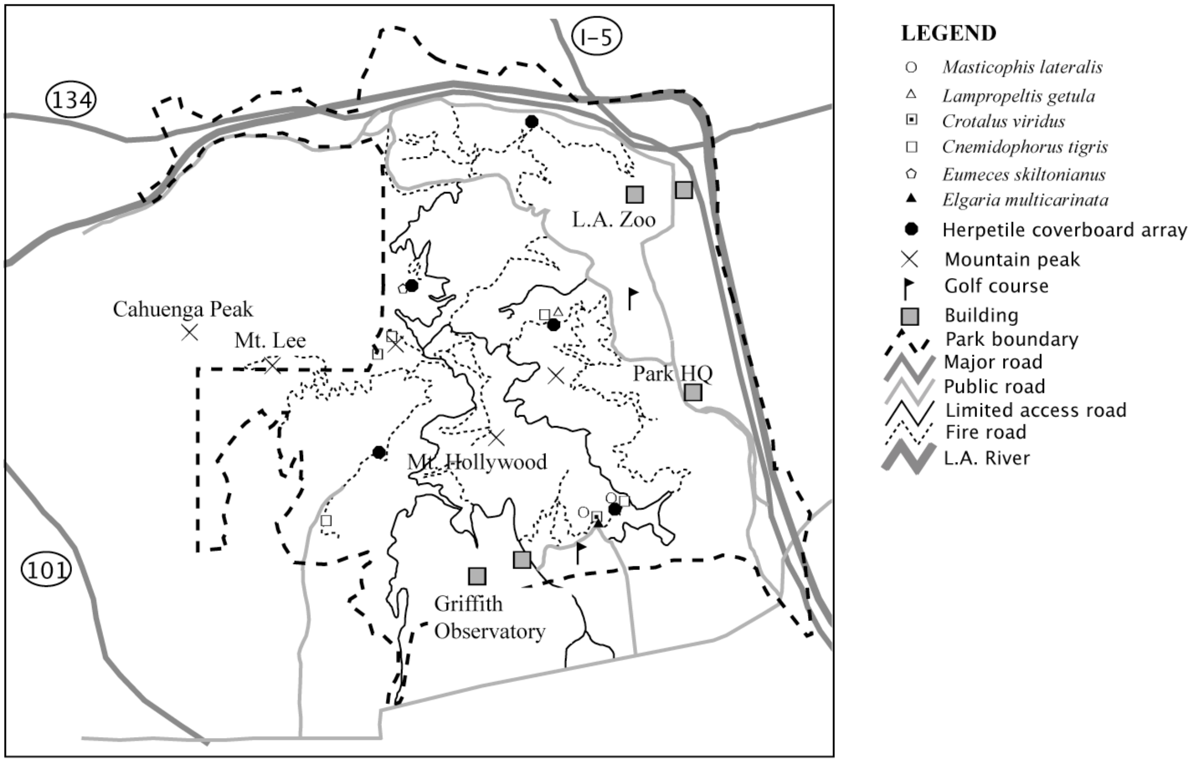


Figure 3b. Locations of herptile coverboard arrays along selected roads and trails in Griffith Park. Please see section 2.4 for a note about GIS map development. Also shown are herptile species other than the Western Fence Lizard (*Sceloporus occidentalis*) encountered during the surveys. *S. occidentalis* was observed at nearly every detection station and coverboard array, and was seen frequently in other areas of the park.

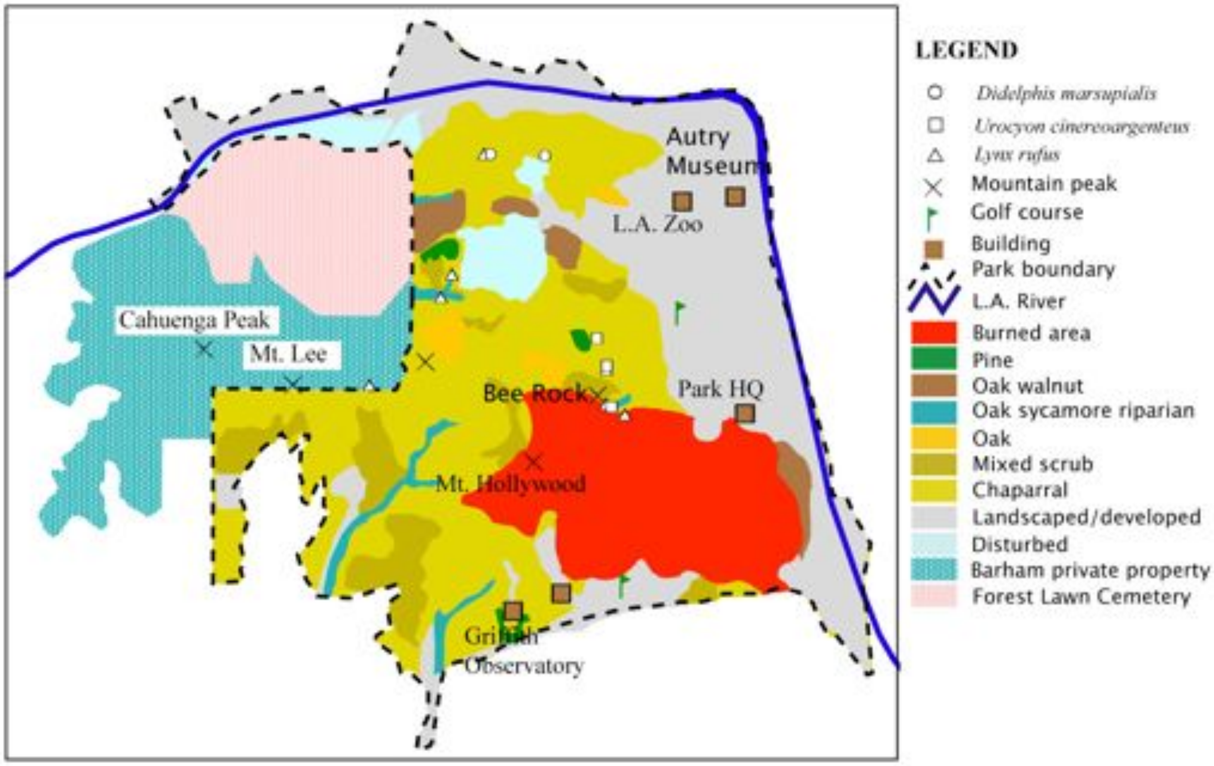


Figure 4a. Locations of the less commonly detected carnivore species — opossum (*D. maruspialis*), gray fox (*U. cinereoargenteus*), and bobcat (*L. rufus*) — at detection stations in different vegetation types in Griffith Park. Please see section 2.4 for a note about GIS map development.

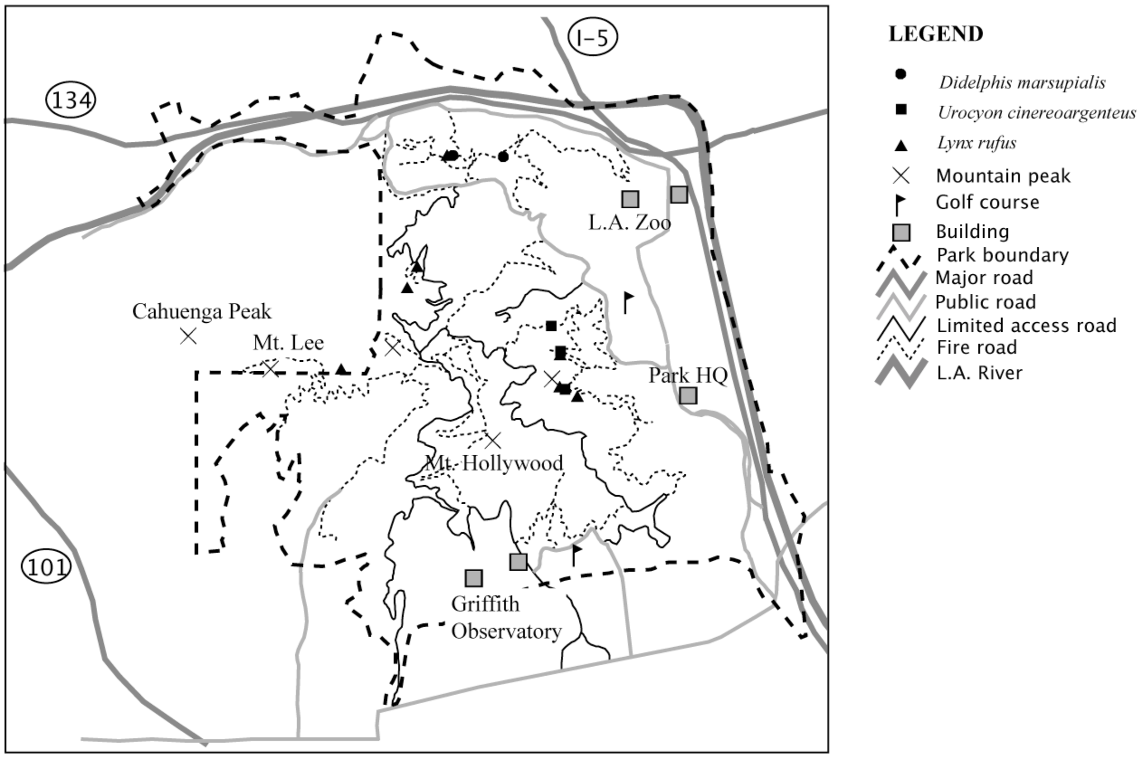
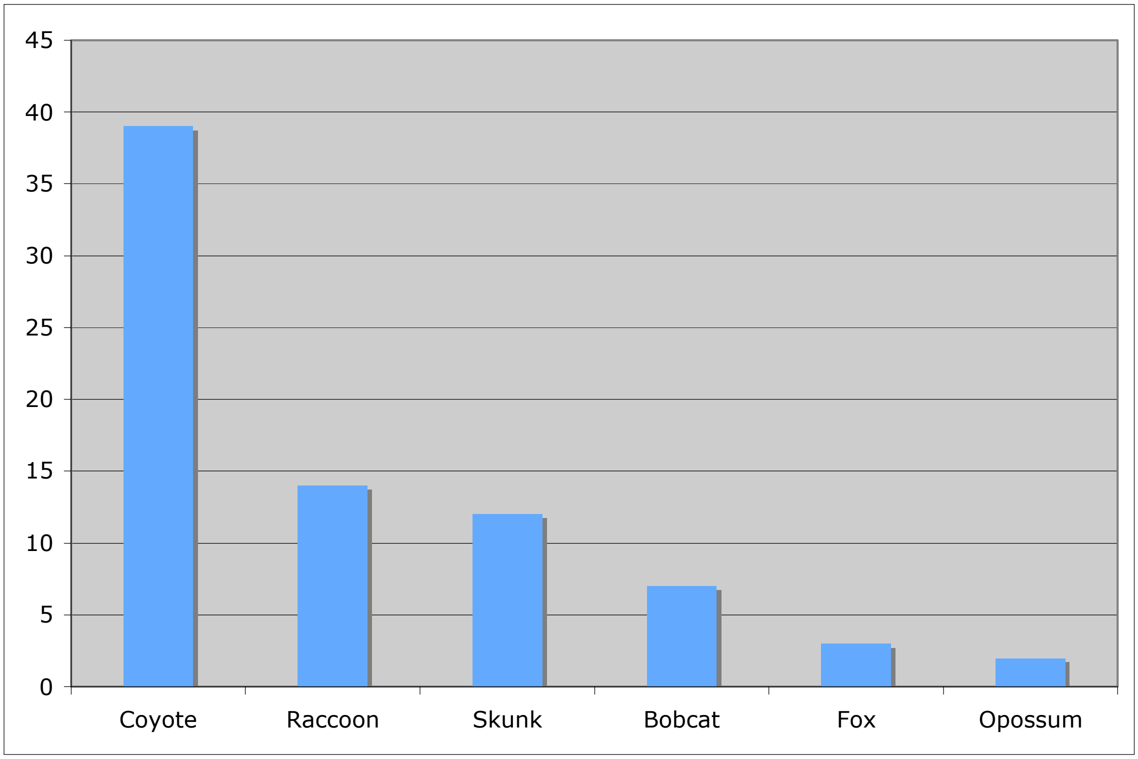


Figure 4b. Locations of less commonly detected carnivore species — opossum (*D. maruspialis*), gray fox (*U. cinereoargenteus*), and bobcat (*L. rufus*)—at detection stations along selected roads and trails in Griffith Park. Please see section 2.4 for a note about GIS map development.

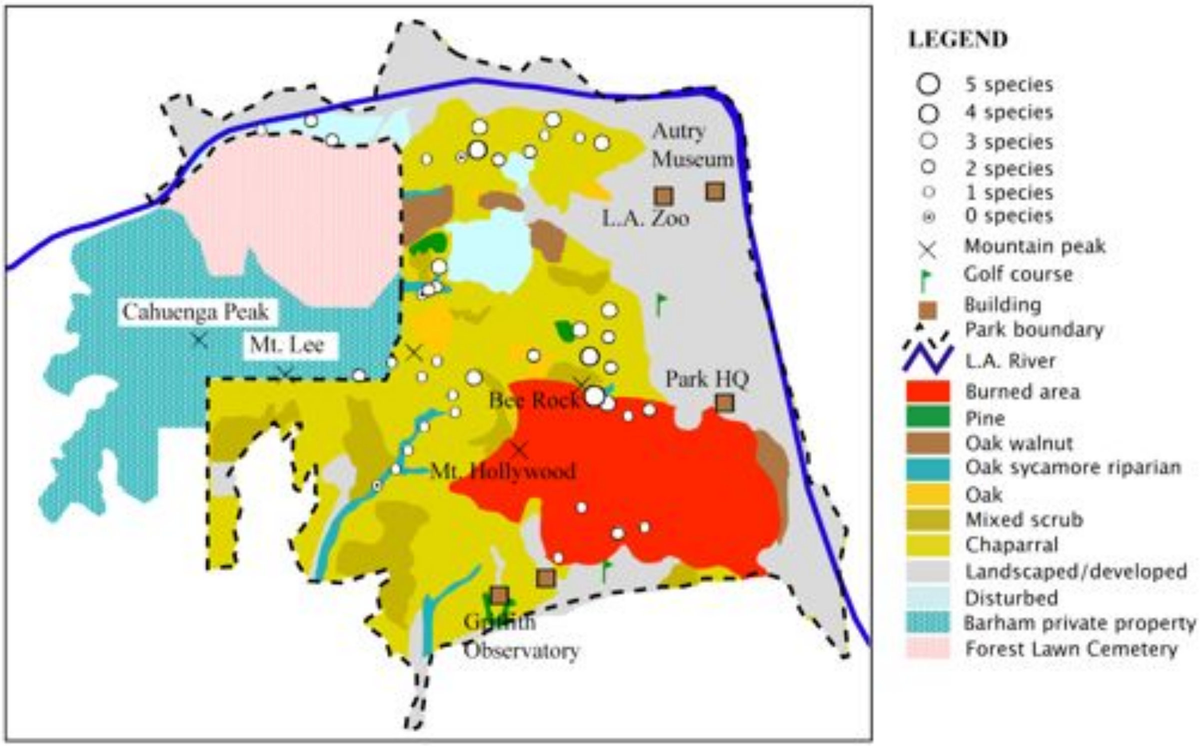
Appendix A. Individual detection station details and days operated.

Station	Type	Altitude (ft)	Survey Effort (days)	Vegetation Type
Skyline 1	Tracking	550	12	Chaparral
2	Tracking	670	12	Chaparral
3	Hair Snare	872	12	Chaparral
4	Tracking	886	12	Chaparral
5	Hair Snare	789	12	Chaparral
6	Tracking	859	12	Chaparral
7	Hair Snare	781	12	Chaparral
8	Tracking	666	12	Chaparral
9	Hair Snare	697	12	Chaparral
10	Tracking	723	12	Chaparral
Brush 1	Hair Snare	692	12	Oak-Sycamore riparian
2	Tracking	754	12	Oak-Sycamore riparian
3	Hair Snare	872	12	Chaparral
4	Tracking	956	12	Oak-Sycamore riparian
5	Hair Snare	1083	12	Chaparral
6	Tracking	1122	12	Chaparral
7	Hair Snare	1256	12	Chaparral
8	Tracking	1372	12	Mixed Scrub
Royce 1	Hair Snare	917	12	Oak-Sycamore riparian
2	Tracking	848	12	Oak-Sycamore riparian
3	Hair Snare	872	12	Oak-Sycamore riparian
4	Tracking	882	12	Chaparral
Old Zoo 1	Tracking	673	13	Burn
2	Hair Snare	717	13	Burn
3	Tracking	679	13	Burn
4	Hair Snare	675	13	Oak-Sycamore riparian
5	Tracking	601	13	Chaparral
6	Hair Snare	667	13	Chaparral
7	Tracking	741	13	Chaparral
8	Hair Snare	725	13	Chaparral
9	Tracking	899	13	Chaparral
10	Hair Snare	1094	13	Oak forest
Aberdeen 1	Tracking	1022	13	Burn
2	Hair Snare	936	13	Burn
3	Tracking	1014	13	Burn
4	Hair Snare	961	13	Burn
Hollywood 1	Tracking	1311	11	Chaparral
2	Hair Snare	1311	11	Chaparral
3	Tracking	1500	11	Chaparral
Headworks 1	Tracking	433	4	Disturbed
2	Tracking	473	4	Disturbed
3	Tracking	454	4	Disturbed

Appendix B. The number of stations at which carnivore species were detected, out of a total of 42 stations.



Appendix C. Number of carnivore species found at different detection stations in different vegetation types in Griffith Park. Please see section 2.4 for a note on GIS map development.



Appendix D. List of all herptile and mammal species identified in Griffith Park by sight or sign during the study.

Scientific name[1]	Common name[1]
MAMMALIA	
ARTIODACTYLA	
Cervidae	
Odocoileus hemionus	Mule deer
CARNIVORA	
Canidae	
Canis latrans	Coyote
Urocyon cinereoargenteus	Gray fox
Felidae	
Lynx rufus	Bobcat
Mustelidae	
Mephitis mephitis	Striped skunk
Procyonidae	
Procyon lotor	Raccoon
LAGOMORPHA	
Leporidae	
Sylvilagus audubonii	Desert cottontail
MARSUPIALIA	
Didelphidae	
Didelphis virginianus	Virginia opossum
RODENTIA	
Cricetidae	
Neotoma spp.	Woodrat species
Sciuridae	
Sciurus griseus	Western gray squirrel
Sciurus niger	Fox squirrel
Spermophilus beecheyi	California ground squirrel
REPTILIA	
Anguidae	
Elgaria multicarinata	Southern alligator lizard
Colubridae	
Masticophis lateralis	California whipsnake
Lampropeltis getula	Common kingsnake
Phrynosomatidae	
Sceloporus occidentalis	Western fence lizard
Scincidae	
Eumeces skiltonianus	Western skink
Teiidae	
Cnemidophorus tigris	Western whiptail lizard

Viperdae		
	Crotalus viridis	Western rattlesnake

1 Mammalian scientific and common names from the IUCN Redlist. Available at <http://www.iucnredlist.org>. Reptilian scientific and common names from: Stebbins, R.C. 2003. Peterson Field Guides: Western Reptiles and Amphibians, Third Edition. Houghton Mifflin Company: New York.