BAT SURVEY OF GRIFFITH PARK

Los Angeles, California

DRAFT REPORT

20 February 2009

Prepared for:

Los Angeles Department of Recreation and Parks

by:

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INTRODUCTION

Bats comprise about one quarter of all mammalian species and are a major component of our local fauna. As the primary predators of night-flying insects, bats play a vital role in the local ecology. Their decline or loss from an area can cause population explosions of their prey species, impacting humans as well as other organisms. Due to their high consumption of insects, including pest species, and to the fact that bats appear to be dead-end hosts of the West Nile Virus (Davis et al. 2003), bat presence on the wildland-urban interface could play an important role in the control of this disease.

Most bat species are intolerant of the urban environment, and those species and individuals that survive habitat loss by taking advantage of artificial structures for roosting often become targets of vandalism, extermination efforts, and inadvertent roost disturbance. Habitat loss, roost disturbance, and vegetation modification and removal pose major threats to bat populations in the "South Coast Ecoregion", the biologically diverse zone of coastal plains, inland valleys, and mountains in southern California from the Santa Barbara area to northwestern Baja California (Figure 1). Fire and fire suppression practices, pest control operations, and recreational activities can also negatively impact bats. Bats are exposed to all of these impacts in and near urban areas, and the cumulative effects on local populations can be substantial, yet difficult or impossible to measure because of their nocturnal habits.

State and federal land management agencies officially recognize over two-thirds of the South Coast Ecoregion's 24 bat species as "Sensitive" (Table 1), which affords them a measure of protection provided their local populations are known; however, most species are very poorly-known and difficult to detect, much less monitor, particularly compared to groups like birds and plants.

On May 8, 2007 a wildfire originating in Aberdeen Canyon near Los Feliz burned more than 817 acres (3.3 km^2) in the southeast corner of Griffith Park in Los Angeles, one of the largest urban parks in the North America (Figure 2), which spurred interest in documenting its flora and fauna (see Cooper and Mathewson 2009). As a group, bats are particularly poorly-known in Griffith Park and the eastern Santa Monica Mountains, and this represents the first formal survey of the park. Surrounding land uses, including golf courses, Forest Lawn Cemetery, the Greek Theater, Hollywood Reservoir, undeveloped open space, and residential areas present a combination of potential attractions and impacts to bats occurring in the park. Because bats have separate roosting and foraging habitat requirements, it is likely that at least some bats roosting in the park forage well outside its boundaries, and some roosting outside its boundaries forage within the park.

This survey employed several methods of bat detection (see Methods below), and relied on a cadre of volunteers from the surrounding communities. We identified three main goals at the outset of the project: to develop a bat species list for Griffith Park; to locate bat foraging areas within the park, and to identify potential roost sites. Though our knowledge of bat ecology in the Los Angeles area is still in its infancy, a major survey of bats in the Santa Monica Mountains National Recreation Area (large area of protected open space that starts c. 5 miles west of Griffith Park) was recently published (Brown and Berry 2005) and provides a good comparison with our findings.

Figure 1. Ecoregions of California (blue dot represents Griffith Park).

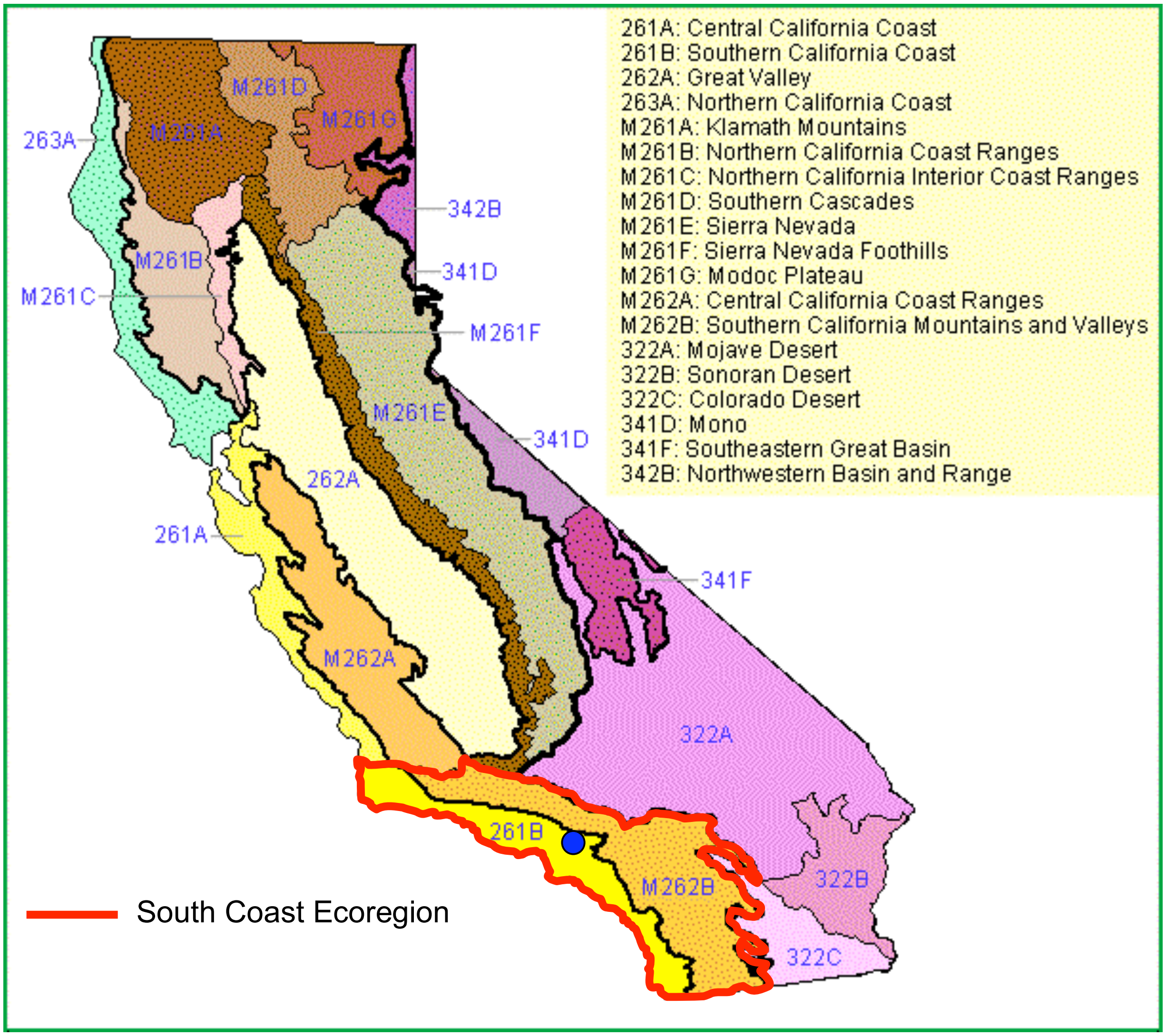

Figure 2. Griffith Park (shaded green; 3-dimentional view north). Hollywood Reservoir (Los Angeles Dept. of Water and Power) is at left; Interstate-5 (red) and Los Angeles River (blue) form eastern boundary. Olive-brown area at right is the 2007 burn zone.

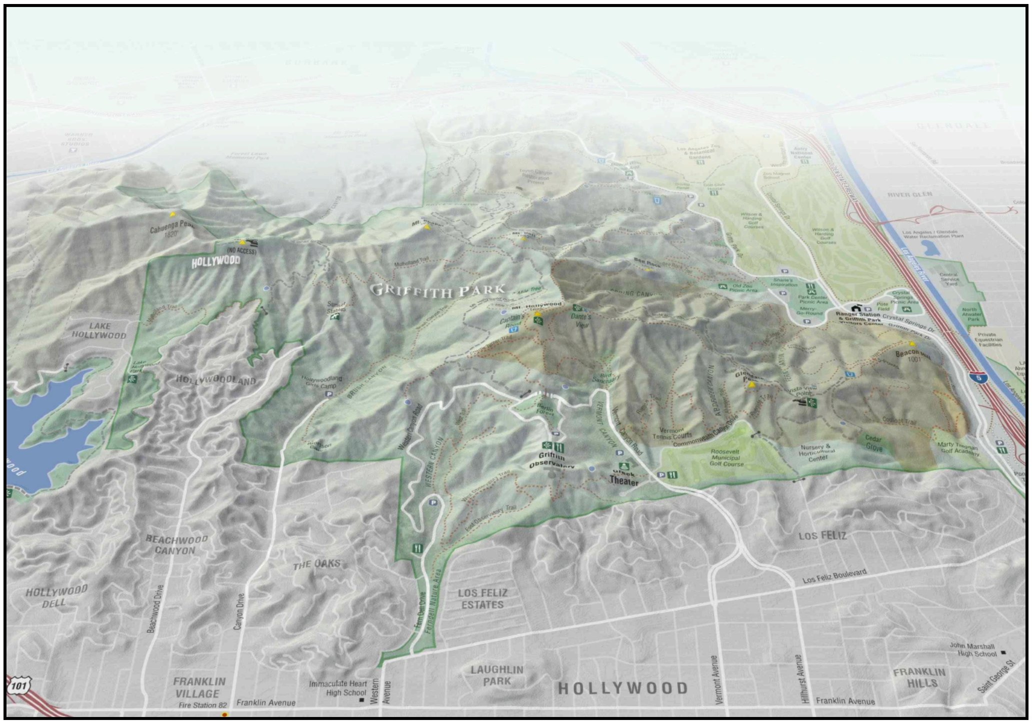

Table 1. Bats of the South Coast Ecoregion, including legal status and known occurrence in the Santa Monica Mountains (asterisked species) and Griffith Park prior to this study.

Latin name/code	Common name	Legal status	Occurrence in Griffith Park
Phyllostomatidae	**American leaf-nosed bats**		
Macrotus californicus MACA	California leaf-nosed bat	CSC, FSS, BLM	
Choeronycteris mexicana CHME	Mexican long-tongued bat	CSC	
Leptonycteris curasoae yerbabuenae LECU†	Lesser long-nosed bat	FE	
Vespertilionidae	**Mouse-eared bats**		
Myotis lucifugus MYLU	Little brown bat	None	
Myotis yumanensis MYYU*	Yuma myotis	FSC, BLM	
Myotis velifer MYVE†	Cave myotis	CSC, BLM	
Myotis evotis MYEV	Long-eared myotis	FSC, BLM	
Myotis thysanodes MYTH	Fringed myotis	FSC, BLM	
Myotis volans MYVO	Long-legged myotis	FSC, BLM	
Myotis californicus MYCA*	California myotis	None	
Myotis ciliolabrum MYCI*	Small-footed myotis	FSC, BLM	
Lasionycteris noctivagans LANO	Silver-haired bat	None	
Parastrellus hesperus PAHE*¥	Western pipistrelle	None	
Eptesicus fuscus EPFU*	Big brown bat	None	X
Lasiurus blossevillii LABL*	Western red bat	CSC, FSS	
Lasiurus xanthinus LAXA	Western yellow bat	CSC	
Lasiurus cinereus LACI*	Hoary bat	None	X
Euderma maculatum EUMA*	Spotted bat	CSC, FSC, BLM	
Corynorhinus townsendii COTO	Townsend's big-eared bat	CSC, FSC, FSS, BLM	
Antrozous pallidus ANPA*	Pallid bat	CSC, FSS, BLM	
Molossidae	**Free-tailed bats**		
Tadarida brasiliensis TABR*	Mexican free-tailed bat	None	X
Nyctinomops femorosaccus NYFE	Pocketed free-tailed bat	CSC	
Nyctinomops macrotis NYMA	Big free-tailed bat	CSC	
Eumops perotis californicus EUPE*	Western mastiff bat	CSC, FSC, BLM	(X)

Key to Symbols and Acronyms

Occurrence at Griffith Park based on specimens from the park (see Cooper and Mathewson 2009) using on-line searches of museum databases; two of these species known from specimens, *Eptesicus fuscus* and *Tadarida brasiliensis* also detected in a recent one-day survey of the Los Angeles Zoo grounds (K. Dearborn, to DSC).

***** Known to occur in the Santa Monica Mountains (Brown and Berry 2005)

† Currently known in the state from only two or three recent public health records from urban areas (Constantine 1998).

FE	Federal Endangered	CSC	California Species of Special Concern
FSC	Federal Species of Concern	BLM	Bureau of Land Management Sensitive
FSS	Forest Service Sensitive		

¥ Formerly known as *Pipistrellus hesperus*
(X) *Eumops perotis californicus* (western mastiff bat) known locally from a 1991 specimen from "Hollywood".

METHODS

Survey area

Griffith Park covers over 4,000 acres at the eastern end of the Santa Monica Mountains, and supports various native habitat types (chaparral, coastal sage scrub, oak-walnut woodland, riparian), as well as exotic and ornamental vegetation. Its topography is rugged, ranging from 384 feet to 1,680 feet above sea level (at Mt. Lee), including deep canyons, rocky outcrops and escarpments, perennial and ephemeral streams, and portions of the Los Angeles River. Land use in the park is overwhelmingly dominated by recreation, with no area of the park formally protected for habitat preservation. However, the ruggedness of the topography has kept human disturbance minimal over large areas of the park's interior.

Although Griffith Park lies within the Santa Monica Mountain Range, it, along with an adjacent block of privately-help open space north of the Hollywood Reservoir, is isolated from undeveloped habitat in the main part of the range by urbanization. Griffith Park and this adjacent open space is bordered by Burbank and the 134 Freeway to the north, Glendale and Interstate-5 to the east, Los Angeles to the south, and by a variety of urban land uses, including the 101 Freeway, to the west (Figure 2).

Though we attempted to cover as much of Griffith Park as possible, several sites were selected for particular attention due to the combination of geographic and habitat features felt to likely provide good roosting and/or foraging habitat for bats (Figure 3). These include rocky features such as Bee Rock and Bronson "Cave"; several of the park's major canyons – Brush, Spring, Fern, Royce, Western, and Vermont; manicured areas with large trees, such as the Old Zoo and picnic areas; and water features, including the Los Angeles River and the Hollywood Reservoir. Because it is possible for bats to roost in the park and forage outside its boundaries, and vice versa, two residential areas just beyond the southwestern park boundary were also sampled. In all cases, security for observers and equipment were major factors in site selection. For interpreting data in this study, the park was divided into five regions based on geography and access (Table 2).

Figure 3. Griffith Park acoustic monitoring areas (park boundary indicated by solid green line).

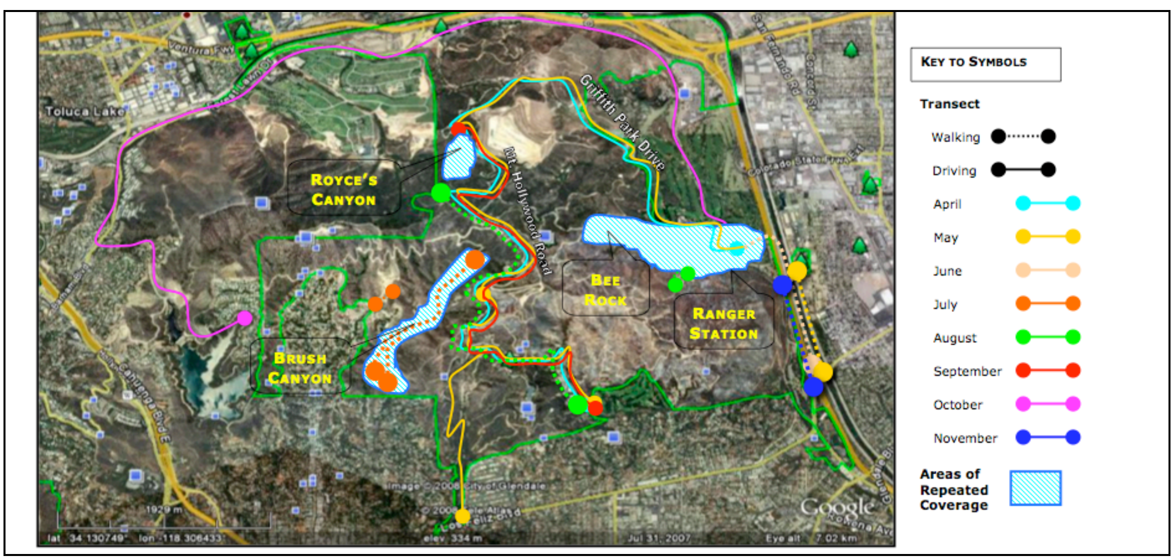

Table 2. Regions of Griffith Park, as delineated for this study.

Region	Description
Central	Bee Rock, Old Zoo, Merry-go-round, Fern Canyon, Ranger Station
East	Los Angeles River (between Los Feliz and Colorado Blvd. exit of I-5)
North	Royce Canyon, Griffith Park Rd. & Mt. Hollywood Rd.
South	Bird Sanctuary, Western and Vermont Canyon rds.
West	Bronson "Cave" (tunnel), Brush Canyon, & Hollyridge Trail

Survey Protocol

We surveyed the park at least once a month between April and November 2008 (Table 3). Two or more visits were made in May, August, September, and November. Each survey was 2-3 hours in duration, beginning in the half-hour period before sunset. Visits were extended through summer into fall to capture the full range of behaviors and activities of local bats. For example, April through September roughly coincides with the maternity season. April/May and October/November also correspond with migration seasons; the fall is also associated with breeding in some species ("breeding season" is distinct from maternity season both in activity and timing; the former involves mating, and the latter involves birth and the rearing of young. Breeding can occur from late fall through early spring).

Locally, the majority of the activity during the peak period often occurs within the first two hours after sunset, but varies among species and with season, geographic region, habitat, and ambient conditions (including both natural and human-related; pers. obs.)[1]. In this study, due to uncertainty about the security of equipment deployed remotely, all gear was retrieved at the end of each survey period, except in one instance when recording equipment was left on the roof of a residence adjacent to the park for two nights.

Because the behavioral and ecological diversity among bat species precludes the use of a universal sampling method for detecting all species, sampling species diversity requires a combination of techniques (Pierson 1993, Pierson 1998). Each technique has its advantages, limitations and biases, so a combination of these techniques can yield a more complete overall picture of diversity and distribution (Pierson 1998, O'Farrell and Gannon 1999). In this study, to minimize impacts on bat populations already potentially impacted by fire, and to maximize coverage and participation of volunteer observers, **acoustic sampling** was selected as the primary technique ("A" in Table 3), involving both active and passive detection and driving transects employed (described below)[2]. Some visual roost searching was also done ("V" below). Because bats are very vocal animals, producing anywhere from one to more than 200 calls per second, often at frequencies inaudible to humans (>20 kHz), ultrasonic detectors are valuable tools for passively monitoring presence-absence and general activity (Fenton 1988, Thomas and LaVal 1988, Pierson 1993).

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[1] Mist-netting studies at water sources in the 1970s (O'Farrell and Bradly 1970, Kunz 1973) identified bats' primary nightly activity period as occurring within the first five hours after sunset, but recent acoustic studies have shown substantial variation from this pattern (O'Farrell, pers. comm., pers. obs.).

[2] Mist netting is a more effective means of surveying some species that are not easily detected acoustically (e.g., *A. pallidus* will sometimes blunder into mist nets when they are not echolocating), and it allows positive species identification and the assessment of age and reproductive condition (Pierson 1993, P.E. Brown, pers. comm., pers. obs). However, not all species have an equal probability of being caught. Mist netting is a labor-intensive sampling method that favors the capture of low-flying species (such as *Myotis*, *Antrozous* and *Eptesicus*), while the molossids (*Eumops, Tadarida* and *Nyctinomops*) rarely fly low enough for capture. Townsend's big-eared bat (*Corynorhinus townsendii*) is very adept at avoiding nets, and western mastiff bats *(Eumops perotis)* are not easily caught in them because they fly higher than most mist nets are set (P.E. Brown, pers. comm., pers. obs.).

Table 3. Field sites and dates in 2008 (Each line represents an Anabat recording site).

DATE	SITE	METHOD
7-Apr	Bee Rock (N)	A
7-Apr	Bee Rock (S)	A/V
7-Apr	Drainage	A
7-Apr	Transect - Bee Rock, Griffith Park Drive, Mt. Hollywood Road, Vermont Canyon Drive	A/V
5-May	Bee Rock (S)	A
5-May	Transect - Western Canyon Rd, Vermont Canyon Dr., Mt. Hollywood Rd., Griffith Park Dr.	A/V
5-May	Residence, just south of Park Boundary at Brush Canyon	A
6-May	Residence, just south of Park Boundary at Brush Canyon	A
30-May	Ranger Station/Crystal Springs Picnic Area	A/V
30-May	Spring Canyon/Old Zoo	A/V
30-May	Bee Rock, Los Angeles River	A/V
2-Jun	Bee Rock, Los Angeles River	A/V
2-Jun	Old Zoo, Los Angeles River	A/V
2-Jul	Lower Brush Canyon	A/V
2-Jul	Hollyridge Trail (Sunset Stables)	A/V
2-Jul	Bee Canyon, Old Zoo, Merry-go-round area	A/V
2-Jul	Bird Sanctuary	A/V
3-Aug	Fern Canyon (trailhead & edge of burn)	A/V
3-Aug	Lower Brush Canyon	A/V
3-Aug	Bronson "Cave"	A/V
3-Aug	Bee Rock, Old Zoo	A/V
6-Aug	Bronson (east & west entrances)	A/V
6-Aug	Lower Brush Canyon	A/V
10-Aug	Brush Canyon (lower and middle)	A/V
12-Aug	Brush Canyon (lower and middle)	A/V
20-Aug	Sunset Stables, lower Brush Canyon	A/V
22-Aug	Residence, 0.5 mi SW of Bronson	A/V
23-Aug	3-mile Trail area	A/V
1-Sep	Ridge south of Royce Canyon, Mt. Chapel, Mt. Hollywood Road	A/V
2-Sep	Bee Rock (top), Old Zoo Trail (unburned & burned), Fern Canyon Road, Merry-go-round p. lot	A/V
2-Sep	Brush Canyon (upper, middle, lower), Bronson	A/V
2-Sep	Merry-go-round area	A/V
2-Sep	Royce Canyon and Mt. Hollywood Road	A/V
7-Sep	Royce Canyon to Griffith Park Drive via Toyon Canyon Trail	A/V
14-Sep	Royce Canyon	A/V
21-Sep	Royce Canyon	A/V
1-Oct	Bee Rock, Old Zoo, Crystal Springs Drive, Forest Lawn Drive, Hollywood Reservoir (North end)	A/V
1-Oct	Bronson to lower Brush Canyon	A/V
1-Oct	Upper Brush Canyon to lower Brush	A/V
1-Oct	Old Zoo, Merry-go-round area	A/V
3-Nov	Old Zoo, Bee Rock, Los Angeles River	A/V
3-Nov	Bronson and Brush Canyon	A/V
30-Nov	Upper Brush Canyon to lower Brush	A/V

Visited on monthly scheduled surveys

Additional, randomly-scheduled, volunteer-run acoustic surveys

Sampled only during the "Santa Monica Mtns. BioBlitz", May 31, 2008

Anabat surveys: To measure activity levels and to identify species, echolocation signals were recorded on all surveys using the "Anabat II" system by teams of two to four observers (including volunteers). Recordings were made using both "active" (simultaneously observing bats in flight) and "passive" (detectors deployed remotely) approaches. Calls recorded on the Anabat detector were stored on a laptop computer and/or on compact flash cards for species identification and calculation of activity levels. Heterodyne detectors (Pettersson D100 and D240) were used in addition to the Anabat to monitor activity levels and to detect calls too faint for the Anabat. The Anabat/ZCAIM setups were powered by 12-volt, 2-amp-hour external batteries, which are lightweight enough to allow observers to be easily mobile. Most units were actively monitored, but some were deployed remotely to passively monitor bat activity.

Active monitoring involved a stationary period at the beginning of the survey to look for early-flying bats in designated areas, followed by walking and driving transects. The protocol for driving transects involved driving at a speed of less than 10 mph along a designated route. When a bat was detected, the driver would stop for one minute. If no further detections occurred, the transect would continue. If additional calls were recorded during the one-minute period, monitoring would continue for a minimum of five minutes and a maximum of 15 minutes. Walking surveys were similar, but the time periods varied. Calls recorded with in the first hour of sunset were considered indicators of bats roosting nearby.

Total activity levels were calculated for each survey date by using "Analook" software, and overall activity levels and activity by site were evaluated[3]. All identifiable[4] calls were labeled, and a species list was thus generated.

In the surveys, the following assumptions were made:

1. The louder bats will be over-represented; Mexican free-tailed bats (*Tadarida brasiliensis*) and western mastiff bats (*Eumops perotis*) emit such loud, low frequency calls that they can be recorded from hundreds of feet away, while “whispering” bats such as Townsend’s big-eared bats (*Corynorhinus townsendii)* emit such faint calls, they may not be recorded at all. Pallid bats *(Antrozous pallidus)* often hunt without echolocating, either visually or by passively listening.
2. The number of calls recorded can be used as an index of relative bat activity – it is not possible to determine the *number* of bats from the number of calls recorded.
3. Although certain calls are diagnostic for a particular species, there is no existing key to the calls of California bats and not all call sequences are identifiable. Different bat species can sometimes use similar signals, and members of the same species can vary the calls they use based on behavior at a given moment and the surrounding habitat. Calls can also vary regionally, and the ability to identify species varies with the experience of the person using the equipment; knowing which bats occur in the area and which are common are important considerations in identification.

To account for similarities and overlap among the calls of several groups of bat species, Anabat identification in this study was based on a modified version of Stokes’ protocol (Table 4; D. Stokes, pers. comm.). Calls not identifiable as a particular species were used to calculate activity levels for the site only. Table 5

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3 Measured activity levels can vary temporally and spatially – with dramatic differences from night to night and among detectors spaced at a distance of only 50 meters (Remington 2000, Stokes, pers. comm.). Reception on the detectors can be influenced by environmental conditions, such as temperature, humidity, and elevation (Livengood 2001), and by the makeup of the individual detector used (Stokes, pers. comm., pers. obs.). Low activity levels recorded once a month at a site are not necessarily evidence of long-term patterns of use.

4 Species identification using Anabat recordings is made by comparison with “voucher” calls from known hand-released bats and by observing bats while recordings were made. Interpretation of acoustic data is affected by biases and limitations of the equipment used to collect it. Not all bat species are equally detectable by this method. Its effectiveness depends on the frequency and intensity of a call (Pierson 1993), the habitat and weather conditions in which a bat is foraging (Fenton 1984, Livengood 2001), whether or not a bat is echolocating, and the detector used (Rainey 1995).

summarizes some of the known local identification challenges; Table 6 lists southern California species known to produce diagnostic calls (species codes are based on the first two letters of the Latin names).

Bat calls that are fragmented (and unidentifiable or equally likely to be one of several species) are discarded, as are those for which there is no additional evidence to indicate one over the others; bat calls that are likely of a particular species, but not diagnostic were also discarded.

Table 4. Criteria for using call sequences to identify species.

Criteria	Accept Call	Reject Call
Call is diagnostic of a particular species	X	
Call is diagnostic but fragmented	X	
Call is in a species repertoire but is not diagnostic; ID is made in combination with other evidence (e.g. visual observation)	X	
Call is not diagnostic and equally likely to be made by 2 or more species; habitat/season/altitude, etc., suggest candidate species		X
Call is fragmented; no evidence suggests one species over another		X

Table 5. Identification Challenges (see Table 1 for 4-letter codes).

Species producing similar calls	Possible additional methods of distinguishing the species
LACI / NYFE	Season, elevation
LACI / TABR	Season
NYFE / TABR	NYFE is audible to some people
TABR / EPFU	Visual observation; season (TABR is more likely to be active in the winter)
EPFU / ANPA	Visual observation of behavior; ANPA sometimes emits distinctive social calls
ANPA / MYEV	ANPA sometimes emits distinctive social calls
MYCA / MYYU[5]	MYYU forages over water
MYYU / LABL	Visual observation of behavior; red bats easily recognized visually with spot-lighting

5 Because there is so much overlap in call structure within the "50kHz *Myotis*" group (*M. californicus* and *M. yumanensis* produce calls that terminate at approximately 50kHz), identification is made conservatively with respect to this group. Unless the individual was observed or produced long sequences highly indicative of one species or the other, calls within this group were labeled MY50.

Table 6. Species in southern California producing diagnostic calls (see Table 1 for 4-letter codes).

Species Producing Diagnostic Calls	Usually	Often	Sometimes
LABL		x	
LACI			x
PAHE	x		
EPFU			x
ANPA			x
TABR			x
NYFE			x
NYMA			x
EUPE	x		

Roost searches: Roost searches are the most efficient method for detecting colonial, cavity-dwelling species such as Townsend's big-eared bat (which are not easily detected by either acoustic methods or mist-netting), but not for crevice-dwelling species such as western pipistrelle (Pierson 1998). Roost searches were done on buildings and enclosures in the vicinity of the Old Zoo, and when acoustic activity or visual observations at a site indicated the presence of a nearby roost. In the latter case, at least one subsequent search for the source of early-exiting bats was conducted.

RESULTS

Distribution and Diversity: A total of 1,092 call files were recorded on 21 nights from the five recording regions, with 744 files containing call sequences identifiable to species. Seven species (of the eleven bat species documented in the Santa Monica Mountains Recreation Area) were confirmed in Griffith Park from acoustic records during this study, basically doubling the number previously known from the park (Table 7), and representing over half the species known from the Santa Monica Mountains. An eighth species, the western mastiff bat, is known from a modern specimen from "Hollywood", and so may also occur in the park.

The highest species richness was found in the central and west regions of the park (the park's interior), with six species detected in each region (Table 8). These two areas received the greatest survey effort, so these data should be treated as preliminary until additional surveys can be made in the under-visited regions. Of the seven species confirmed in this study, all but Yuma myotis was confirmed in the central region. The list generated for the west region is nearly identical. The regions of lowest activity and diversity were the north and south, with just three species detected in each of these regions (hoary bat, Mexican free-tailed bat, and western pipistrelle). Two species, Mexican free-tailed bat and hoary bat, were detected in all five regions, not surprising as both are known for making long-distance foraging rounds[6]. Western pipistrelle was the only species confirmed acoustically during every month of the survey period, and was detected in all regions but the east (Los Angeles River).

[6] Driving transects produced a few dispersed detections of primarily the fast-flying species that often forage high above the ground, namely Mexican free-tailed bat and hoary bat. All recordings from the north region outside of Royce's Canyon were detected by driving transects, but no foraging 'hot spots', or concentrations of species or individuals, were detected here.

Table 7. Bats detected in Griffith Park in 2008 (this study) and their representation in the Santa Monica Mtns. National Recreation Area in 2002-2004 (Brown and Berry 2005).

Latin name	Common name	Documented in the Santa Monica Mountains NRA	Potentially Occurring in Santa Monica Mountains NRA	Documented in Griffith Park
Phyllostomidae	**American leaf-nosed bats**			
Macrotus californicus	California leaf-nosed bat		E	
Leptonycteris curasoae yerbabuenae†	Lesser long-nosed bat		X	
Vespertilionidae	**Evening bats**			
Myotis yumanensis	Yuma myotis	X		X
Myotis velifer	Cave myotis		PH	
Myotis evotis	Long-eared myotis		X	
Myotis thysanodes	Fringed myotis		X	
Myotis volans	Long-legged myotis		X	
Myotis californicus	California myotis	X		X
Myotis ciliolabrum	Small-footed myotis	X		
Lasionycteris noctivagans	Silver-haired bat		X	
Parastrellus hesperus	Western pipistrelle	X		X
Eptesicus fuscus	Big brown bat	X		X
Lasiurus blossevillii	Western red bat	X		X
Lasiurus xanthinus	Western yellow bat		X	
Lasiurus cinereus	Hoary bat	X		X
Euderma maculatum	Spotted bat	X		
Corynorhinus townsendii	Townsend's big-eared bat		X	
Antrozous pallidus	Pallid bat	X		
Molossidae	**Free-tailed bats**			
Tadarida brasiliensis	Mexican free-tailed bat	X		X
Nyctinomops femorosaccus	Pocketed free-tailed bat		X	
Nyctinomops macrotis	Big free-tailed bat		X	
Eumops perotis californicus	Western mastiff bat	X		

E – Potentially extirpated
PH – only known occurrence in Los Angeles County is from 3 Public Health records

We found detection rates (pooling all species) highest in the west, east, and central regions. Specifically, Brush Canyon and the eastern slopes from Bee Rock to Fern Canyon near the Merry-go-round had the most consistently high activity levels. The Los Angeles River received relatively little survey effort, but likely sees regular foraging activity for at least two species for most of the year. The north and south regions appear to contain potentially good bat habitat, and comparable survey effort to that expended in the central and west regions would likely find greater diversity and activity here than we documented.

Table 8. Bat species detected by region in Griffith Park (see Table 1 for 4-letter codes).

Region	EPFU	LABL	LACI	MY50	MYCA	MYYU	PAHE	TABR
Central	X	X	X		X		X	X
East		X	X	X		X		X
North			X				X	X
South			X				X	X
West	X	X	X	X			X	X

<u>Seasonal distribution</u>: This study yielded important details on usage of the park at different seasons by the various species of bats. As expected, peak detections occurred during the warmest months (Aug. - Sept., Table 9a), but species representation varied strongly by month (Table 9b). Mexican free-tailed bat was detected in every month but November, and confirmed at every recording site except Royce Canyon, with the greatest concentration of activity in August and September in Brush Canyon and the area south of the Old Zoo between Bee Rock and Fern Canyon. Western pipistrelle activity was greatest in the summer and fall, and in three areas of the park: Brush Canyon, Bronson "Cave," and Bee Rock. Big brown bat was detected during the late summer and fall, with the greatest activity levels recorded in Brush Canyon, though relatively high activity levels were also recorded for this species in the area south of the Old Zoo between Bee Rock and Fern Canyon. Hoary bat, a known migrant in this region, was detected primarily in the spring and fall months of the survey period, with activity peaks in April and September. Western red bat was confirmed at every recording site except Bronson Cave and the Hollyridge Trail, with the highest activity levels recorded near Bee Rock and the area between Bee Rock and Fern Canyon. Migratory patterns can vary substantially from year to year in southern California (pers. obs.), but western red bat exhibited a similar temporal pattern in the park to that of hoary bat (spring/fall), but at a much lower activity level. For example, it was detected only five times during the survey period (three times in the vicinity of Bee Rock and once each in Brush Canyon and at the Los Angeles River). Both species of *Myotis* were infrequently recorded; however, the few detections of Yuma myotis came from the Los Angeles River (in June and November), and the only California myotis detected was in the central region in July.

Table 9a. Bat species detected by month in Griffith Park in 2008.

Acronym	April	May	June	July	August	Sept	Oct	Nov
LABL	X	X				X	?	X
LACI	X	X			X	X	X	
MYCA				X				
MYYU			X					X
MY50			X	X				
PAHE	X	X	X	X	X	X	X	X
EPFU				?	X	X	X	
TABR	X	X	X	X	X	X	X	

Table 9b. Total bat detections by month in Griffith Park in 2008.

MONTH	REGION					TOTAL
	Central	East	North	South	West	
April	73		9			82
May	19	6		22		47
June	13	25				38
July	19				54	73
August	148		6		240	394
September	207		53		25	285
October	30				132	162
November					11	11
TOTAL	**509**	**31**	**68**	**22**	**462**	**1092**

Roosting: Though ample roost habitat was observed during the study, no specific roosts were confirmed visually. However, the timing of acoustic data indicates that at least six species (of the seven detected) roosted within the park or very near by during the survey period (Table 8). The highest number of species detected in the early evening (four) occurred in Brush Canyon, but at least two bat species were detected early in the evening (suggesting a nearby roost) in every region of the park. Table 8 also illustrates how roosting behavior varied in the park throughout the year, with several species roosting only seasonally. The lone exception to this temporal variation was the ubiquitous (at Griffith Park) western pipstrelle, which may roost year-round; it was detected within 30 minutes of sunset in every region of the park but the river, and were almost definitely roosting within the park's boundaries prior to these observations.

Table 10. Potential use of Griffith Park by roosting bats in 2008 (see Table 1 for 4-letter codes).

	MONTH								REGION				
	April	May	June	July	Aug	Sept	Oct	Nov	C	E	N	S	W
LABL		R								X			
LACI	r					R	r		X		X		X
MY50													
MYCA													
MYYU			r							X			
PAHE	R	R	R	R	R	R	R	R	X		X	X	X
EPFU					r		r						X
TABR		R	r		r	R			X	X		X	X
Totals	**2**	**3**	**3**	**2**	**2**	**3**	**3**	**1**	**3**	**3**	**2**	**2**	**4**

Key to Abbreviations
R = Day roost inferred from detection within 30 minutes of sunset (higher confidence of roost)
r = Day roost inferred from detection within one hour of sunset

Two species, Yuma myotis and western red bat, were detected within an hour of sunset only at the Los Angeles River, and could have been roosting inside or outside the park boundaries. Big brown bat and Mexican free-tailed bat also appear to be roosting within the park, the former detected early in Brush Canyon, and the latter recorded in the early evening in all regions but the north. The earliest (in the evening) detections of free-tailed bat were made at the trailheads of Western and Fern Canyons (in May and September, respectively).

DISCUSSION

Neither diversity nor activity levels correlated directly with survey effort, in part because bats are not distributed evenly over the landscape; water sources and canyons tend to funnel bat activity, and large water bodies may provide foraging opportunities even on cold nights[7]. For example, the east region, which consisted exclusively of the Los Angeles River, received the lowest survey effort – 1.9 hours total – yet had the second-highest diversity and rate of detection, with four species detected during three approximately 40-minute visits to the river. The temperature during the final November survey was much colder than it was on other surveys during the study and the only bat detected that night was recorded at the river.

So, while higher measured bat activity in specific regions and months is partly related to actual higher activity levels of the species involved, it is probably also due to uneven survey effort in the different regions (the number of survey hours per region varied from 1.9 to 37.4). Two sites in particular deserve additional investigation with regard to bat usage:

Los Angeles River: Of the four species detected along the Los Angeles River - Yuma myotis, Mexican free-tailed bat, hoary bat and western red bat - the first two are the two most commonly-observed species in urban southern California. Both are often detected near water sources, where the myotis specializes in the capture of emergent aquatic insects, and Mexican free-tailed bat forages opportunistically. The Los Angeles River is a likely feature to funnel activity of both species. Another water source that likely concentrates bat activity, particularly of these two species, is the Hollywood Reservoir. This area was not visited during this survey period due to access difficulties.

Royce Canyon: The bulk of detections from the north region came from Royce Canyon, which, although it was a target of this study, was surveyed only four times – all during the month of September – partly due to logistical constraints. The cliffs and vegetation at this site represent good potential bat habitat, and a more extensive study of this canyon (and the entire difficult-to-access northern slope of the park), both spatially and temporally, would likely reveal more species and activity.

Some findings of the survey were wholly expected; for example, the distribution of Yuma myotis is highly correlated with the presence of permanent water sources, and this species was not confirmed anywhere in the park except the L.A. River, where it was detected in June and November (and it probably forages there through most of the year). However, several noteworthy findings were made with regard to species status and distribution:

Western Pipistrelle - more common than expected: As noted above, the western pipistrelle was the only species confirmed acoustically during every month of the survey period, and calls of this species also comprised the highest percentage of total calls of all species detected in this study, suggesting that Griffith Park is an important location for this species. The fact that is was found so consistently and commonly was a somewhat surprising finding, as the species is unusual in urban and urban-edge parks in southern California, where the 'big three' - the predominant species detected - are Mexican free-tailed bat, Yuma myotis, and big brown bat (Remington 2000, Stokes, pers. comm.). This is probably due, at least in part, to the extensive open space, especially the relatively abundant cliff and rock features present in Griffith Park (the preferred known roosting habitat of this species), features that are atypical of most urban sites in the region. However, it is probably also related to the relative ease in identifying their calls; western pipistrelle produces diagnostic calls

[7] All bat species will drink when given the opportunity, and since water sources tend to attract insects, bats tend to forage there as well.

more often than most other species, so a smaller proportion of recorded call sequences of this species remained unidentifiable or inconclusive.

Mexican free-tailed bat - less common than expected: At least one urban-adapted bat species at Griffith Park may be less common than would be expected given its location surrounded by urbanization. During this study, measured activity levels of the Mexican free-tailed bat were not as high, nor as consistently high, as is typical for other urban or urban-edge sites (Remington 2006; S. Remington, pers. obs.). Like other urban-adapted species, it is typical for this bat to have greater dominance in areas of lower overall diversity, which typify urban areas, because of their tendency to form large colonies (and thus become numerically dominant); their generalist, highly opportunistic, feeding habits; their greater tolerance for urban features compared to most other bat species; and their tendency to produce high-intensity, low-frequency calls that are relatively easily recorded by ultrasonic detectors. These atypical data from Griffith Park could indicate any of the following:

- Sampling frequency was too low to capture population peaks that are part of natural variability in activity patterns.
- Observers were too often out of vertical range of existing activity of this species, which tends to be a high-altitude forager.
- Foraging activity was concentrated in areas that outside focus of this study (e.g., the Los Angeles River).
- Activity of this species is lower in Griffith Park than in other urban parks due to habitat constraints related to foraging and/or roosting (e.g., and more conducive to cliff-roosting western pipistrelles).

Griffith Park may be important for sensitive/declining bat species: During the 1930s and 40s, Krutch (1948) found 13 species to be common or abundant in San Diego County; nearly half of these are now classified as "Sensitive" by wildlife regulatory agencies, most being California Mammal Species of Special Concern. Just one of these was confirmed in the park during the 2008 survey, western red bat, a California Species of Special Concern. The local distribution of this solitary, migratory bat when both roosting and foraging is linked to mature/intact sycamore and cottonwood riparian vegetation, and it was considered widespread and abundant in San Diego County (where now uncommon) in the 1930s and 40s (Krutzsch 1948, Bolster 1998). Although individuals of this species have been detected in urban Orange and San Diego Counties, particularly in areas with ornamental trees (Krutzsch 1948, Remington 2000, D. Stokes unpublished), urbanization and the destruction of riparian areas by uses like the creation of water storage reservoirs can result in a double loss for the species. Like many riparian-dependent wildlife species in the state, with the decline in that habitat type it is now rare throughout southern California[8] (S. Remington, pers. obs.). Both of the lasiurine bats in the park (hoary bat and western red bat) are foliage-roosting species and tend to move the location of their day roost daily from tree to tree; therefore a range of tree options is important for this group of bats.

[8] Evidence of this species breeding in southern California has surfaced within the last ten years. In Los Angeles County, Brown and Berry (2005) captured three during their study, all in sycamore riparian habitat, including a lactating female in Malibu Creek State Park in the western Santa Monica Mountains. In San Diego County, a female bat with quadruplets was turned in for rehabilitation in July 1999, but all five died of suspected pesticide poisoning (C.E. Shriver, pers. comm.). A lactating female and two juveniles caught simultaneously in a net on 2 August 2002, and a few other juveniles that have been captured since 1996 during the summer months provide additional evidence of breeding in southern California (D. Stokes, unpublished data). This species is rarely captured or recorded acoustically in Orange County (pers. obs.). Krutzsch (1948) considered its presence in San Diego County directly influenced by the availability of suitable trees and shrubs for roosting.

Table 11. Western red bat *Lasiurus blossevillii* detections in Griffith Park in 2008.

	Central	East	North	South	West
April	Bee Rock (2)				
May		L.A. River (1)			
June					
July					
August					
September	Fern (1)				
October					
November					Brush (1)

Two other bat species detected during this survey, the hoary bat and the California myotis, are not recognized as Sensitive by regulatory agencies, but are believed to have declined in recent years in the region, and thus are of some conservation concern.

The hoary bat is a migratory species in southern California that relies on woodland and riparian habitats, similar to those of the western red bat (Krutzsch 1948, Barbour and Davis 1969). This species has identified by the Western Bat Working Group (WBWG; a consortium of bat specialists in the western U.S.) as a "medium" priority species, meaning that the species is considered in need of greater research and conservation actions[9]. Orange County Public Health records indicate that hoary bats have declined dramatically in the county during the last two decades (Remington 2000); systematic monitoring during winter and spring is necessary to determine the timing and location of their presence on the site, as well as its local status. Until recently, the hoary bat was primarily encountered in the fall, winter, and spring in Orange and San Diego Counties (Krutzsch 1948, Remington 2000, D. Stokes, pers. comm.), so fieldwork conducted primarily in the summer in these areas tended to miss them entirely. However, Brown and Berry (2005) detected individual hoary bats all year in the Santa Monica Mountains National Recreation Area, including through the summer months[10]. In Griffith Park, hoary bats were detected in every region of the park, but not confirmed in June, July, or November[11].

A third species, the California myotis, appears to rely on intact wooded habitat at lower elevations – an increasingly rare commodity in southern California. It was historically considered ubiquitous in most habitats in the southwest below 7,000 feet (Krutzsch 1954, Barbour and Davis 1969), and while roosts in a variety of habitats, it is not urban-adapted, and has been found to be uncommon at urban-edge habitat in Orange and San Diego counties during much of the last two decades (pers. obs., D. Stokes, pers. comm). In Orange County, it persists in open space up to the urban edge, but does not appear to be common on the Santa Ana Mountains, so appears to be genuinely scarce now; in 2008, this myotis was confirmed once near the picnic area east of the Old Zoo, which is near fairly extensive oak and sycamore-canyon habitats (e.g, Spring Canyon).

Comparison with previous research: Just one major bat study has been conducted in the Santa Monica Mountains (Brown and Berry 2005). Though the methods used in calculating detection rates were not identical to

[9] Currently, it is not possible to determine the population status of this species within the South Coast Ecoregion due to either the seasonal or elevation bias of studies conducted in the region, or a lack of comparable historical data (Miner and Stokes 2003).

[10] Hoary bat migratory patterns tend to be quite variable from year to year. In 2004, there was a surge in hoary bat activity in October, but were detected in low numbers for most of the next three years until 2007, when activity peaked again. In 2006, they were detected throughout the summer in Orange County, but in 2007 they were virtually absent again in the summer.

[11] The summer detections may reflect intensive sampling in sites where they occur sporadically or regularly in low numbers. A year-round long-term approach is necessary to evaluate bats' spatial and temporal patterns of use of the park. This is particularly true for species that occur only periodically, or consistently in low numbers.

previous studies[12], the Griffith Park data are striking for the dominance of western pipistrelle, and for the relatively smaller contributions of two urban bats, the Mexican free-tailed bat and Yuma myotis, as well as for the relatively larger contribution of hoary bat when compared to westerly sites in the Santa Monica Mountains National Recreation Area (NRA; Tables 12a, 12b).

Table 12a. Detection rates in the Santa Monica Mountains NRA (SMMNRA) and Griffith Park.

Family/Latin name	Code	Detection rate in the SMMNRA in 2002-04 (%)	Detection rate in Griffith Park in 2008 (%)
Vespertilionidae	**Evening bats**		
Myotis yumanensis	MYYU	21.6	1.9
Myotis californicus	MYCA	4.6	
Myotis ciliolabrum	MYCI	8.7	
Parastrellus hesperus	PAHE	18.5	46.5
Eptesicus fuscus	EPFU	9.7	14.1
Lasiurus blossevillii	LABL	< 1	< 1
Lasiurus cinereus	LACI	< 1	9.4
Euderma maculatum	EUMA	< 1	
Antrozous pallidus	ANPA	2.3	
Molossidae	**Free-tailed bats**		
Tadarida brasiliensis	TABR	30.4	27.4
Eumops perotis californicus	EUPE	< 1	

[12] Brown and Berry calculated percentage of minutes in which there were calls of each species; the Griffith Park study uses a direct percentage of the total number of calls.

Table 12b. Status of bats of the SMMNRA (Brown and Berry 2005) and Griffith Park (this study).

Family/Latin name	Code	SMMNRA (2002-2004)	Griffith Park (2008)
Vespertilionidae	**Evening bats**		
Myotis yumanensis	MYYU	X	X
Myotis californicus	MYCA	X	X
Myotis ciliolabrum	MYCI	X	
Parastrellus hesperus	PAHE	X	X
Eptesicus fuscus	EPFU	X	X
Lasiurus blossevillii	LABL	X	X
Lasiurus cinereus	LACI	X	X
Euderma maculatum	EUMA	X	
Antrozous pallidus	ANPA	X	
Molossidae	**Free-tailed bats**		
Tadarida brasiliensis	TABR	X	X
Eumops perotis californicus	EUPE	X	

Key to color code (based on Brown and Berry 2005) in the SMMNRA

Relatively common

Detected less frequently

Occurs in low numbers and/or sporadically or have very restricted habitat requirements.

Constraints on local bat populations: Low detection rates of a typically abundant and widespread species merit further investigation because they may signal a deeper problem in the ecological community, and early identification of a potential decline in a hardy species can prevent potential long-term problems by providing management solutions before other species are affected. Within the 2007 burn area at Griffith Park, the recent fire may have diminished the prey base. However, since no data exist on the pre-fire bat and insect populations of Griffith Park (or post-fire insect fauna), it is impossible to know whether a significant decline in the insect prey base occurred, how insect populations may be recovering, or whether the Griffith Park insect population currently supports fewer individuals of certain species. Other ongoing management may also be affecting bat populations; for example, if pesticides are applied within the park or on the property of any adjacent lands – golf courses, cemetery, water sources, etc. – this could have a similar lowering effect on insect prey abundance and, consequently, might affect the distance individual bats must fly during foraging rounds.

Constraints on the survey: Moreno and Halffter (2000) found that in order to sample 90% of the bat diversity at a given site, 5 to 18 survey nights are necessary. Extrapolating from this, it is likely that all but one species was detected in Griffith Park. However, since surveys in this study were heavily biased toward the early evening and limited to particular regions of the park, it is likely that rare, vagrant, and late-flying species were under-represented or missed entirely. It is possible that at least some of the four species detected in the SMMNRA but not in Griffith Park as well as some of the additional unconfirmed species potentially occurring in the Santa Monica Mountains would be detected with more intensive study.

The size of the park made it impossible to survey it completely – a constraint compounded by terrain. The wide-ranging habits of this species, which increase the probability of getting at least a few detections, make it likely that in the absence of a concentrated source of insect prey, individuals would be frequently moving around beyond the range of the ultrasonic detectors. Other factors potentially influencing recorded activity levels included environmental conditions – such as temperature, relative humidity, cloud cover, moon phase – and issues related to the equipment – such as battery strength and varying sensitivities of individual detectors.

Equipment problems had a greater impact in regions with lower survey effort, particularly in the south, where an Anabat failure at the Bird Sanctuary constituted 50% of the survey effort in that region. Low temperatures on the November 3 survey affected the totals of the central and west regions much less than the L.A. River, where it constituted a third of the survey effort.

ACKNOWLEDGEMENTS

This project was funded largely by the Los Angeles Department of Recreation and Parks (Contract #2930) as part of the Griffith Park Wildlife Management Plan. We also thank Jennifer Robinson and the Sierra Club, Angeles chapter, and the Franklin Hills Residents Association for additional funding and Patricia E. Brown for sharing unpublished data. This survey relied on several dedicated volunteers, especially Mary Button and Gerry Hans and Alec Giordano; we also thank Marian and Steve Dodge, Carol Henning, Laura Howe, Janet Jack, Mark Jacobi, Craig Olsson, Lisa Stege and Marie Vester.

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