BAT SURVEYS OF THE PUENTE HILLS
(WHITTIER HILLS, HACIENDA HEIGHTS, LA HABRA HEIGHTS, and ROWLAND HEIGHTS)

Los Angeles County, California
June 2005 – May 2006

FINAL REPORT

Conducted for
The Puente Hills Landfill Native Habitat Preservation Authority
7702 Washington Avenue, Suite C
Whittier, CA 90602

by
Stephanie Remington
P.O. Box 12383
Costa Mesa, CA 92627

14 July 2006

TABLE OF CONTENTS

INTRODUCTION

State and federal land management agencies officially recognize over two-thirds of the south coast ecoregion's 24 bat species as sensitive, and four additional species have been proposed to become California Species of Special Concern in the latest draft of "Mammal Species of Special Concern in California" (Table 1).

Habitat loss, roost disturbance, and vegetation modification and removal pose major threats to bat populations in the south coast ecoregion. 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, but difficult or impossible to measure.

The Puente Hills Preserve consists of 3,850 acres of varied habitat types and topography isolated by urbanization to the north, west, and south. The Preserve, containing native and introduced vegetation and numerous vertebrate species, is fragmented by urban developments and several major roads, including one freeway.

East of Harbor Boulevard, the Puente Hills are heavily grazed by cattle. West of Harbor, a greater variety of land uses occur, including recreation, habitat restoration, and biological research. Some areas are more heavily visited than others. In at least one site in the western section, large limbs and small trees were removed for road widening. All areas in the western section immediately adjacent to urban developments received mosquito-abatement treatments during the spring, summer, and fall.

During seven surveys of the eastern Puente Hills in 2004, five bat species were detected (Brown, Berry, and Remington 2004). Six others were considered to potentially occur in the area (Table 1).

From June 2005 through May 2006, a more intensive study was conducted within the Puente Hills Preserve in the jurisdiction of the Puente Hills Landfill Native Habitat Preservation Authority (henceforth known as the Habitat Authority) (Figure 1). During this period, all but one species previously identified were detected; all but one considered potential were confirmed; and an additional species was confirmed (Table 1).

Table 1. Bats of the south coast ecoregion detected in the Puente Hills in 2004.

Family/Latin name	Common name	Legal status	Puente Hills	
			2004	2005-06
Phyllostomatidae	**American leaf-nosed bats**			
Macrotus californicus	California leaf-nosed bat	CSC, FSS, BLM		
*Choeronycteris mexicana**	Mexican long-tongued bat	CSC		
Leptonycteris curasoae yerbabuenae†	Lesser long-nosed bat	FE		
Vespertilionidae	**Mouse-eared bats**			
Myotis lucifugus	Little brown bat	none		
*Myotis yumanensis**	Yuma myotis	FSC, BLM	X	X
Myotis velifer†	Cave myotis	CSC, BLM		
*Myotis evotis**	Long-eared myotis	FSC, BLM		
Myotis thysanodes	Fringed myotis	FSC, CSC*, BLM		
Myotis volans	Long-legged myotis	FSC, CSC*, BLM		
*Myotis californicus**	California myotis	none	X	¥
*Myotis ciliolabrum**	Small-footed myotis	FSC, BLM	§	
Lasionycteris noctivagans	Silver-haired bat	none		
*Pipistrellus hesperus**	Western pipistrelle	none	§	X
*Eptesicus fuscus**	Big brown bat	none	X	X
*Lasiurus blossevillii**	Western red bat	CSC*, FSS	§	X
*Lasiurus xanthinus**	Western yellow bat	CSC*		X
*Lasiurus cinereus**	Hoary bat	none	§	X
Euderma maculatum	Spotted bat	CSC, FSC, BLM		
*Corynorhinus townsendii**	Townsend's big-eared bat	CSC, FSC, FSS, BLM		
*Antrozous pallidus**	Pallid bat	CSC, FSS, BLM	X	
Molossidae	**Free-tailed bats**			
*Tadarida brasiliensis**	Mexican free-tailed bat	none	X	X
*Nyctinomops femorosaccus**	Pocketed free-tailed bat	CSC	§	X
*Nyctinomops macrotis**	Big free-tailed bat	CSC		
*Eumops perotis californicus**	Western mastiff bat	CSC, FSC, BLM	§	X

Source: California Department of Fish & Game

Key to Symbols and Acronyms

***** Known to occur in Orange County (Remington 2000)

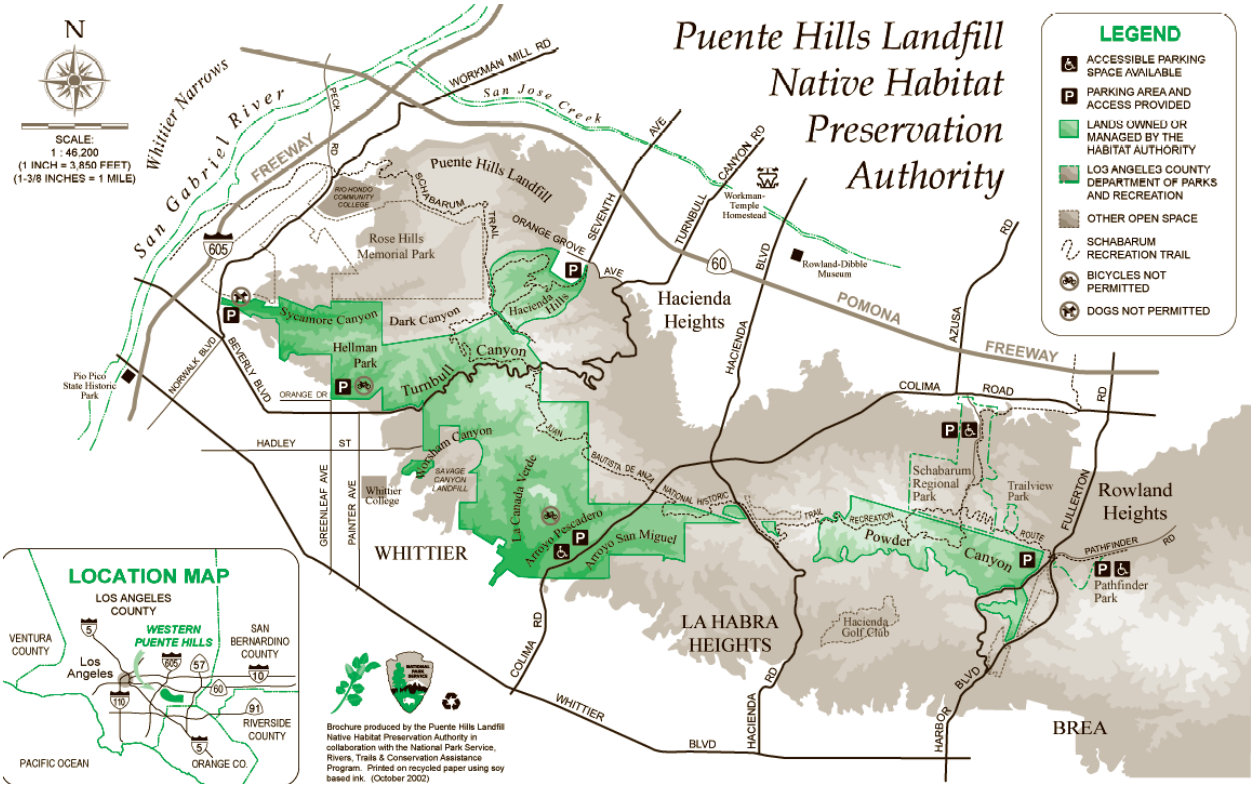
† Currently known in the state from only two or three recent public health records from urban areas in the ecoregion (Constantine 1998).

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

§ Considered potentially occurring in the area based on known range and habitat preferences.

¥ Occurrence is possible, based on acoustic records, but overlap in call structure precludes confirmation.

Figure 1. Habitat Authority Jurisdiction.



PROJECT GOALS

- *Determine species diversity*
  This is the second bat survey of the Puente Hills and the first to be conducted for more than a single season.

- *Locate Roosting Areas*
  Several bat species form maternity colonies in the spring and use them through early fall to give birth to and raise their young. Locating roosts of Species of Special Concern, such as the western mastiff bat (*Eumops perotis*) and the pallid bat (*Antrozous pallidus*), as well as common species such as the big brown bat (*Eptesicus fuscus*) and Mexican free-tailed bat (*Tadarida brasiliensis*), is important to managing their populations. Migratory species, such as the lasiurines – hoary bat (*Lasiurus cinereus*), western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) – rely on woodland and riparian habitats for both roosting and foraging.

- *Identify foraging hot spots*
  Foraging areas are as important to protect as roost sites. Bats need foraging and roosting areas in relatively close proximity, particularly pregnant and nursing females that don't travel as far as the males to get water and food. Feeding can be inferred by either the occurrence of feeding buzzes (the increase in the rate of call production to as many as 200 per second that bats typically produce when they approach an object, such as an insect) or a high level of acoustic activity in an area.

- *Identify potential impacts to bat habitat*
  Impacts to bat populations can be direct or indirect. Direct impacts, such as deliberate and inadvertent roost disturbance or destruction, include vegetation removal or modification that damages or destroys existing roosts, and human visitation and vandalism. Indirect impacts can occur from impacts to foraging habitat or the prey base (insect populations), including vegetation removal or modification and pest eradication treatments.

- *Make recommendations for managing bat populations*

METHODS

Survey areas:
Turnbull Canyon, Sycamore Canyon, Powder Canyon, Arroyo Pescadero (including La Cañada Verde), Arroyo San Miguel, and others were selected based on a combination of vegetative and geologic features that identified them as having high potential as bat habitat. (Tables 2 and 3, Figures 2, 3, and 4). These canyons contain riparian habitat, oak woodland, scrub, cliff and rock features, and water sources that are important – especially in combination – to bats. Within sites, consideration was given to accessibility via roads and hiking trails since the areas needed to be safe to walk in after dark by field personnel carrying gear.

Table 2. Field Site Acronyms

TUCA	Turnbull Canyon	**SCPA**	Schabarum Park
SYCA	Sycamore Canyon	**HAHE**	Hacienda Heights
POCA	Powder Canyon	**GIHO**	Gibson House
ARPE	Arroyo Pescadero	**ECCA**	Ecology Canyon
ARSM	Arroyo San Miguel	**FANP**	Fan Property
CAVE	La Cañada Verde		

Six sites were surveyed only once or twice (Table 3). The Fan Property and Schabarum Park can be considered in the same vicinity as Powder Canyon. Hacienda Heights includes Canyon 8. The Gibson House and Ecology Canyon are in distinct regions of the Puente Hills.

Table 3. Field Sites and Dates

TUCA	SYCA	ARPE/CAVE	ARSM	POCA	OTHER SITES
15-Jun-05	16-Jun-05	21-Jul-05	28-Jul-05	25-Jul-05	20-Jun-05 TRAN
18-Jul-05	20-Jul-05	27-Oct-05	29-Oct-05	19-Sep-05	22-Jun-05 CAN8
10-Aug-05	18-Aug-05	15-Nov-05	14-Nov-05	28-Sep-05	22-Aug-05 FANP
12-Sep-05	15-Sep-05	7-Dec-05	12-Dec-05	23-Oct-05	25-Aug-05 SCPA
12-Oct-05	13-Oct-05	24-Jan-06	30-Jan-06	6-Nov-05	29-Aug-05 ECCA
1-Nov-05	13-Nov-05	31-Jan-06	13-Feb-06	6-Dec-05	25-Mar-06 HAHE
4-Dec-05	5-Dec-05	9-Feb-06	26-Mar-06	20-Apr-06	
17-Jan-06	23-Jan-06	14-Feb-06	19-Apr-06	6-May-06	
12-Feb-06	8-Feb-06	22-Mar-06	10-May-06		
24-Mar-06	23-Mar-06	12-Apr-06			
13-Apr-06	18-Apr-06	7-May-06			
9-May-06	8-May-06				

Figure 2. Survey Sites in Turnbull and Sycamore Canyons, Hacienda Heights, and upper Cañada Verde.

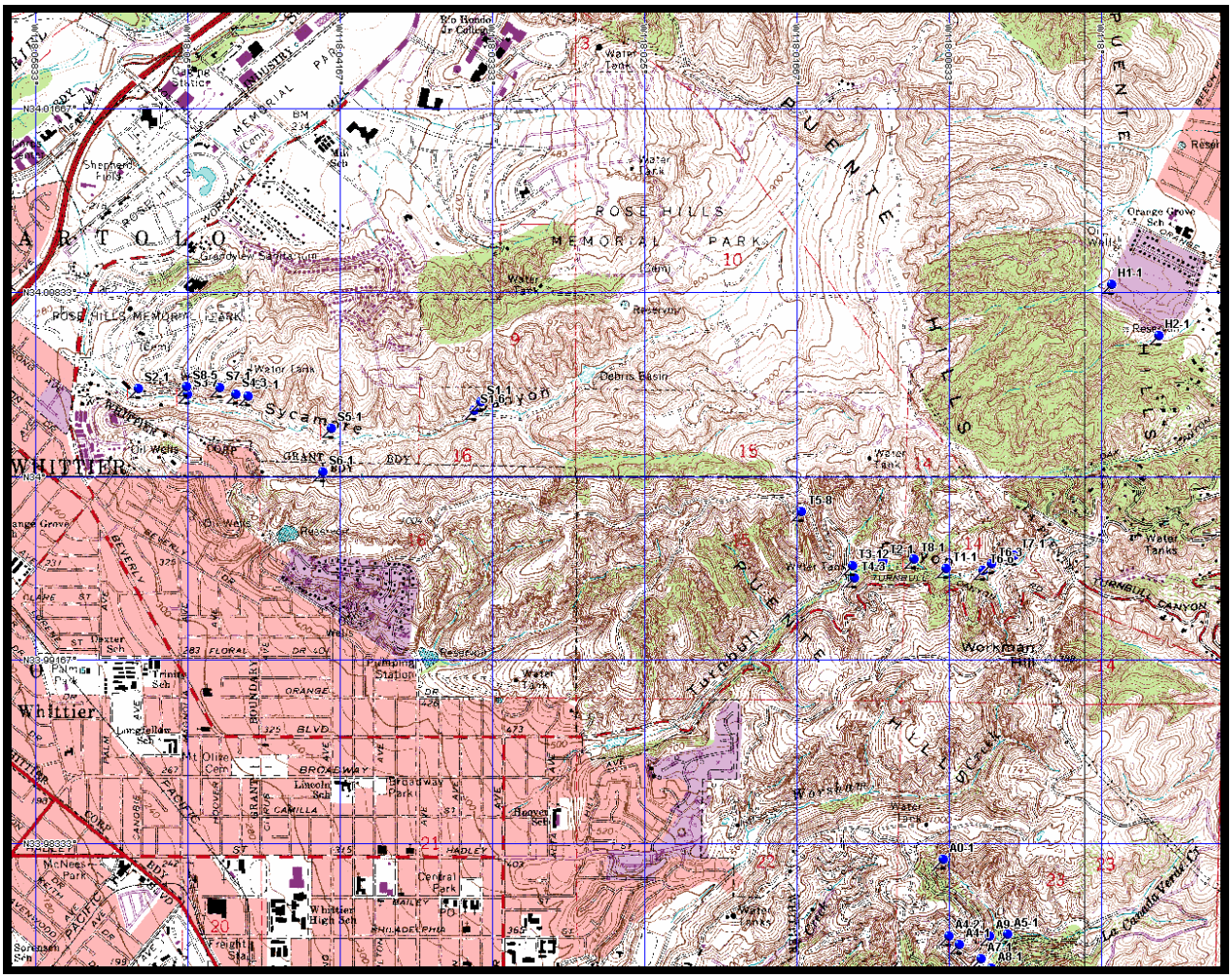


Figure 3. Survey Sites in Arroyo Pescadero, Arroyo San Miguel, and La Cañada Verde.

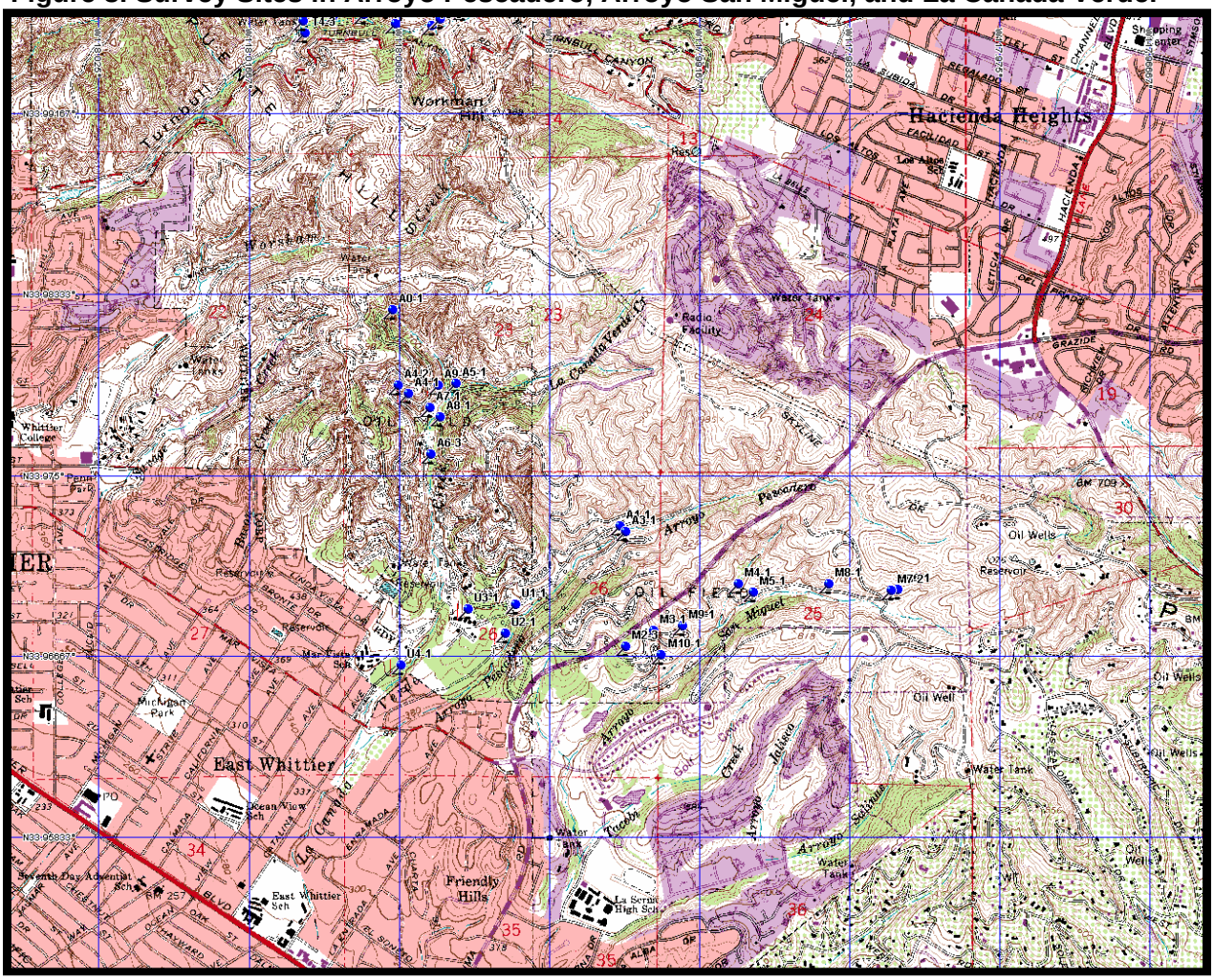
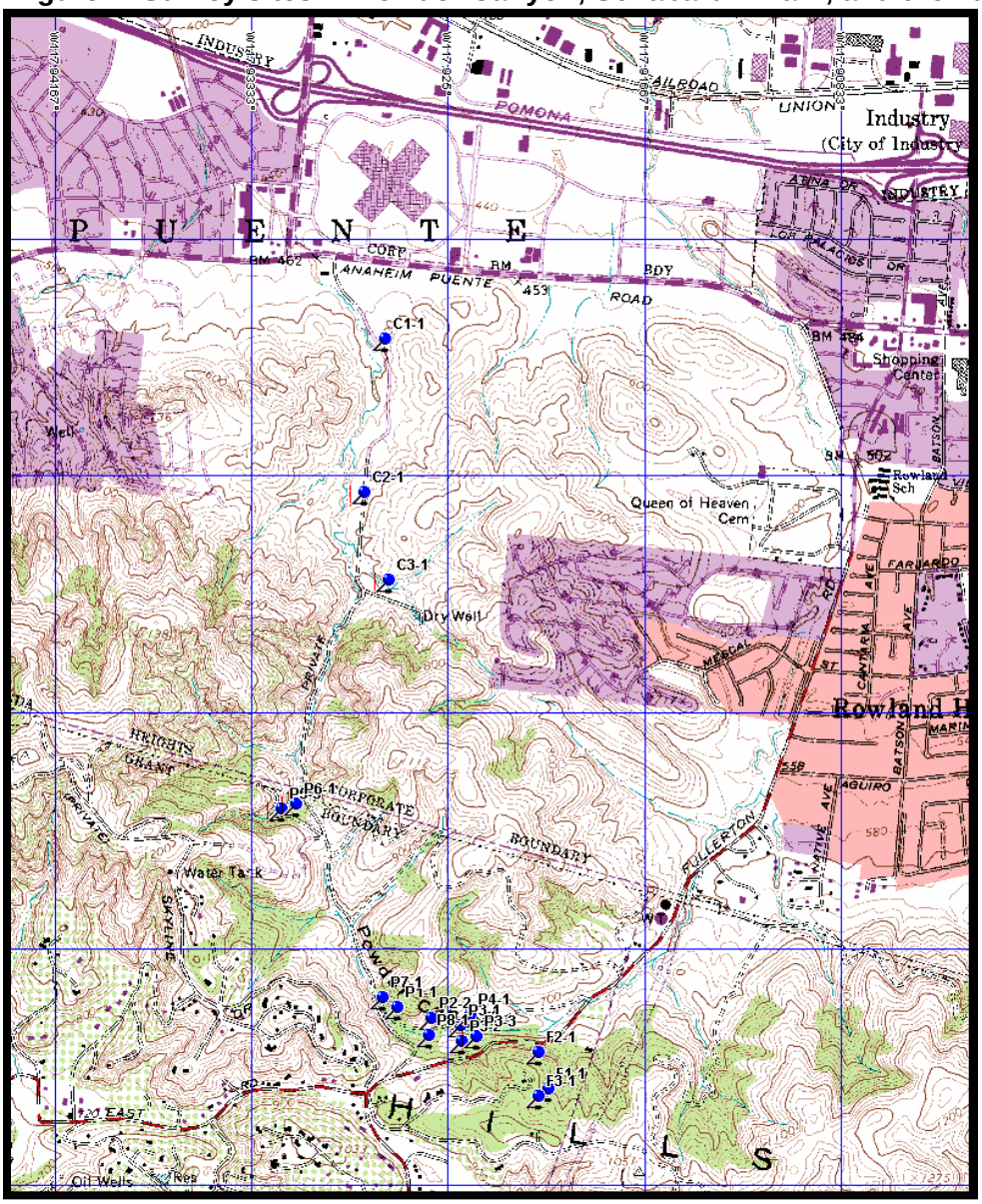


Figure 4. Survey sites in Powder Canyon, Schabarum Park, and the Fan Property.



Timing:
Turnbull and Sycamore Canyons were surveyed once a month between June 2005 and May 2006. Arroyo Pescadero, Arroyo San Miguel, and Powder Canyon were surveyed at least once per season. The remaining sites were surveyed once each. Although timing cannot be defined exactly, spring and summer coincide approximately with maternity season; fall and spring with migration; and winter with hibernation. 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.

Capture studies have found that bats' primary nightly activity period occurs within the first five hours after sunset (O'Farrell and Bradly 1970, Kunz 1973), but recent long-term acoustic studies have shown that this can vary substantially (M. O'Farrell, pers. comm.). Locally, the majority of the activity during the peak period often occurs within the first two hours after sunset, but this varies among species, seasons, and with ambient conditions – both natural and human-related (pers. obs.). In this study, each survey began a half an hour to an hour before sunset, and continued until at least three hours after sunset in the spring, summer, and fall. During winter, sampling continued for a minimum of two hours after sunset. When a site with a low probability of theft or vandalism was located, detectors were left over night to sample activity.

Survey Protocols*:*
The behavioral and ecological diversity among bat species precludes the use of a universal sampling method that is adequate 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).

However, due to logistical constraints and low ground-level bat activity, acoustic methods were employed nearly exclusively. Limitations in interpretation are described below.

Acoustic: 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).

To measure activity levels and to identify species, echolocation signals were recorded on all surveys using the Anabat II system, heterodyne detectors (Pettersson D100), or a combination of the two. Calls received on the Anabat detector were stored on a laptop computer and/or compact flash cards for species identification. The heterodyne detectors were used in addition to the Anabat to monitor activity levels and to pick up calls too faint for the Anabat. The Anabat detectors were set in a fixed position to record calls, while the heterodyne detectors were handheld and allowed mobility within a given survey. 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 the following formula: Call density is 10 times Total # calls divided by (# Anabats times # minutes). Call-minutes are the total number of minutes in which calls were recorded on a given survey. Activity levels were compared among species by assigning them relative ranks, based on the total number of calls recorded for each one over the survey period. 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.

Species identification using Anabat recordings is made by comparison with "voucher" calls from known hand-released bats. 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).

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 the perceptual task and the surrounding habitat. Calls can also vary regionally. 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.

Anabat identification in this study follows Stokes' protocol (D. Stokes, pers. comm.). There are similarities and overlap among the calls of several groups of bat species (Table 4). To standardize Anabat identifications, a confidence level (high, medium, or low) is assigned to call sequences based on the known range of call characteristics for the group of species occurring in an area (Table 5). (See Table 7 for the key to species acronyms.)

Table 4. Identification Challenges.

Species producing similar calls	Possible additional methods of distinguishing the species
LACI/NYFE	season, elevation
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	observe MYYU foraging over water when call is recorded
MYYU/LABL	visual observation of behavior; red bats easily recognized visually with spot-lighting

Table 5. Criteria for assigning confidence levels to call sequences.

Criteria	Confidence Level			
	High	Medium	Low	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		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

A high confidence level is assigned only to those calls that appear diagnostic of the species (Table 6). A medium confidence level is assigned to calls for either of two reasons: 1) a call is known from the repertoire of two species but there is other evidence (such as habitat, time of year, elevation, etc.) supporting a tentative identification; 2) a call is diagnostic but fragmented. A low confidence rating is given when a call appears equally likely to be from two or more species, but when considered with other evidence, one species is more likely to have produced it than the others.

Table 6. Species in southern California producing diagnostic calls.

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

Because there is so much overlap in call structure within the *Myotis*, identification is made conservatively with respect to this group. High confidence level ratings within this taxon are usually restricted to Yuma myotis that were visually observed to exhibit typical foraging behavior while being recorded.

Bat calls that are fragmentary – and therefore unidentifiable or equally likely to be one of several species – and there is no additional evidence to indicate one over the others, are discarded.

Mist netting: Mist netting is a more effective means of surveying some species that are not easily detected acoustically (e.g., pallid bats are sometimes captured in 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. *C. 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.).

Another limitation of mist nets is that they sample an extremely small area relative to that used by free-flying bats. O'Farrell and Gannon (1999) found that when sampling simultaneously with nets and the Anabat II analysis system, acoustic sampling detected significantly more species than captures did. Western mastiff bats, *Eumops perotis*, and western red bats *(Lasiurus blossevillii)* were identified acoustically but never caught in nets.

In this study, with one exception mist-netting was not employed due to 1) a paucity of appropriate and/or accessible sites to place nets; 2) high mountain bike visitation and/or very low bat activity in the few areas where nets might have been placed. On a single survey at Hacienda Heights, a net was placed over an ephemeral pond created by rains.

Roost searches: Roost surveys are the most efficient method for detecting colonial, cavity-dwelling species such as *C. townsendii* (which are not easily detected by either acoustic methods or mist-netting), but not for crevice-dwelling species such as *P. hesperus* (Pierson 1998).

In this study, acoustic activity near dusk was used to attempt tracking down roosts. At least one attempt was made to locate bats exiting the roost after bats were observed or recorded shortly after dusk. Lasiurines may be observed exiting a particular tree roost, but generally do not roost in the same location from night to night. When species in this group were detected early, at least one attempt was made to locate exiting bats within the same general vicinity.

A species list for the Puente Hills Preserve has been compiled, based on acoustic data collection.

RESULTS and DISCUSSION

Distribution and Diversity:
Over the 12-month survey period, 1,035 minutes (17 hours) of calls were recorded at 62 Anabat stations during 580 total Anabat-hours of recording (Table 9). Recorded calls represented 3% of the total effort.

Ten bat species were detected acoustically during this survey (Tables 7 and 8), including nine detected within an hour of sunset, indicating that they roost nearby. The only roost discovered was a palm tree in Arroyo San Miguel, and this did not appear to have been used regularly.

This doubled the list of five species identified during the previous surveys of the eastern Puente Hills (Brown, Berry, and Remington 2004), although *Antrozous pallidus* was not detected in the 2005-06 study. *Myotis californicus* was identified in 2004 potentially occurs on the Puente Hills Preserve but overlap in call structure between this species and *M. yumanensis* precluded confirmation (the designation 'U' indicates species whose calls were tentatively identified acoustically, but that were unconfirmed; 'P' indicates species determined to be potentially occurring in the area based on knowledge of its range and habitat requirements).

Five of the six species considered potentially occurring during the 2004 surveys were confirmed during the 2005-06 study (*Myotis ciliolabrum* was not detected during either study), and an additional species (western yellow bat, *Lasiurus xanthinus*) was detected (Table 2; Table 7).

Four species were detected in at least 10 of the 12 months of the 2005-06 survey period (Table 10). Mexican free-tailed bats were detected in 10 months and at all but the two sites in Hacienda Heights. Western pipistrelles (*Pipistrellus hesperus*) were detected in every month but March, but only in Turnbull and Sycamore Canyons. Western red bats (*Lasiurus blossevillii*) and hoary bats (*L. cinereus*) were each detected in 10 months, unconfirmed only in July/May and June/July, respectively. Both were detected at six of the 12 sites.

Big brown bats were detected commonly at six of the twelve sites during the spring, summer, and early fall, but not at all during the late fall and winter months. Calls of *Myotis* (*M. yumanensis* and possibly *M. californicus*), were recorded occasionally during the summer months at six sites (Table 11) and at least one of these species probably occurred during other months, as well, but the relatively high calls they produce attenuate relatively quickly in the atmosphere and can, therefore, be more difficult to record unless the bat is close to the detector.

The remaining species were detected at least once at up to five different sites. The western mastiff bat (*Eumops perotis*) was the least frequently-detected species, having been identified during a single survey at Arroyo Pescadero in July, late in the evening. All others were detected during at least two months of the survey period at three or more sites. *Eumops* is also the only species confirmed during this survey period that was not recorded at least once early in the evening.

The spring and summer months tended to have the highest overall activity, but peaks in activity varied widely across sites and months (Figure 5).

Turnbull and Sycamore Canyons had by far the highest species diversity and activity levels (Tables 10 and 11; and Figures 6 and 7).

Table 7. Bat Species Detected in the Puente Hills from 2004-2006.

Family/Latin Name	Common Name	Acronym	2004	2005-06
Vespertilionidae	**Mouse-eared bats**			
Lasiurus blossevillii	Western red bat	LABL	P	X
Lasiurus cinereus	Hoary bat	LACI	P	X
Lasiurus xanthinus	Western yellow bat	LAXA		X
Myotis californicus	California myotis	MYCA	X	U
Myotis yumanensis	Yuma myotis	MYYU	X	X
Pipistrellus hesperus	Western pipistrelle	PIHE	P	X
Eptesicus fuscus	Big brown bat	EPFU	X	X
Antrozous pallidus	Pallid bat	ANPA	X	
Molossidae	**Free-tailed bats**			
Tadarida brasiliensis	Mexican free-tailed bat	TABR	X	X
Nyctinomops femorosaccus	Pocketed free-tailed bat	NYFE	P	X
Eumops perotis californicus	Western mastiff bat	EUPE	P	X

Table 8. Bat Species Detected in the Puente Hills in 2005-2006.

Acronym	Month												Evidence of Near-by Roosting
	J	J	A	S	O	N	D	J	F	M	A	M	
LABL	X		X	X	X	X	X	X		X	X		Y
LACI			X	X	X	X	X	X	X	X	X	X	Y
LAXA					X	X			X	X			Y
MYCA		P			P								?
MYYU		X			X								Y
PIHE	X	X	X	X	X	X	X	X	X		X	X	Y
EPFU	X	X	X							X		X	Y
TABR	X	X	X	X	X	X			X	X	X	X	Y
NYFE			X	X		X	X						Y
EUPE		X											

KEY TO ABBREVIATIONS
Month
Ja = January, F = February, Mr = March Ap = April, My = May, Ju = June, Jl = July, A = August, S = September, O = October, N = November, D = December

Table 9. Survey Effort and Bat Activity at All Sites in 2005-06.

Date	Site	# Anabats	Call Minutes	Total Minutes	% Call Minutes	Total # Species	Total Early Species
21-Jul-05	ARPE	4	20	775	3%	4	0
31-Jan-06	ARPE	4	0	523	0%	0	0
14-Feb-06	ARPE	4	4	605	1%	2	0
26-Mar-06	ARPE	4	1	529	0%	1	1
28-Jul-05	ARSM	3	9	627	1%	2	1
29-Oct-05	ARSM	4	5	774	1%	2	2
14-Nov-05	ARSM	3	11	598	2%	1	0
12-Dec-05	ARSM	4	0	680	0%	0	0
30-Jan-06	ARSM	4	4	530	1%	1	1
13-Feb-06	ARSM	4	12	614	2%	1	1

Table 9 is continued on the following page.

Table 9. Continued

Date	Site	# Anabats	Call Minutes	Total Minutes	% Call Minutes	Total # Species	Total Early Species
19-Apr-06	ARSM	3	15	425	4%	3	2
10-May-06	ARSM	3	4	419	1%	3	1
22-Jun-05	CAN8	1	0	197	0%	2	0
27-Oct-05	CAVE	4	1	775	0%	1	1
15-Nov-05	CAVE	4	17	741	2%	3	3
7-Dec-05	CAVE	4	0	518	0%	0	0
24-Jan-06	CAVE	4	4	537	1%	1	0
9-Feb-06	CAVE	4	15	602	2%	2	2
22-Mar-06	CAVE	4	0	521	0%	0	0
12-Apr-06	CAVE	4	1	558	0%	1	0
7-May-06	CAVE	3	1	386	0%	1	1
29-Aug-05	ECCA	4	12	832	1%	2	1
22-Aug-05	FANP	3	3	351	1%	3	2
25-Mar-06	HAHI	3	3	354	1%	1	1
25-Jul-05	POCA	4	15	828	2%	3	0
19-Sep-05	POCA	3	4	230	2%	2	1
28-Sep-05	POCA	4	10	694	1%	2	1
23-Oct-05	POCA	3	4	601	1%	2	0
6-Nov-05	POCA	3	4	507	1%	1	1
6-Dec-05	POCA	4	0	543	0%	0	0
20-Apr-06	POCA	4	6	612	1%	1	1
6-May-06	POCA	1	3	127	2%	1	1
25-Aug-05	SCPA	3	4	559	1%	2	1
16-Jun-05	SYCA	3	25	440	6%	3	2
20-Jul-05	SYCA	4	135	776	17%	4	3
18-Aug-05	SYCA	4	79	1106	7%	2	1
15-Sep-05	SYCA	4	30	844	4%	5	5
13-Oct-05	SYCA	3	23	490	5%	3	2
13-Nov-05	SYCA	4	3	1285	0%	1	0
5-Dec-05	SYCA	4	9	579	2%	2	2
23-Jan-06	SYCA	4	18	601	3%	2	2
8-Feb-06	SYCA	4	24	598	4%	3	3
23-Mar-06	SYCA	4	131	710	18%	4	3
18-Apr-06	SYCA	4	25	584	4%	4	3
8-May-06	SYCA	3	57	495	12%	4	4
20-Jun-05	TRAN	1	1	164	1%	2	0
15-Jun-05	TUCA	3	40	580	7%	3	1
18-Jul-05	TUCA	4	41	882	5%	5	2
10-Aug-05	TUCA	4	54	938	6%	5	4
12-Sep-05	TUCA	3	19	516	4%	5	2
12-Oct-05	TUCA	4	13	786	2%	3	3
1-Nov-05	TUCA	4	42	798	5%	4	4
4-Dec-05	TUCA	4	2	720	0%	2	2
17-Jan-06	TUCA	4	1	513	0%	1	0
12-Feb-06	TUCA	3	14	486	3%	3	1
24-Mar-06	TUCA	4	11	634	2%	3	3
13-Apr-06	TUCA	4	22	658	3%	3	2
9-May-06	TUCA	3	24	392	6%	3	3

Total Time	Minutes	Hours
Recording	34,747	579
Activity	1,035	17

Table 10. Species Detected Each Month at All Sites.

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Totals
MYCA	P	P			P								
MYYU	P	X	X		P								2
MY50	X	X	?	?	X								3
PIHE	X	X	X	X	X	X	X	X	X		X	X	11
EPFU	X	X	X	X						X		X	6
LABL	X		X	X	X	X	X	X	X	X	X		10
LACI			X	X	X	X	X	X	X	X	X	X	10
LAXA				X	X	X			X	X			5
TABR	X	X	X	X	X	X			X	X	X	X	10
NYFE			X	X		X	X						4
EUPE		X											1
Totals	5	5	6	7	6	6	4	3	4	5	4	4	

Figure 5. Bat Activity at the Five Main Sites from June 2005 – May 2006.

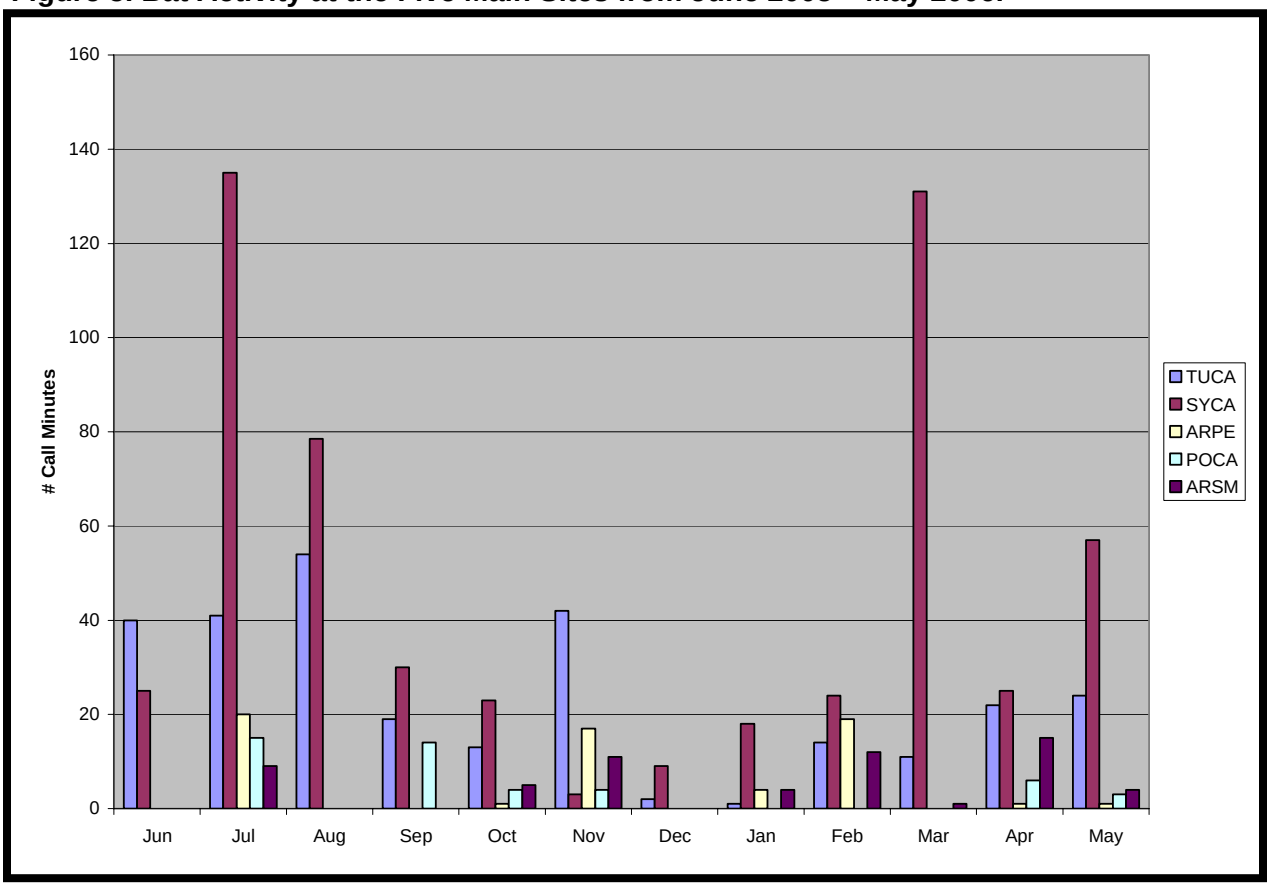


Table 11. Species Diversity at Each Site Sampled in 2005-2006.

	TUCA	SYCA	POCA	ARPE	ARSM	FANP	SCPA	ECCA	CAN8	HAHI	GIHO	CAVE	Totals
MYCA	P	P	P	P	P				P				?
MYYU	X	P	X	X	P				P				3
MY50	X	R	X	X	X		X		X				7
PIHE	R	R											2
EPFU	R	R	X	X	X	R					X		7
LABL	R	R	R		R			X				R	6
LACI	R	R	R	R	R	X				?		R	7
LAXA	R	R	X		R							R	5
TABR	R	R	X	X	X	R	R	X		?	X	R	10
NYFE	X	R	X										3
EUPE				X									1
Total	8	8	6	5	5	3	2	2	1	1	2	4	10
R	6	7	2	1	3	2	1	0	0	1	0	4	9

X = Detected during the survey period.
R = Detected within the first hour of sunset and presumed to have been roosting nearby.
P = Potentially occurring, but overlap in acoustic characteristics precludes confirmation.
? = Acoustic characteristics indicate a particular species, but calls are too fragmentary to confirm.

Figure 6. Bat Activity during the First Four Hours after Sunset.

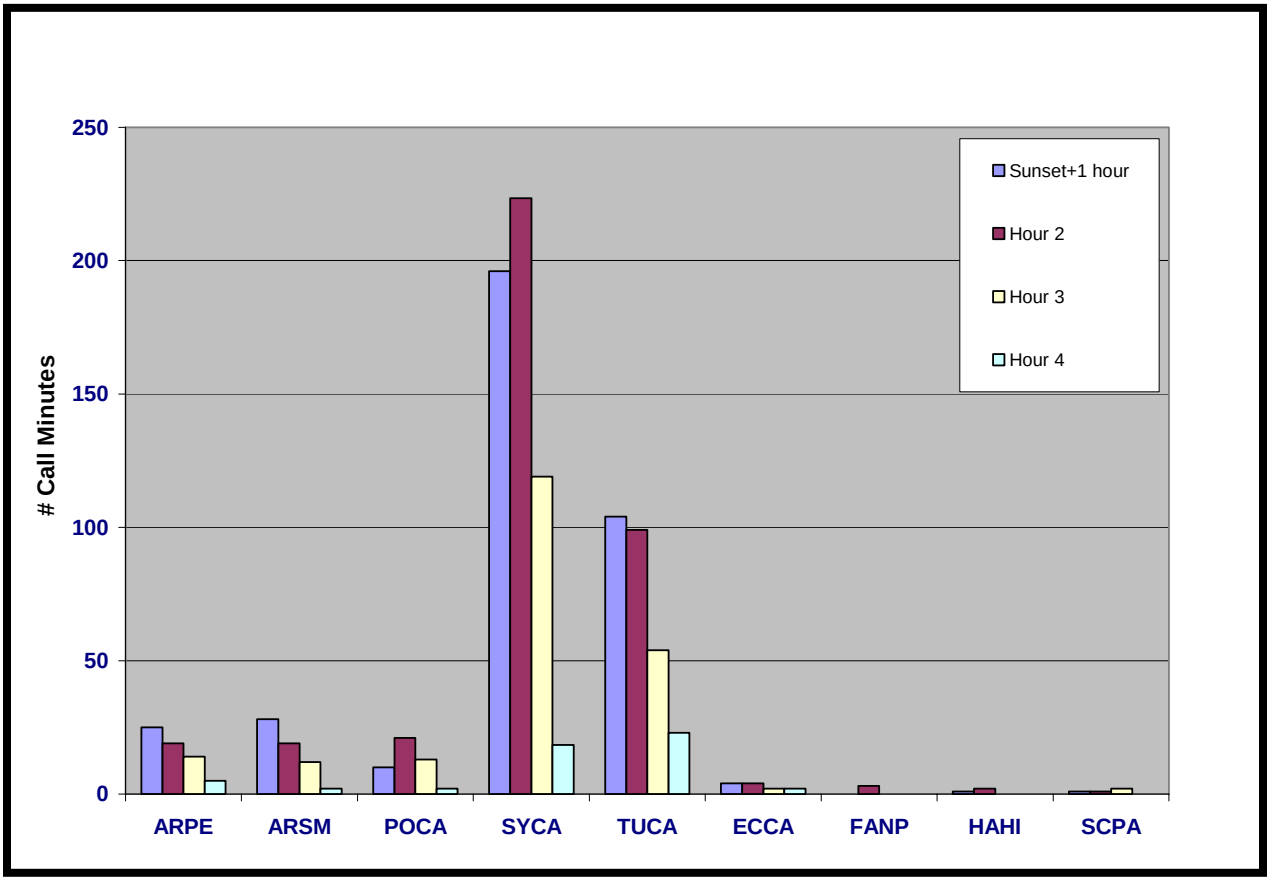
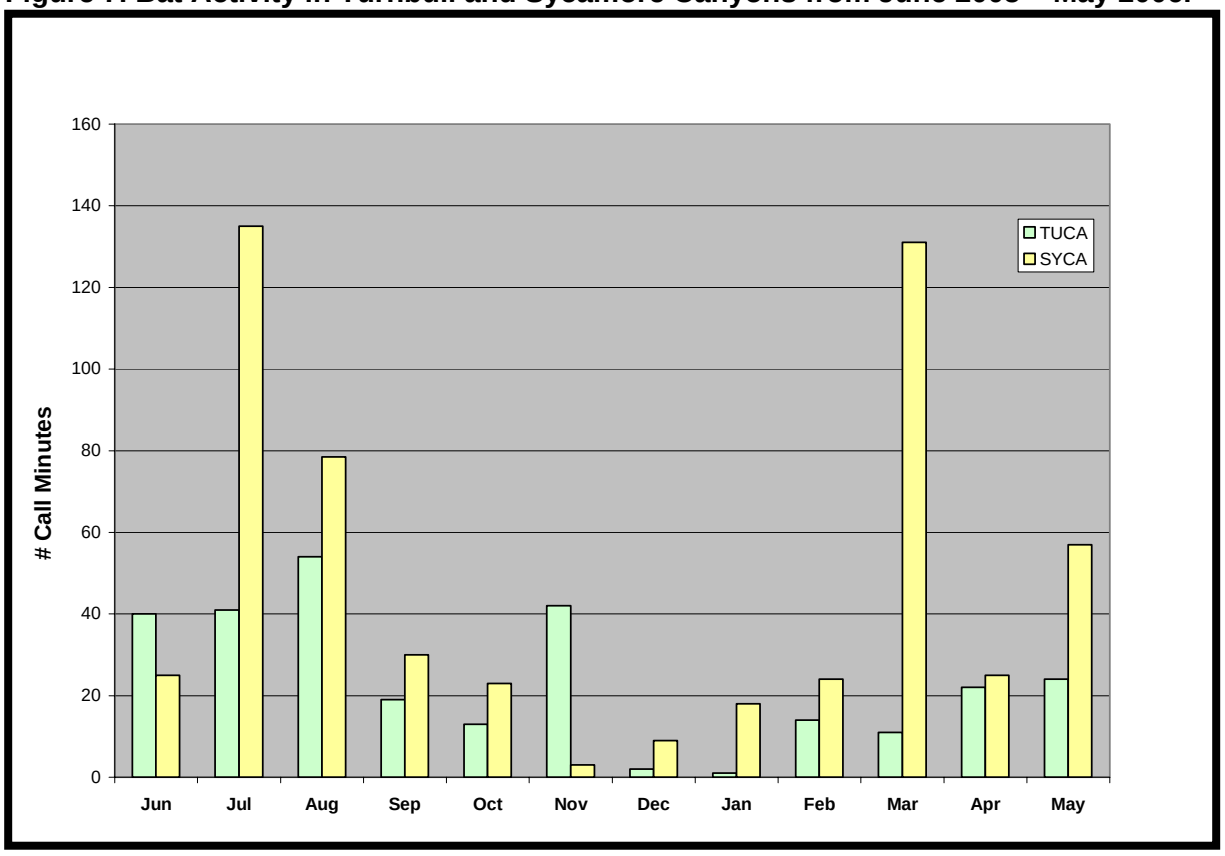


Figure 7. Bat Activity in Turnbull and Sycamore Canyons from June 2005 – May 2006.



SYCAMORE CANYON

Sycamore Canyon is the western-most canyon in the Puente Hills Preserve and is on the immediate urban interface. Its combination of gradual and steep sandstone slopes and native, exotic, and ornamental vegetation is located between the city of Whittier to the west and south, and Rose Hills to the north. Turnbull Canyon is to the east.

At least eight species were recorded in Sycamore Canyon during the survey period, and at least seven of these were detected within the first hour of sunset, indicating that at least some individuals were roosting in the immediate or near vicinity (Table 12). However, the bulk of activity tended to occur during the second and third hour after sunset (Figure 8).

Exceptions to this pattern in March and May 2006 resulted primarily from migratory hoary bats roosting in the creek vegetation and foraging in the general vicinity. Another less dramatic exception in September 2005 was due to briefly concentrated early activity of several species, including hoary bats, red bats, yellow bats, pipistrelles, big brown bats, and Mexican free-tailed bats.

Overall activity levels here were substantially higher than at any other site. At eight acoustic monitoring stations, 559 minutes with calls were logged in 8,508 minutes of sampling. Activity comprised 7% of the total sampling time at this site (Figure 2 and Table 13). Acoustic monitoring stations S2, S6, and S7 were each sampled a single time. All other sites were monitored at least four times and as many as 12 times.

The highest bat activity was recorded at S1, S3, and S4 (Figure 9), the stations where sampling effort was the highest. Activity levels at S3 and S4 would likely have been higher if logistical constraints had not prevented placing detectors more optimally. A substantial amount of activity was observed above the canopy immediately over the sycamore riparian vegetation south of the cliffs below S4 and above the mixed willow riparian and ornamental vegetation at S3. In the first, concentrated foraging activity occurred. In the second, activity was primarily of commuting bats, heading toward the west. The bats above S3 did forage along the way, but most were not observed 'working' the area for extended periods as they did near S4. S7 was located relatively near S4 and had similar activity levels.

Monthly activity was highest in spring and summer, particularly July and March (Figure 8). The majority of summer activity was comprised of big brown bats (*Eptesicus fuscus*) and Mexican free-tailed bats (*Tadarida brasiliensis*), followed by western pipistrelles (*Pipistrellus hesperus*). Late fall and winter activity was consistently low. In winter and spring, migratory hoary bats (*Lasiurus cinereus*) made up the greatest proportion of total activity. Activity peaks in March and May 2006 were largely from this species. *Myotis* species, western red bats (*L. blossevillii*), western yellow bats (*L. xanthinus*), and pocketed free-tailed bats (*Nyctinomops femorosaccus*) were confirmed less frequently.

The least bat activity was recorded at S2 and S6, with two and zero calls recorded, respectively. S2 and S3 were selected during the first month of surveying to see if these stagnant pools of water served as drinking water or foraging area for bats. S3 was maintained for the entire survey period. S2 was dropped after the first survey. No insects were observed at either of these pools or at a larger one below the oil rigs during the survey period; nor were any bats observed foraging over them. The absence of insects at water sources is unusual, but it is unclear what caused this. It may have been sulfur, an oil-related compound, or mosquito treatments.

S6 was the only sampling station within the Sycamore Canyon area located on a ridge.
It is not possible to conclude that S2 and S6 will always, or even usually, have low bat activity based on a single survey. Detections at more frequently-monitored stations are more likely to represent actual activity levels during the survey period, but may or may not predict future activity at the same sites.

Table 12. Bat Diversity in Sycamore Canyon.

Species	2005-06	Roosting
LABL	x	x
LACI	x	x
LAXA	x	x
MY50	x	x
MYCA	P	?
MYYU	P	?
PIHE	x	x
EPFU	x	x
ANPA		
TABR	x	x
NYFE	x	x
EUPE		
Totals	**8 (9)**	**8 (9)**

Figure 8. Bat Activity in Sycamore Canyon for the First Four Hours after Sunset.

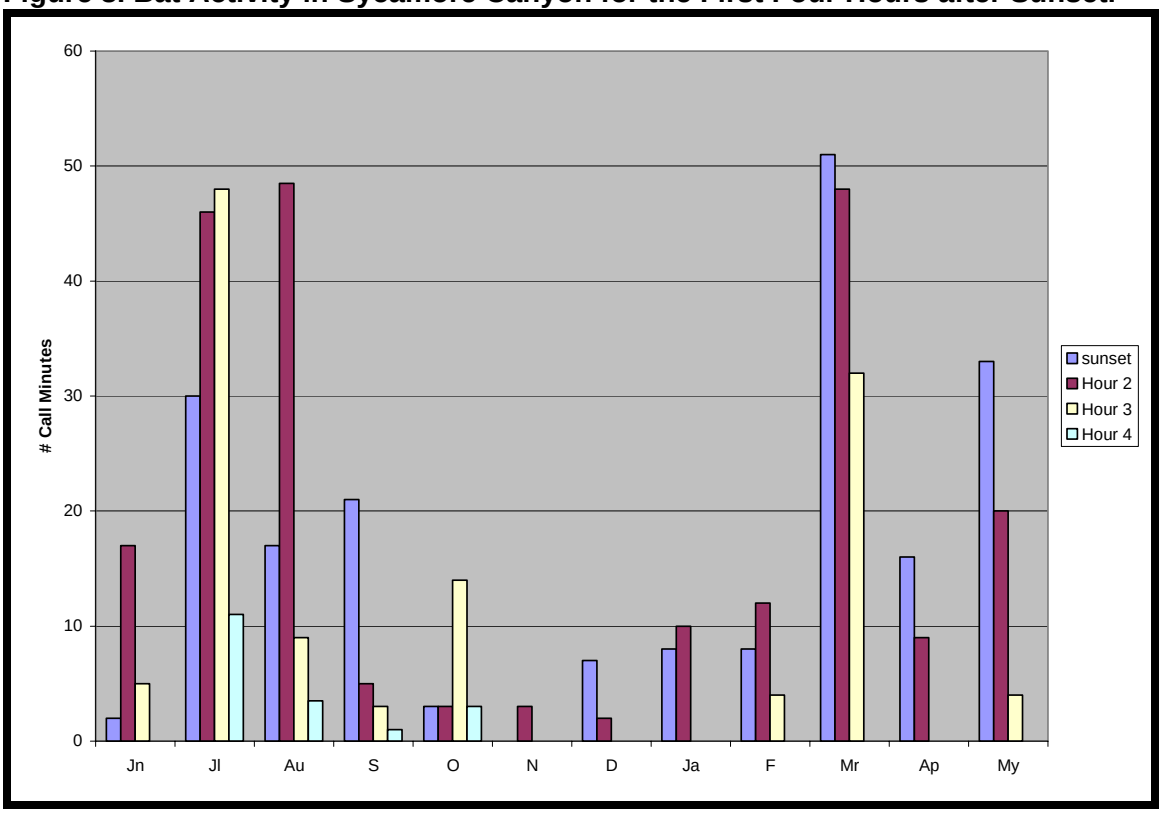
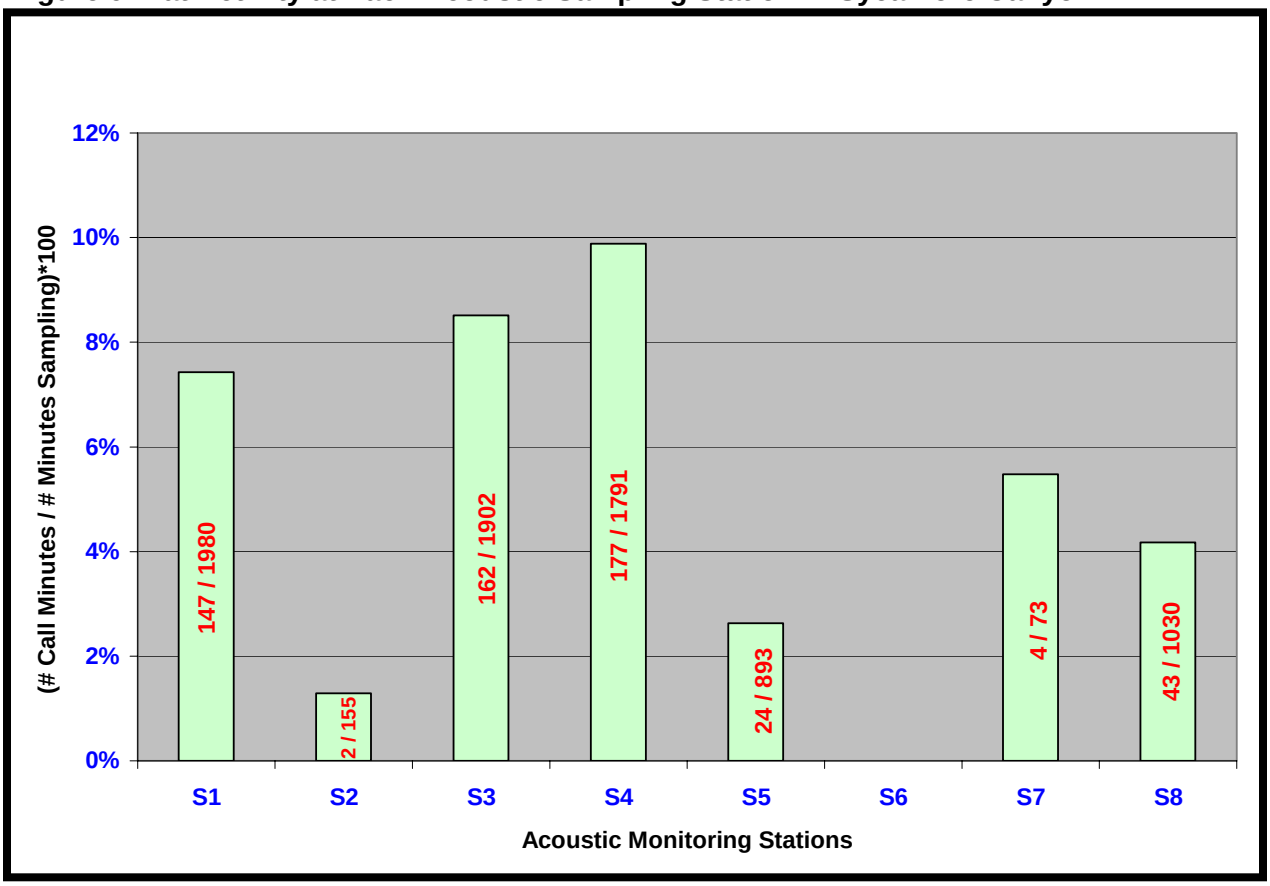


Table 13. Acoustic Sampling Stations in Sycamore Canyon.

#	Northing	Westing	Description	Habitat	# Call Minutes	# Minutes Sampling	% Call Minutes
S1	34.00301	-118.034	End of driveable road	SR, OW, WR	147	1980	7%
S2	34.00361	-118.053	Stagnant water	WR, OW	2	155	1%
S3	34.00337	-118.051	Just east of oil rigs	WR, O	162	1902	9%
S4	34.00323	-118.047	Cinderblock below cliffs	Sc, C	177	1791	10%
S5	34.00181	-118.043	~0.5mi west of S1	SR	24	893	3%
S6	33.99982	-118.043	0.25mi west of helipad	G, Sc	0	684	0%
S7	34.00363	-118.049	West of S4 below cliffs	Sc, C	4	73	5%
S8	34.00371	-118.051	100ft above S3	Sc, WR, O	43	1030	4%
					559	**8508**	**7%**

SR	Sycamore Riparian
OW	Oak Woodland
WR	Willow Riparian
O	Ornamentals
Sc	Scrub
C	Cliffs
G	Grassland

Figure 9. Bat Activity at Each Acoustic Sampling Station in Sycamore Canyon.



TURNBULL CANYON

Turnbull Canyon is located farther from concentrated urban areas than Sycamore Canyon, but its proximity to Turnbull Canyon Road (Figure 2) contributed to its being the most heavily visited site of those sampled in this study. It is the only study site other than Sycamore Canyon with significant sycamore riparian habitat. And, like Sycamore Canyon, it contains a patchy mix of native, exotic, and ornamental vegetation – although not as many ornamentals.

At least eight species were recorded in Turnbull Canyon during the survey period, and at least six of these were detected within the first hour of sunset, indicating that at least some individuals were roosting in the immediate or near vicinity (Table 14). During the summer months – as in Sycamore Canyon – however, most of this activity occurred after the first hour of monitoring (Figure 10).

Mexican free-tailed bats, western pipistrelles, and western red bats – in decreasing order of detection frequency – were confirmed in all seasons in Turnbull Canyon. Big brown bats were commonly detected in summer and early fall, but not confirmed in either winter or spring in this canyon. Hoary bats were detected during all seasons but summer, with the greatest activity levels recorded in spring. Yellow bats were detected during the winter and spring. Pocketed free-tailed bats were confirmed during the summer and fall, and may have occurred year-round (or nearly so) in Turnbull Canyon, but overlap in call structure with hoary bats precluded confirmation in winter and spring.

During the fall, winter, and spring, activity was lower overall, but most often concentrated during the first hour. A dramatic spike of activity (primarily *Tadarida*) occurred just after sunset on 1 November, which was an unusually warm night. During this survey foraging activity was concentrated during the first hour of monitoring and then abruptly died down.

Much of the shift in activity timing toward earlier in the evening appears to have been influenced by the lasiurines – hoary bat, red bat, and yellow bat. Hoary bats, in particular, are not generally present during the summer months, but begin migrating in during the fall and stay through spring. In terms of detections, their peak of activity occurred in spring, with the highest early activity measured in April (Figure 10).

Overall activity was higher here than at any other site except Sycamore Canyon. At eight acoustic monitoring stations, 283 minutes with calls were logged in 7,903 minutes of sampling. Activity comprised 4% of the total sampling time at this site (Table 15).

The highest bat activity was recorded at T1 and T3, respectively, with all other stations detecting levels of activity similar to each other's (Figure 11). Although in Sycamore Canyon the areas with the highest activity were those that received the most sampling effort, in Turnbull Canyon, this was not consistently the case. Sampling effort and activity at T3 were both relatively high. (Table 15 and Figure 11). But only moderate activity levels were detected at T5, where sampling effort was greatest.

Part of this could be due to T5 being place high on a slope where activity tends to be more dispersed than in the canyons, where existing activity may be 'funneled' along corridors.

At the remaining sites, activity and sampling effort more closely paralleled each other. T2, T7, and T8 had low numbers for both measures.

Table 14. Bat Diversity in Turnbull Canyon.

Species	2005-06	Roosting
LABL	x	x
LACI	x	x
LAXA	x	x
MY50	x	
MYCA	P	?
MYYU	x	?
PIHE	x	x
EPFU	x	x
ANPA		
TABR	x	x
NYFE	x	
EUPE		
Totals	8 (9)	8 (9)

Figure 10. Bat Activity in Turnbull Canyon during the First Four Hours after Sunset.

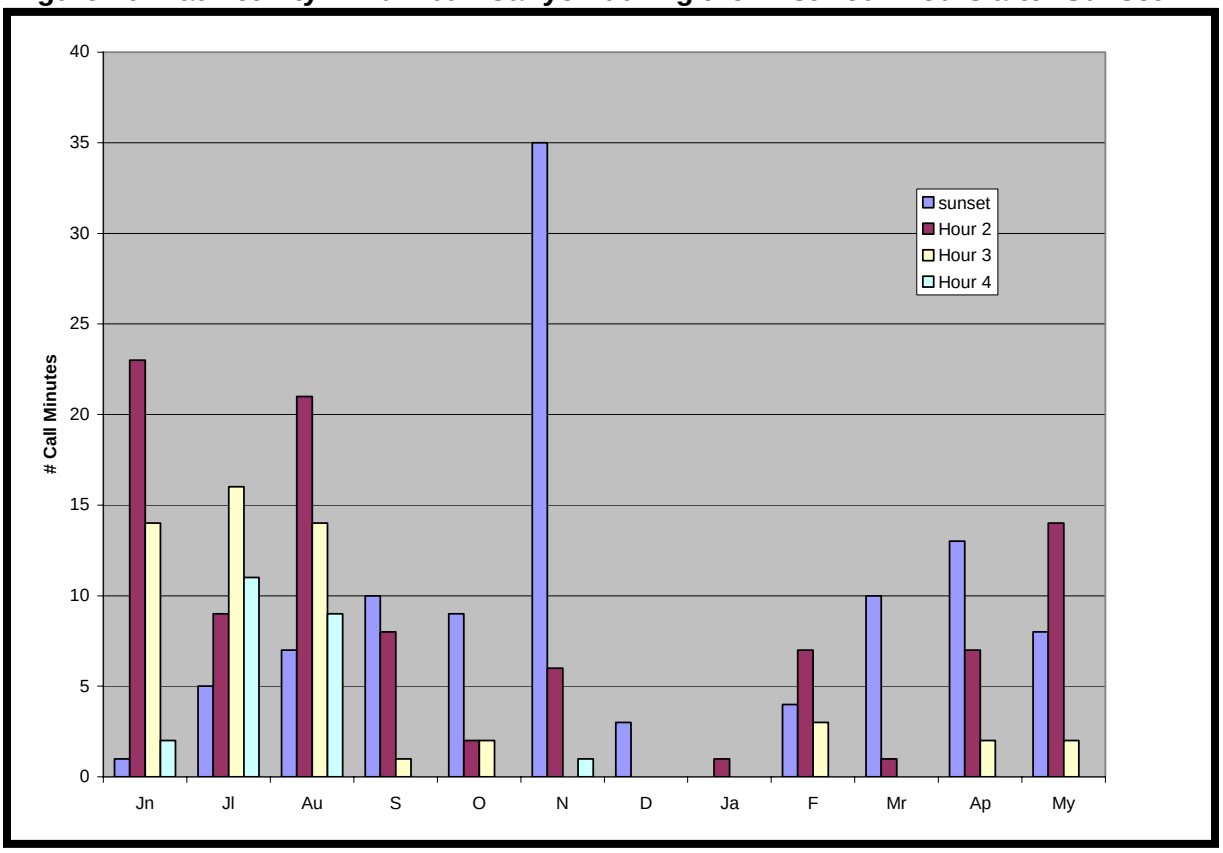
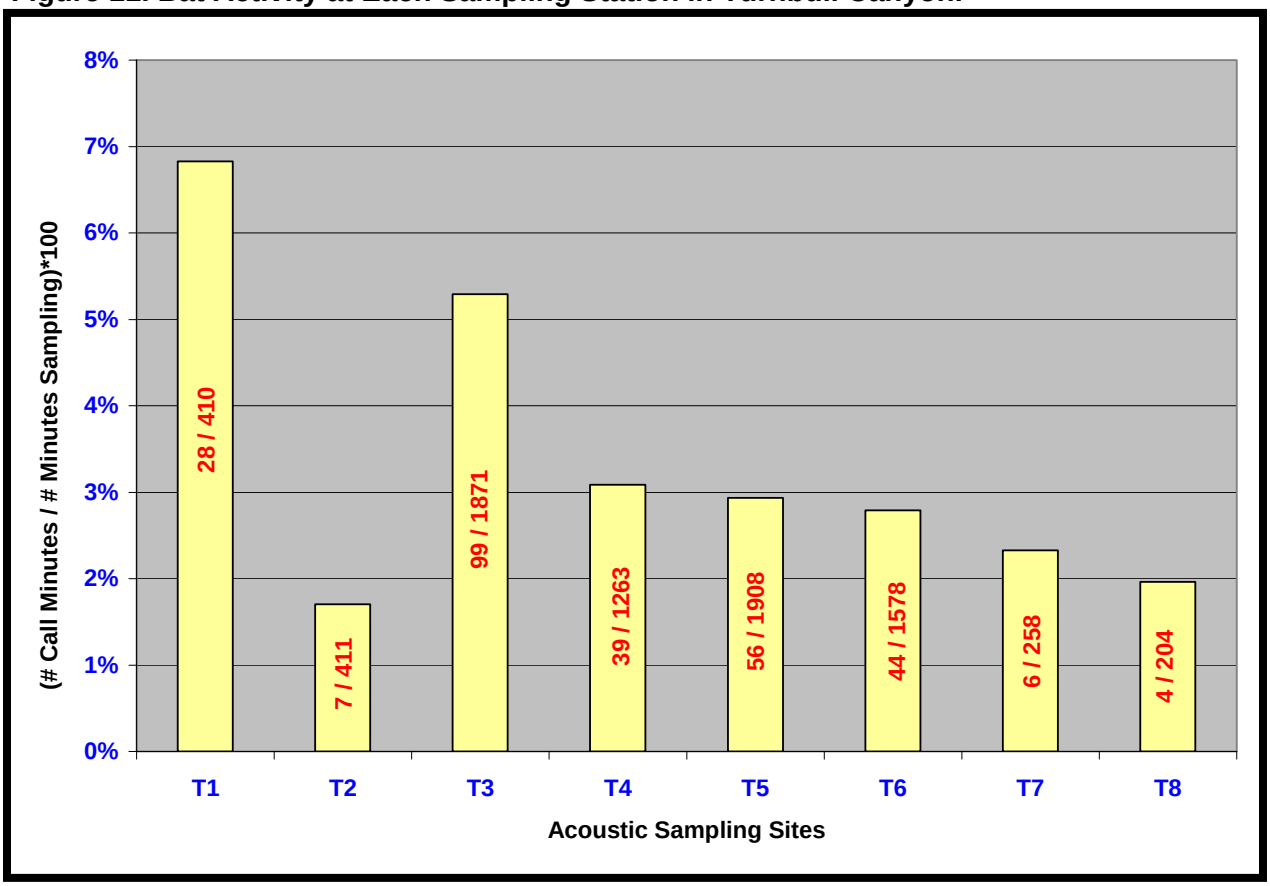


Table 15. Acoustic Sampling Stations in Turnbull Canyon.

#	Northing	Westing	Description	Habitat	# Call Minutes	# Minutes Sampling	% Call Minutes
T1	33.9954	-118.009	Edison Road, 0.3mi east of T3	SR, OW	28	410	7%
T2	33.9958	-118.012	Edison Road, 0.1mi east of T3	SR, OW	7	411	2%
T3	33.9955	-118.014	Fire Road 3 & Edison Access Road	Sc, SR, MR	99	1871	5%
T4	33.995	-118.014	200ft south of T3	SR, G	39	1263	3%
T5	33.998	-118.017	slope below Skyline ridge	Sc	56	1908	3%
T6	33.9954	-118.007	south side of former washout	G, Sc	44	1578	3%
T7	33.996	-118.005	0.5 mi E of T3	G, Sc	6	258	2%
T8	33.9958	-118.011	0.2 mi E of T3	SR, OW	4	204	2%
				Totals	**283**	**7903**	**4%**

SR	Sycamore Riparian
OW	Oak Woodland
MR	Mulefat Riparian
Sc	Scrub
G	Grassland

Figure 11. Bat Activity at Each Sampling Station in Turnbull Canyon.



ARROYO PESCADERO, LA CANADA VERDE, and ARROYO SAN MIGUEL

Arroyo Pescadero and La Cañada Verde
These two sites were considered together in this study. The Arroyo proper was surveyed four times – in July, January, February, and March. La Cañada Verde was monitored from October 2005 through May 2006. Habitat consisted of a combination of mulefat and willow riparian, scrub, exotics, and ornamentals. Topography was variable, including some relatively steep-sided slopes.

Recorded overall activity in both drainages was low, but significant. Five species were identified in the Arroyo and four in La Cañada Verde (Table 11), for a total of seven species in the two areas. The Arroyo was the only site where western mastiff bats were detected. The only species detected early in the evening there was the migratory hoary bat. Western red bats and western yellow bats were both detected in La Cañada Verde, but not in the Arroyo. All four species detected in La Cañada Verde were detected early in the evening and inferred to be roosting nearby.

Table 16. Acoustic Monitoring Stations in Arroyo Pescadero and La Cañada Verde.

#	Northing	Westing	Description	Habitat	# Call Minutes	# Minutes Sampling	% Call Minutes
A1	33.9722	-117.997	north side of washout	WR, Sc	10	799	1%
A2	33.9722	-117.996	east side of washout	WR, Sc	7	504	1%
A3	33.972	-117.996	south side of washout	WR, Sc	7	452	2%
A4	33.9784	-118.008	0.75mi NW of Ranger House	Sc, C	4	1,218	0%
A5	33.9788	-118.006	0.78mi north of Ranger House	Sc, WR	0	462	0%
A6	33.9756	-118.007	0.5 mi north of Ranger House	Sc, MR	15	1,004	1%
A7	33.9777	-118.007	0.7 mi north of Ranger House	Sc, MR	0	319	0%
A8	33.9773	-118.006	in arroyo east of A7	MR, Sc	13	1,049	1%
A9	33.9788	-118.007	west slope above A5	Sc, G	7	459	2%
A10	33.9822	-118.009	slope ~1mi north of Ranger House	Sc, G	0	127	0%
A11	33.9686	-118.002	~50ft west of chain gate	Eu, G	0	134	0%
A12	33.9673	-118.003	500ft west of U1	Eu, G	0	134	0%
A13	33.9684	-118.005	~0.1mi E of Ranger House	G, Eu, Sc	1	146	1%
A14	33.9658	-118.009	~300ft ENE of the Catalina gate	Eu, MR	0	115	0%

WR	Willow Riparian
MR	Mulefat Riparian
Sc	Scrub
G	Grassland
Eu	Eucalyptus
	Arroyo Pescadero
	La Cañada Verde

Arroyo San Miguel
Situated immediately to the south of Arroyo Pescadero, the major separation between these sites is Colima Boulevard. Habitat and topography in both areas are very similar. Six of the seven species detected in the Arroyo Pescadero area were also confirmed in Arroyo San Miguel. Activity was also low, but bats could be seen foraging south over the Arroyo, well out of reach of any site logistically feasible for placing detectors.

POWDER CANYON

By appearances, Powder Canyon would seem to contain excellent foraging habitat for roosting bats. Although at least seven species were detected there, activity was very low. Even the occasional flurries of activity noted in Arroyo Pescadero and Arroyo San Miguel were not recorded in Powder Canyon. The habitat looked particularly good for foraging pallid bats, but none were detected during this study period.

The only two species confirmed early in the evening at this site were the foliage-roosting lasiurines: the hoary bat and western red bat. The latter was confirmed only once.

Several of the oaks and walnut trees looked as though they could provide appropriate roosting habitat, as well, but the paucity of bats at this site, particularly early in the evening, suggests that roosting opportunities may not be adequate for species foraging in the area.

This site also posed several obstacles to monitoring. Human interference, both deliberate and unintentional disrupted recording on several nights. One detector was shot twice with a paintball gun. Three others had recordings obliterated by ambient electronic noise. A fifth was flipped upside down (in defense of human visitors, this may have been done by a coyote). And one survey had to be halted early due to unpredicted rain.

The Fan property and Schabarum Park, to the south and north – respectively – of Powder Canyon, also had very low activity on the single night each was surveyed.

It is probable that without interference, detections would have been higher. But the consistent low activity at unimpeded detectors in Powder Canyon and surrounding areas suggests that appropriate roosting habitat may be in short supply, available forage may be inadequate, or both.

MINOR SITES

Ecology Canyon, on the Rio Hondo College Campus, and the Gibson House were each surveyed once during the summer. The Hacienda Heights area was surveyed on two separate nights, once each in the summer and spring.

Ecology Canyon had low, but regular, bat activity on the night it was surveyed. Two species were confirmed: the Mexican free-tailed bat and the western red bat. The former was detected early in the evening and presumed to be roosting nearby.

Two species were confirmed at the Gibson House – Mexican free-tailed bats and big brown bats – both later in the evening.

Calls recorded on both surveys of Hacienda Heights were fragmentary and inadequate for confirming species. Species that could potentially have produced the calls include Mexican free-tailed bat, big brown bat, hoary bat, and Myotis species.

CONCLUSIONS

The land managed by the Habitat Authority has an impressive diversity of bat species given its relatively isolated condition and proximity to the urban interface. Numbers of individuals, however, did not appear to be high at any site at dusk, nor were the activity levels of those detected consistently high.

Low numbers of individuals observed may be due to a limited number of available roost sites on the Puente Hills Preserve. Or it could be that some bats are roosting in the surrounding neighborhoods and arriving later to forage. Few bat species tolerate human proximity, but Mexican free-tailed bats, big brown bats, and Yuma Myotis are known to frequently roost in human-made structures. Bats that are able to adapt to human presence often become targets of vandalism and extermination efforts. Bats roosting in neighboring communities likely have unstable roosting situations.

The low overall bat activity at survey sites likely reflects a variety of factors related to one main issue – available forage. Except in some areas of Sycamore Canyon and Arroyo San Miguel, bat activity did not appear to be consistently concentrated in any particular location, and existing activity was generally high above ground level where calls were less easily detected by the Anabats – or out of their range entirely. This indicates both a dispersed insect population and a paucity of insects below canopy level.

The reasons for this could relate to natural conditions, such as water quality or availability. It could be due to the unintentional suppression of the non-mosquito prey base from mosquito abatement programs. It could reflect a tendency of bats to forage later in the evening when detectors were generally not operating. Or it could be due to some combination of these and additional factors, such as environmental temperatures or air flow patterns.

In Sycamore Canyon, where open water exists year-round, the complete lack of insects in or near them indicates a problem with the water quality. Mosquito treatment may also be an issue here. At Hacienda Heights, only two bat calls were recorded in spring high above a temporary pond formed by seasonal rains. Insect activity around the pond was minimal and the timing of bat activity did not indicate the existence of nearby roosts.

Running water below vegetation at Arroyo Pescadero, Arroyo San Miguel, and La Cañada Verde generally did not have large numbers of insects associated with it either.

Due to the risk of theft and vandalism, Anabats were deployed overnight only a handful of times, and all-night recordings tended to be disturbed by electronic or other ambient noise. At the few survey sites where detectors could be securely deployed all night, none of the recordings revealed high levels of activity later in the evening. However, successful all-night recordings occurred too infrequently to draw conclusions about late night activity patterns.

The above issues can be addressed in the following ways:

1) Install and manage new water sources.
2) Monitor and control illegal human entry.
3) Construct and install alternative bat roosts.
4) Monitor bat and insect activity over the long term.
5) Implement cooperative agreements with agencies potentially impacting bat habitat.
6) Expand public education programs to include bat ecology and natural history.

MANAGEMENT RECOMMENDATIONS

Water Sources

Bat foraging habitat can be enhanced by providing good quality drinking sources. Filling existing stock tanks can be helpful at any time, and may be vital during drought years. During the summer months when water sources are drying up, lactating female bats often return to the roost multiple times a night to nurse young (pers. obs.). During the drought, successfully raising young may have been energetically unfeasible in some areas of Orange County due to the distances involved combined with reduced forage. This was likely the case in southern L.A. County as well. Providing additional water sources during this period of high energetic demand could decrease the distance from roost to water sources and provide concentrated sources of insects.

If tanks are placed in habitat restoration sites and/or in areas that will drain naturally into creeks, mosquito abatement concerns can be addressed by regularly emptying and refilling tanks, and using the water to irrigate restoration plots.

Access

Impacts on roosting sites from activities related to illegal entry are unknown, but potentially a major problem if bat boxes are placed at sites that are regularly vandalized. The two sites with the most illegal entry were Turnbull and Powder Canyons.

In Turnbull Canyon, late night trespassers consisted primarily of cyclists and vandals. No roosts were discovered at either of these sites, and impacts from either of these two groups are unknown. Of the two groups, the vandals would be the most likely to discover and harm any roosting bats in the area, especially those attracted to bat boxes placed onsite. Bats most at risk would be any flightless young roosting in the vicinity of the water tank at the intersection of Fire Road 3 and the Edison access road, where spray-painting is concentrated.

At Powder Canyon, observed after-dark trespassers included adventure-seeking teenagers, an intoxicated adult, and a vandal shooting a paintball gun. As at Turnbull Canyon, the impacts of illegal visitation on roosting bats are unknown, and the biggest potential threats to roosting bats would be at highly visible bat boxes.

Roosting Habitat

Bat boxes placed on Habitat Authority lands where the threat of vandalism is low could increase local bat populations, especially if colonies roosting in neighboring communities face regular disturbance or extermination.

Big brown bats, Mexican free-tailed bats, and Yuma myotis are known to use bat boxes. If illegal entry could be controlled, Turnbull Canyon would be a good site to place bat boxes because existing activity includes relatively high, although inconsistent, activity of all three species known to use them. Based on current human visitation, boxes would be most secure in Sycamore Canyon, Arroyo San Miguel, and La Cañada Verde.

Bat houses are most successfully occupied when they are placed near a site where bats are losing their roost due to eviction, construction, or other activities. Residents wanting to exclude bats could coordinate the timing so that the Habitat Authority could construct and install bat houses in advance near the exclusion site.

Monitoring
Impacts to bat populations can best be assessed over a period of years of monitoring. Anabat detectors can be deployed passively for months or years at a stretch. Each unit can be modified to include weather-proofing, weather sensors, and solar panels, so that the timing of incoming calls can be correlated with temperature, relative humidity, and wind speed. Calls can be regularly downloaded and basic information about bat activity can be assessed by Habitat Authority personnel who have received training in using the system. Species identification of acoustic data must be done by biologists experienced with the Anabat system. However, some information about frequency range can be used by personnel with less extensive training to sort calls into groups of species.

Widespread and abundant species tend to get neglected in wildlife surveys when rare species are the focus. But monitoring populations of Big Brown Bats (*Eptesicus fuscus*) and Mexican Free-tailed bats (*Tadarida brasiliensis*) can provide an early warning system for other species if declines are detected. Lumping calls within a particular frequency range could enable estimates of the relative input of these two species – and of hoary bats – to overall activity levels.

Monitoring insect abundance and bat activity concurrently would further help evaluate fluctuations in bat activity. Evaluating insect diversity – even to the level of order – is much more difficult. However, these types of data combined with long-term acoustic data, would help fill in big gaps in knowledge about bat diet and foraging habitat requirements.

Sycamore Canyon and Arroyo San Miguel are the two most appropriate sites for deploying passive, long-term detectors. Both sites had very little human visitation and had substantial activity over riparian vegetation. Mounting the detectors on tall posts reaching near the canopy would allow better detection of bats foraging regularly over riparian corridors.

Interagency Management
Cooperative agreements between the Habitat Authority and other agencies working on the property could minimize inadvertent negative impacts to bat populations from road work, vegetation modification, hazard reduction, and mosquito abatement programs.

Advance notice of the onset and duration of work, as well as materials to be used would be extremely helpful in reducing potential impacts to roosting and foraging bats.

Projects impacting vegetation should be monitored to ensure that large trees and limbs are left intact whenever possible. This is important to avoid impacts to roosting bats during maternity season, but also to lasiurines during migration. Planned removal of large areas of vegetation should, whenever feasible, be done in phases and include re-vegetation before or immediately after clearing to minimize declines of insect populations.

Knowing when mosquito abatement is planned, whether treatment will involve larvacides or adultacides, and how much of either will be applied is important in evaluating potential decreases in the prey base.

Public Education
Increased knowledge of bat biology and behavior has a dramatic affect on popular attitudes toward bats. Public outreach directed at homeowners living on the border of Habitat Authority lands could encourage 1) communication about bat sightings, 2) reporting of bats roosting in roofs and attics, 3) volunteering to monitor bat houses, and 4) building of a local community receptive to sharing the environment with bats.

SPECIES ACCOUNTS

Twenty-four of California's 25 bat species occur in the south coast ecoregion, and 11 of these are known to occur in the Puente Hills (Table 17). 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 and one has never been found in the county.

Table 17. Species Status.

FAMILY/SPECIES	COMMON NAME	LISTING STATUS	WBWG	M & S
Vespertilionidae	**Evening bats**			
Myotis californicus	California myotis	none	●	◇
Myotis yumanensis	Yuma myotis	FSC, BLM	●	◇
Pipistrellus hesperus	Western pipistrelle	none	●	◇
Eptesicus fuscus	Big brown bat	none	●	◇
Lasiurus blossevillii	Red bat	CSC*, FSS	●	◇
Lasiurus cinereus	Hoary bat	none	●	◇
Lasiurus xanthinus	Western yellow bat	CSC*	●	◇
Antrozous pallidus	Pallid bat	CSC, FSS, BLM	●	◇
Molossidae	**Free-tailed bats**			
Tadarida brasiliensis	Mexican free-tailed bat	none	●	◇
Nyctinomops femorosaccus	Pocketed free-tailed bat	CSC2	●	◇
Eumops perotis californicus	Western mastiff bat	CSC2, FSC, BLM	●	◇

Key to Symbols and Acronyms

A = Abundant C = Common U = Uncommon R = Rare X = present, status unknown

1940s status from Krutzsch 1948

Western Bat Working Group (WBWG) priority*

- ● High
- ● Medium
- ● Low

* For funding, planning, and conservation

SCE (South Coast Ecoregion)

- ◇ Records indicate a serious population decline in the ecoregion
- ◇ Stable but uncommon or rare
- ◇ Stable and common
- ◇ Increasing population
- ◇ Stability potentially imperiled by urbanization
- ◇ Status unknown due to insufficient data

Shaded = roosting habitat

Blue = multiple habitat	Yellow = cave roosting
Purple = cliff roosting	Green = foliage roosting

California Species of Concern (CSC, Department of Fish and Game)

Western red bat (*Lasiurus blossevillii*)
The western red bat is a solitary, migratory, foliage-roosting species that relies heavily on intact, mature sycamore and cottonwood riparian habitat for both roosting and foraging (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 creation of water storage reservoirs can result in a double loss for the species.

For species such as the red bat and California myotis (*Myotis californicus*), who rely on intact habitat at the lower elevations in the south coast ecoregion, extensive habitat loss in this zone is believed to have resulted in population declines, although not enough information exists on either species to make a determination (Miner and Stokes 2003). The former has been proposed as a Species of Special Concern by the California Department of Fish and Game (Table 1), but more information is needed at lower elevations in the winter and summer to determine its population status (Miner and Stokes 2003).

Data from the early 20th century indicated that red bats were probably migratory in southern California, but Krutzsch (1948) found both sexes to be common year round. It is no longer common at any time of the year. Major threats to the species are loss of riparian habitat and use of pesticides. Evidence of this species breeding in San Diego County has surfaced within the last five years. A female bat with quadruplets was submitted for rehabilitation in July 1999 in San Diego County (C.E. Shriver, pers. comm.). All five died of suspected pesticide poisoning. 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. Broad-leafed trees and orchards of avocado, apricots, and citrus were used most often as day roosts, and other trees and shrubs with foliage that was sufficiently dense to provide suitable hiding places were also used in areas where the favored tree species were not available. Red bats vary their roosting trees, so identification of a single roost tree is not possible.

This species was detected during 10 months and at six sites (Tables 10 & 11). Near dusk, it was most consistently detected in Turnbull Canyon. The timing of detections indicates that this species both roosts and forages in Turnbull Canyon. Specific roost trees were not identified. Red bats' habit of switching roost trees makes it difficult to identify specific roost trees without the aid of radio-telemetry; protecting roost trees requires protecting available roosting habitat. This species roosts and forages extensively in sycamore and cottonwood riparian habitat.

Pallid bat (*Antrozous pallidus*)
Pallid bats are primarily insectivores, feeding on a wide variety of large arthropod prey that they typically capture on or near the ground (Hermanson and O'Shea 1983). They are generalists in their roosting requirements – using of a variety of structures, including rock crevices, tree hollows, mines, caves, and human structures (Sherwin 1998b).

Krutzsch (1948) found them to be widely and commonly distributed in San Diego County west of the mountains – roosting in colonies of up to several hundred individuals, and Vaughn (1954) considered them the most common and characteristic bat of the citrus belt at the Pacific base of

the San Gabriel Mountains. However, they are intolerant of human disturbance and threatened by roost damage and destruction (Sherwin 1998).

Orange County Public Health records from the 1980s and 1990s indicate this species is declining locally (Remington 2000). Miner and Stokes (2003), in compiling data from studies for the south coast ecoregion, found evidence of dramatic population declines in *Antrozous*, and suggested that their populations could be seriously threatened due to roosting and foraging habitat loss and colony extermination, especially at lower elevations. They are classified as California Species of Special Concern, as well as Sensitive by the U.S. Forest Service and Bureau of Land Management (Table 1). Pallid bats were detected in the eastern Puente Hills during the 2004 surveys, and Powder Canyon contains appropriate foraging habitat for this species. But they were not detected at any site during this study. Potential causes are a shortage of roosting habitat, a depressed prey base, or very low population size that eluded detection.

Pocketed free-tailed bat (*Nyctinomops femorosaccus*)
The pocketed free-tailed bat is a colonial, crevice-dwelling species found in a variety of habitats, but usually associated with high cliffs and rugged rock outcrops where they roost during the day (Barbour and Davis 1969, Krutzsch 1948, Navo 1998). Krutzsch (1948) found them from the foothills to the desert in San Diego County, once sharing a roost with *Eumops perotis*. Colony sizes usually number fewer than100 individuals and they typically do not leave the roost until well after dark (Barbour and Davis 1969, Krutzsch 1948). Pocketed free-tailed bats were confirmed at three sites during four months. It likely occurred more widely and often, but overlap in call structure with hoary bats precluded confirmation in some instances.

Western mastiff bat (*Eumops perotis*)
E. perotis is a California Species of Special Concern and a Federal Species of Concern (Table 1). It is a colonial, cliff-roosting species whose distribution is restricted mostly to areas where there are significant rock features offering suitable roosting habitat. Major threats to the species are urban expansion and activities that disturb or destroy cliff habitat (Pierson 1998). Roosts of this species are usually within crevices high above the ground, and maternity colonies may consist of 30 to several hundred bats (fewer than 100 is more typical) (Pierson 1998). The NIRLR contains an abundance of potential roosting habitat.

In California, *Eumops* is most frequently encountered acoustically as it forages over open areas, such as oak woodland, chaparral, grassland, and agricultural areas (Pierson 1998). The species is a fast-flying moth specialist (although its diet includes a variety of other insects) that typically emerges relatively late in the evening, can cover an extensive area, and can be detected throughout the night (Krutzsch 1948; pers. obs.). Unlike other bat species that hibernate through the cold season, this species is active periodically throughout the year in San Diego County (Krutzsch 1948, D. Stokes, pers. comm.). Orange County Public Health Agency winter records of human-bat encounters support this observation.

The species was detected audibly and recorded several times at Arroyo Pescadero on a single survey in July, but was not detected at any other site or during any other month. July was the only summer month during which Arroyo Pescadero was surveyed. This was the only species (of those confirmed during this study) that was not detected at least once early in the evening.

Western yellow bat (*Lasiurus xanthinus*)
This species foliage roosting species was not found by Krutzsch (1948) in the 1930s and 40s, but in recent years it has become regularly encountered in some urban areas of the south coast

ecoregion, primarily associated with planted palm trees (Miner and Stokes, 2003). It is commonly known to roost underneath palm fronds (Bolster 1998), but P. Brown (pers. comm.) radio-tracked an individual to a cottonwood tree on the Bill Williams river, and this species may roost in other trees, as well. This species was detected at five sites during five months of the survey period (Tables 10 and 11). It was detected at dusk at four sites, all with palm trees. One individual was observed in Arroyo San Miguel at dusk near two palm trees.

Species in Need of Monitoring to Determine Status (Western Bat Working Group)

Hoary bat (*Lasiurus cinereus*)

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 (Barbour and Davis 1969, Krutzsch 1948). This species has not been designated as a State or Federal Species of Concern but has been identified by the WBWG as a "medium" priority species. This means that the species is considered in need of greater research and conservation actions. This is particularly important in Orange County, where its occurrence is only ¼ of what is was in the 1980s. The drop in population of this obligate tree-roosting species is probably due to roosting habitat loss. 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). Since hoary bats are primarily encountered in the winter in Orange and San Diego Counties (Krutzsch 1948, Remington 2000, D. Stokes, pers. comm.) fieldwork conducted primarily in the summer will miss them entirely. Hoary bats were detected at seven of the sites and in every month but June and July (Table 11 and Table 18), and were the most commonly detected species in during the winter and early spring months of the survey period.

Orange County Public Health records indicate that hoary bats (*Lasiurus cinereus*) 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.

Table 18. Hoary Bat Detections in the Puente Hills from June 2005 through May 2006.

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
TUCA						R			X	R	R	R
SYCA				R	R	X	R	R	R	R	R	R
POCA				R	X	R					X	R
CAVE						R		X	R	R	X	R
ARSM					R			R	R		R	?

Key to Symbols
X = present
R = roosting nearby
Shaded = no survey

Peak Activity

Common Species

Big brown bat (*Eptesicus fuscus*)

Big brown bats were very commonly detected during the spring, summer, and early fall at all of the major sites except La Cañada Verde. They are colonial generalists in both roosting and foraging habits. *Eptesicus* was detected early in the evening at Turnbull and Sycamore Canyons and on the Fan Property. And although this species is known throughout North

America to be highly urban-adapted, in Orange County it does not persist in most urban areas, except on the fringes (Remington 2000). Even in good quality habitat that is isolated by urbanization, this species is less common than in similar habitat that is more extensive (pers. obs). Because of this species' hardiness and generalist habits in roosting and foraging, it is important to monitor and should be considered an indicator of overall habitat health – long term declines can signal serious problems with habitat.

Western pipistrelle (*Pipistrellus hesperus*)
This is the only "common" species on this list that is not a generalist in its roosting habits. And, in fact, it is only locally common. It is associated with rocky outcrops and cliff habitat for roosting (Brown, 1998) and was detected only in Sycamore and Turnbull Canyons, most commonly in the former. This species was active virtually year-round in the Puente Hills Preserve, although at much lower levels during the winter.

Yuma myotis (*Myotis yumanensis*)
This species specializes in the capture of emergent insect prey from water surfaces. Its distribution is associated with the availability of permanent water sources (Bogan et al., 1998), but it also forages higher in the canopy of various types of riparian vegetation (pers. obs.). The Yuma bat is one of two species that is relatively common in urban Orange and San Diego Counties (pers. obs., D. Stokes, pers. comm.) and may be more common in the Whittier Hills than the number of detections would indicate. The relatively low detection rate could be due to detectability bias, a slow recovery after the drought, depression of the prey base due to aggressive mosquito abatement programs, or some combination of these factors.

Generally, *Myotis* species are more difficult to detect acoustically than either *Eptesicus* or *Tadarida*, so, although acoustic activity of 50kHz *Myotis* were lower than expected, it could be due to factors relating to acoustics as well as a possible decline in numbers of these species. *M. yumanensis* was confirmed in low numbers at six sites, primarily in July and October (Table 10 and Table 11).

California myotis (*Myotis californicus*)
Although this species is not assigned any special legal status, it appears to rely on intact wooded habitat at the lower elevations – an increasingly rare commodity in southern California. In Orange County it persists in undeveloped areas up to the urban edges. This species was not confirmed due to acoustic overlap with M. yumanensis, but calls potentially of this species were recorded at six sites (Table 11).

Mexican free-tailed bat (*Tadarida brasiliensis*)
Tadarida is the second of the two common bat species in the Puente Hills Preserve. Another generalist in roosting habits – using both natural and human-constructed structures, it is considered a moth specialist, but feeds highly opportunistically. During insect emergences it is common to acoustically detect feeding by this species. Mexican free-tailed bats commonly over-winter in southern California (D. Stokes, pers. comm., pers. obs.) and appeared to be active virtually year-round in the Puente Hills Preserve, but at lower levels during the winter months. *Tadarida* was confirmed at all sites except the Hacienda Hills pair, and in nearly all months (unconfirmed in December and January). From the timing of the detections, it was determined to be day roosting during at least one month at five of the 12 sites (Table 11). In Turnbull and Sycamore Canyons, they were detected early in the evening during most of the spring and summer months.

LITERATURE CITED:

Ball, L. C. 2002. A strategy for describing and monitoring bat habitat. Journal of Wildlife Management 66 (4): 1148-1153.

Bat Conservation International. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, Mexican free-tailed bat (*Tadarida brasiliensis*). February 9-13, 1998, Reno, Nevada.

Bolster, B. C. 1998. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, big brown bat (*Eptesicus fuscus*). February 9-13, 1998, Reno, Nevada.

Brown, P.E., R.D. Berry, and Harmsworth Associates. 2001. Bats in the North Ranch Policy Plan Area, Orange County, California. Report prepared for the United States Fish and Wildlife Service, California Department of Fish and Game, and the Irvine Company. 36 pp.

Fenton, M. B. 1984. Echolocation: Implications for ecology and evolution of bats. The Quarterly Review of Biology, 59:33-53.

Fenton, M. B. 1988. Detecting, recording, and analyzing vocalizations of bats. Pp. 91-104, *in* Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Johnston, D. S. 1996. Foraging flexibility in two populations of pallid bats (*Antrozous pallidus*). Paper presented at the 26th Annual North American Symposium on Bat Research. Illinois Wesleyan University, Bloomington, Illinois, October 23-26, 1996.

Krutzsch, P. H. 1948. Ecological study of the bats of San Diego County, California. Master's Thesis, San Diego State University, California.

Kunz, T. H. 1973. Resource utilization: temporal and spatial components of bat activity in central Iowa. Journal of Mammalogy, 54:32.

Miner, K.L. and D.C. Stokes. 2003. Bats in the South Coast Ecoregion: Status, Conservation Issues, and Research Needs. USDA Forest Service Gen. Tech. Rep. PSW-GTR-xxx. 2003.

O'Farrell, M. J., and W. G. Bradly. 1970. Activity patterns over a desert spring. Journal of Mammalogy, 51:18-26.

O'Farrell, M. J., and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy, 80:24-30.

Pierson, E. D. 1993. Survey protocols for California bats. Wildlife Society, Monterey, California.26 February 1993.

Pierson, E. D. 1998. Tall trees, deep holes, and scarred landscapes. Conservation

Biology of North American bats. Pp. 309-325, *in* Bat biology and conservation (T. H. Kunz and P. A. Racey eds.). Smithsonian Institution Press, Washington and London.

Pierson, E.D., M.C. Wackenhut, J.S. Altenbach, P. Bradley, P. Call, D.L. Genter, C.E. Harris, B.L. Keller, B. Lengus, L. Lewis, B. Luce, K.W. Navo, J.M. Perkins, S. Smith, and L. Welch. 1999. Species conservation assessment and strategy for Townsend's big-eared bat (Corynorhinus townsendii pallescens). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise Idaho.

Remington, S. 2000. The distribution and diversity of bats in Orange County, California. Pomona: Calif. State Polytechnic Univ. 114 p. M.S. thesis.

Rainey, W. E. 1995. Tools for low-disturbance monitoring of bat activity. Pp. 62-71 *in* Inactive mines as bat habitat: guidelines for research, survey, monitoring and mine management in Nevada. Biological Research Center, University of Nevada, Reno.

Sherwin, R. 1998a. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, Townsend's big-eared bat (*Corynorhinus townsendii*). February 9-13, 1998, Reno, Nevada.

Sherwin, R. 1998b. Proceedings of the Western Bat Working Group workshop on ecology, conservation and management of western bat species – species accounts, pallid bat (*Antrozous pallidus*). February 9-13, 1998, Reno, Nevada.

Thomas, D. W., and R. K. LaVal. 1988. Survey and census methods. Pp. 77-89, *in* Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, D.C.

Vonhof, M. J. and M. R. Barclay. 1996. Roost-site selection and roosting ecology of forest-dwelling bats in southern British Columbia. Canadian Journal of Zoology, 74:1797-1805.