BAT USE OF THE GIANT SEQUOIA GROVES IN YOSEMITE NATIONAL PARK

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Eptesicus fuscus (W. Rainey)

EXECUTIVE SUMMARY

Fourteen of the 18 bat species known to occur in Yosemite National Park were detected in the giant sequoia groves (eight by capture, and six by acoustic records). Five had reproductive populations in the groves. The most frequently encountered species in the Mariposa Grove was the big brown bat, *Eptesicus fuscus*, and in the Merced Grove, the fringed myotis, *Myotis thysanodes*.

Guano traps were installed inside basal hollows of 27 giant sequoia trees in the Mariposa Grove and in 8 giant sequoia trees and one incense cedar in the Merced Grove. These traps were monitored from May through October in 2000 and 2001 to assess bat use of the trees. In August 2000 we observed carpenter ants harvesting guano from traps and experiments confirmed rapid ant removal of guano baits. Ant barrier devices installed on the traps for 2001 largely eliminated these losses.

Guano trap data showed that all monitored trees in both the Mariposa and Merced Groves were used by bats, although the extent of use and seasonal patterns of use varied greatly among the trees. Certain trees appeared to be highly preferred by the bats. Patterns of guano deposition varied from tree to tree, and did not follow a predictable seasonal pattern. Nevertheless, overall bat use of the trees increased from early June to late July, and then declined through the end of September; the peak activity in late July coinciding with the time that newly flying young enter the population.

Temperature monitors were installed in basal hollows in 7 trees in the Mariposa Grove and two trees in the Merced Grove and operated through two winters. The resulting temperature profiles showed that temperatures deep in these hollows were very stable and remained above freezing all winter, despite below freezing ambient temperatures. The temperatures of these hollows match documented temperature ranges for many bat hibernacula, so we hypothesize that these tree hollows are used as hibernating sites by bats.

Using a radio-linked detector on a helium balloon, we monitored bat acoustic activity at 67 m above the ground in the Upper Mariposa Grove. Simultaneous data from the lower canopy and ground levels revealed different levels of bat activity and different species, and were consistent with studies elsewhere showing that the canopy provides important if rarely sampled foraging habitat.

We radio-tracked 16 bats of five species (10 *Eptesicus fuscus*, 2 *Lasionycteris noctivagans*, 2 *Myotis volans,* 1 *Myotis thysanodes*, 1 *Antrozous pallidus*) in late summer 2001. We located a total of 32 roosts for 15 individuals. The 32 roost sites were distributed among four tree species (six in ponderosa pines, thirteen in sugar pines, seven in giant sequoias, three in white firs) and three roosts in the rock-outcrop area below Wawona Point. The only tree that was used by more than one radio-tagged individual was the giant sequoia known as the Sunset Tree.

Although white fir, *A. concolor*, is numerically dominant in the grove, comprising over 70 % of the trees, it was used only about 10% of the time by the bats. Incense cedar (*C. decurrens*), the third most abundant tree species in the grove was not used by any of the bats. The other three

species, sugar pine (*P. lambertiana*), ponderosa pine (*P. ponderosa*), and the giant sequoia (*S. giganteum*), were all used significantly more than expected based on their numerical abundance in the plots.

Roost switching occurred for the four species for which we identified roosts. The degree of roost switching was extremely variable among individuals. On average bats spent 2.15 +/- 0.36 days in a roost (range 1-10, *n* = 32) and the average number of roosts per bat was 2.06 +/- 0.37 (range 1-6, *n* = 16). In general, when a bat changed roosts, it selected a roost that was within an average of 0.19 km of its previous roost (range = 0.02-0.78 km, *n* =17).

We also sampled bat activity within the groves acoustically. In the Mariposa Grove we used five stations in five habitat categories (creek, seep, meadow, rock outcrop, and road edge), which were sampled simultaneously for a total of 18 nights between May and September. On each sampling night, we also monitored an additional three or four sites in one of the habitat categories. This allowed us to compare night-to-night variation with site-to-site variation for each habitat category. More bats were detected at the creek than in any other habitat category, but some of the rarer species, which were of greatest interest, were more likely to be detected in other areas, particularly the meadow or rock outcrop. More limited acoustic surveys were also conducted in the Merced and Tuolumne Groves, and suggested some differences in relative abundance of some species in the different groves. Two species, *Lasiurus blossevillii* and *Pipistrellus hesperus* were detected only in the Mariposa Grove.

Management recommendations emerging from this study include visitor guidelines that discourage entry into the basal hollows of the giant sequoias and minimize damage to the landscape around the giant sequoia trees (*e.g.*, water sources and meadows). The information obtained in the radio-tracking study highlighted the importance of mid to late stage snags (particularly sugar and ponderosa pine) as roost trees, suggesting that stringent safety criteria should be applied and trees evaluated for bat use prior to removal.

Additional research suggested by this project would be a more focused study of the use of giant sequoias as hibernating sites, and a more extensive study of roost preferences for tree-dwelling species in other areas of the park.

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1.0 INTRODUCTION

Recent bat research in Yosemite National Park has focused on inventory surveys (Pierson and Rainey 1993, 1995), studies on roosting behavior of two obligate cliff-roosting species (Pierson and Rainey 1996b), and, in partnership with California Department of Transportation, an investigation of seasonal distribution of bat species along an altitudinal gradient from Oakdale to Tioga Pass (Pierson *et al.* 2001).

Yosemite National Park contains three groves of giant sequoia (*Sequoia giganteum*), yet prior to this study virtually nothing was known regarding the bat community in this remarkable habitat in Yosemite. Earlier work at Giant Forest in Sequoia National Park had shown that a number of bat species used fire-scarred basal hollows for both day-roosting and night-roosting (Pierson and Heady 1996). Similar roosting behavior had been documented in coast redwood forests (Gellman and Zielinski 1996, Rainey *et al.* 1992, Zielinski and Gellman 1999). In all these studies guano was collected from these basal hollows and used as an index of bat activity.

Recent work in Canada has documented the importance of the boreal forest canopy to foraging bats (Kalcounis *et al.* 1999). No information was available on bat use of the forest canopy in any forest type in Yosemite. This was of particular interest in giant sequoia habitat.

Thus the goals of this multi-faceted study were to:

1. characterize the bat species assemblages in Yosemite's three giant sequoia groves;
2. investigate bat roosting behavior within the Mariposa and Merced groves by using guano traps in fire-scarred basal hollows in both groves, and radio-telemetry in the Mariposa Grove.
3. investigate bat foraging behavior in association with various habitat features within the groves (using both mist-netting and acoustic detection of the echolocation calls of foraging bats), and
4. assess bat activity at the canopy (recording echolocation calls using a radio-microphone elevated via a helium balloon).

2.0 METHODS

2.1. The Study Area

The study area consisted of the three giant sequoia groves within Yosemite National Park (Figure 1). The focus was on the largest grove, the Mariposa (43.5 ha), with complementary investigations in the other two smaller groves, the Merced (1.7 ha) and the Tuolumne (4.7 ha). These groves occur within a rather narrow elevation band between 1584 and 2085 m. Geographical coordinates for sampling sites were collected in decimal degrees (Datum: NAD27 CONUS), using hand-held GPS units (Garmin 12XL).

Because many of our sites did not have official names, we assigned names for the purposes of this project. Those sites referred to repeatedly by our assigned names are identified as follows:

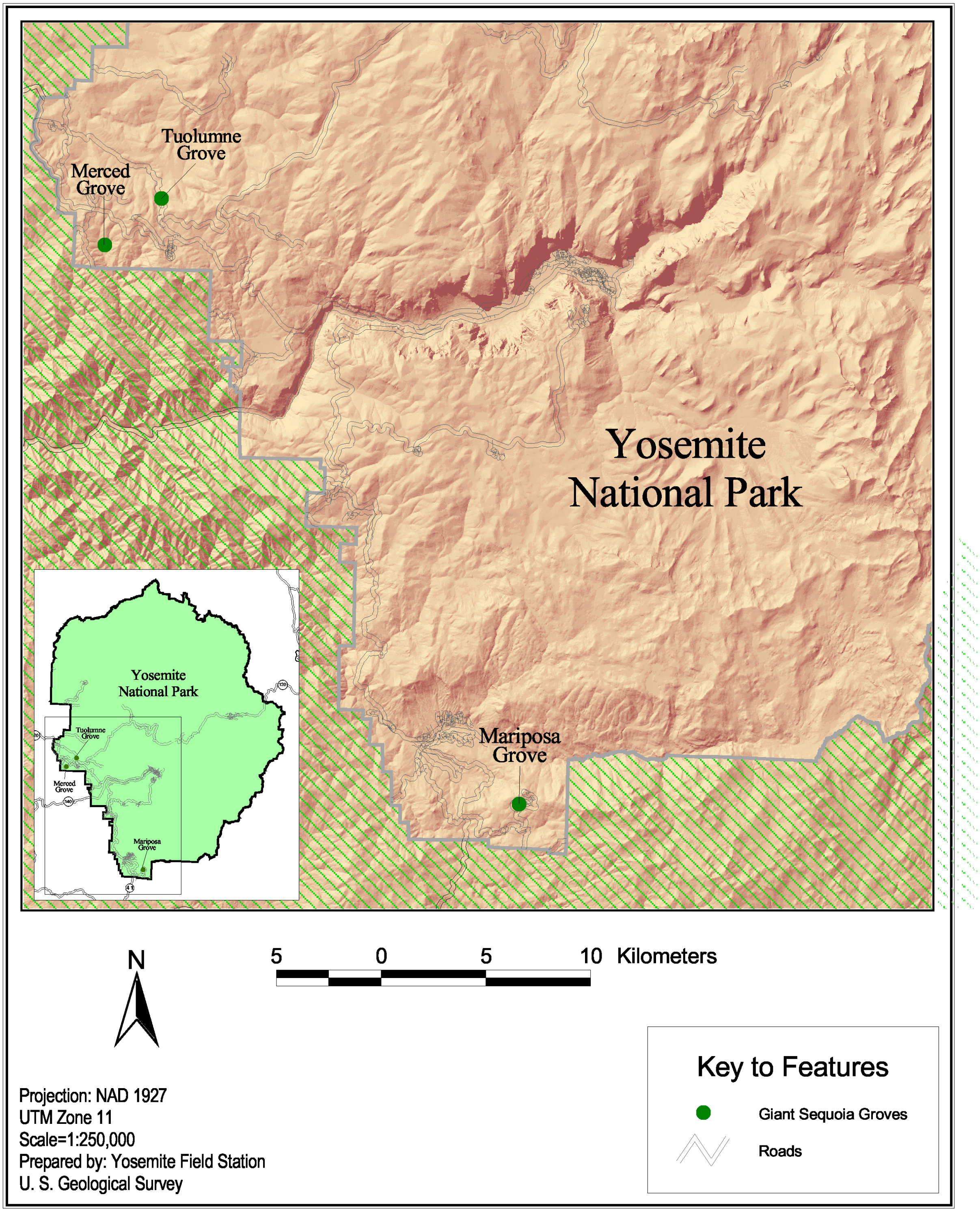


Figure 1. Map of the study area, showing the location of the three giant sequoia groves within Yosemite National Park, California

Boundary Creek – an unnamed creek just south of the grove. Our sampling stations were at or near the road crossing of this creek. This road leads southeast off the main road through the grove at a junction about 100 m before the Grizzly Giant.

Kiosk Creek – an unnamed creek that is a tributary for Rattlesnake Creek. Our station is located just south of the tram kiosk in the parking area.

Rattlesnake Dome – a granite bench located north of the road, about 100 m before the Mariposa Tree, just before entering the Upper Grove.

2.2. Monitoring Bat Use of Giant Sequoia Trees with Guano Traps

We used guano accumulation inside hollow trees as an index of bat activity based on successful efforts in coast redwoods (Gellman and Zielinski 1996, Rainey *et al.* 1992, Zielinski and Gellman 1999) and other giant sequoia groves (Pierson and Heady 1996),

All giant sequoias that appear in the Yosemite National Park inventory were examined for the existence of fire-scarred basal hollows. Twenty-seven trees were selected in the Mariposa Grove and nine trees in the Merced Grove (Appendix I). The numbers assigned to the trees were taken from maps supplied to us by the Park.

No giant sequoias in the Tuolumne Grove had basal hollows.

Suspended screening (flexible window screen) to collect bat guano was installed inside the selected hollows in May 2000 (Figure 2).

During the initial installation, hooks were installed around the perimeter of the hollow ca. 1 m above the ground, screening was cut to fit the size of the hollow and suspended from the hooks using grommets. When it was discovered late in the first season that ants were harvesting guano from the traps, and thus compromising our results, the guano traps were redesigned,

Figure 2. Fire-scarred giant sequoia (Tree #285) with suspended guano trap.

and an ant barrier was installed between each hook and the attachment point on the screening (Figure 3). Each barrier consisted of a 7.5 cm length of 4.5 cm diameter clear plastic tubing, into which was inserted a foam plug, through which was run a piece of wire, the ends of which formed the attachment points. Foam surfaces were coated with Tanglefoot, a sticky barrier avoided by ants and other insects. The clear plastic shroud prevented large organisms from contacting the Tanglefoot.

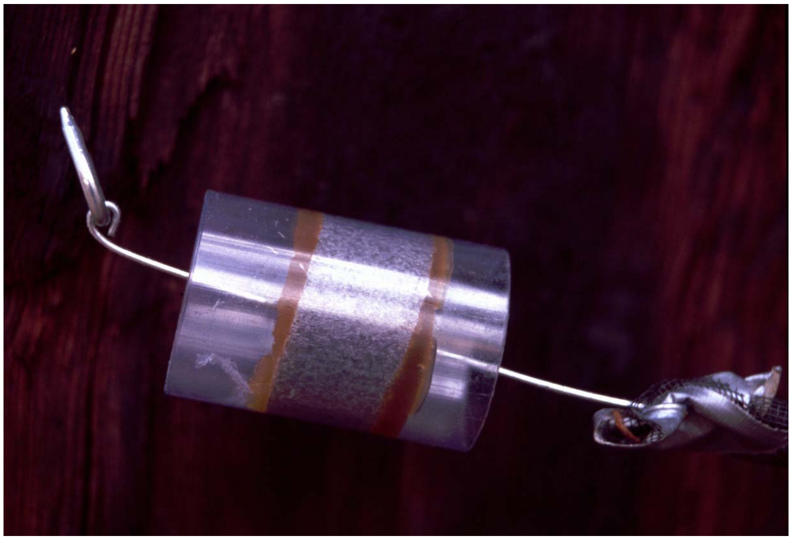


Figure 3. Ant barrier with foam plug and tangle-foot.

Guano was collected from all 36 traps bi-monthly from late June to late October in 2000 and early May to mid-October in 2001.

2.3. Mist Net Surveys and Capture Techniques

Mist nets were used to capture bats both in foraging areas and at or near roost trees (see Appendix II for inventory of sampling effort). We followed the procedures outlined by Kunz and Kurta (1988) -- 1.5 inch mesh black nylon or polyester mist nets of a size appropriate to the location (8.5’ x 8.5’, 18’ x 7’, 30’ x 7’, 42’ x 10’, 60’ x 10’, and/or 100’ x 30’) were set on sectional poles, and generally run for an average of 2.5 to 3.1 hours after sunset.

On-site processing of netted bats involved species identification (see van Zyll de Jong 1985 for keys); measurement of the forearm with digital calipers; assessment of age class (adult, juvenile) from ossification of the metacarpal phalangeal joints (Anthony 1988); determination of sex and reproductive condition. For females reproductive condition was evaluated by palpation of the abdomen to determine stage of pregnancy. Also, mammae were evaluated for nipple development, presence of milk (by expression), and loss of hair. For males, characterization of reproductive condition involved examination of the testes and checking epididymal tissue for pigmentation or distention.

2.4. Acoustic Surveys

2.4.1. Survey Design

Acoustic surveys were used to monitor bat use of individual trees, and to sample the bat assemblage in foraging areas (see Appendix III for inventory of sampling effort). For investigations of bat activity in foraging areas, two recent acoustic studies (Hayes 1997, Ballantyne and Sherwin 1999) indicate that night to night variation in bat activity is sufficiently high that valid comparative data can be obtained only by many nights of repeat sampling at the same sites or by establishing multiple survey points that are sampled concurrently. We attempted to accommodate both approaches in our survey design.

We identified single stations in five habitat categories (creek, seep, meadow, rock outcrop, and road edge), and repeat sampled these sites for two to four consecutive nights between May and September, for a total of 18 nights (Appendix IV). On each sampling night that five repeat stations were sampled, we would sample an additional three or four sites in one of the habitat categories. This allowed us to compare night-to-night variation with site-to-site variation for each habitat category.

Figure 4. Balloon in trial launch in Wawona Meadow

In all, we sampled 41 different sites during 196 sampling sessions, generally running 8-10 detectors simultaneously per night. Acoustic stations were set up prior to sunset, and run until after sunrise, insuring coverage of all time when bats might be active.

Figure 5. Balloon prior to launching in Upper Mariposa Grove

Additional monitoring was conducted within the sequoia canopy. A bat detector was extensively modified to transfer data by radio to a computer on the ground and elevated to 67 m via a helium balloon, tethered by three high strength lines (Figure 4). After testing the system in Wawona Meadow, we deployed it in the clearing near the museum in the Upper Mariposa Grove, where the balloon could be positioned relatively close to giant sequoias, while minimizing the risk of snagging the balloon in the canopy (Figure 5).

2.4.2. Acoustic Equipment

Acoustic sampling used primarily broad band frequency dividing Anabat detectors with low frequency microphones (Titley Electronics, Ballina, NSW, Australia) coupled to laptop computers via zero-crossing analyzers (zcaims). Ultrasound events were stored as files on the computer hard drive for later analysis. For monitoring individual trees, we also used other detectors (D980 and D230 from Pettersson Elektronik AB, Uppsala, Sweden) linked to a DAT recorder, night vision devices and/or infrared video recording.

2.4.3. Acoustic Identification of Species

The effectiveness of acoustic surveys for locating and identifying bats depends on two parameters: 1) how readily a bat can be detected, and 2) with what degree of reliability it can be identified once detected. Detectability is a function of call frequency, call intensity and distance. Species with low frequency, high intensity calls will be detected at the greatest distance. Detection of audible bat calls (<20 kHz) is usually reduced by filters that also suppress extraneous noise from insects and wind, but we used low frequency microphones (5-20 kHz) to enhance detection of species calling in this range.

Identifying bat species based on echolocation calls relies on analysis of a number of call parameters including base frequency, call shape (slope as measured in octaves per second and overall pattern), pattern of calls within a sequence, inter-pulse interval, and call duration.

For some species, particular combinations of call characteristics allow them to be readily distinguished from all other taxa that might occur in a survey area. Basic knowledge of the species expected is important because some species could be readily distinguished from all other local species in one area and not in another.

Conducting bat acoustic surveys generally requires knowledge not only of the species specific call characteristics, but also of the biology and ecology of the species involved. For the 14 species that we identified as occurring in the study area, there are eight that can be readily identified from Anabat call sequences alone, and six for which identification is frequently problematic. The eight species that can be readily identified using the Anabat system are: *Antrozous pallidus*, *Euderma maculatum*, *Eumops perotis*, *Lasiurus blossevillii*, *Lasiurus cinereus*, *Myotis evotis*, *Myotis thysanodes*, and *Pipistrellus hesperus.*

Identification based solely on echolocation calls is problematic for three sets of taxa. *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Tadarida brasiliensis* produce similar echolocation calls in a frequency range of between 20 kHz and 30 KHz. Although all three (especially *T. brasiliensis*) do produce sequences that are diagnostic, a large percentage of calls in this frequency range cannot be assigned to a species unless the animal has also been visually observed.

Likewise, *Myotis californicus* and *Myotis yumanensis*, both of which give echolocation calls with a characteristic frequency of circa 45-50 KHz, can be difficult to distinguish based on call structure alone, although some calls of each species appear to be diagnostic. If visual observation is possible, differences in flight style and foraging behavior often serve to distinguish these species -- *e.g.*, *M. yumanensis* commonly forage by skimming the water surface and *M. californicus* often forage along an irregular flight path in close association with vegetation, often at canopy height. We generally made no attempt to distinguish between these two species for passive acoustic data. However, we were able to confirm by active acoustic monitoring (spot-lighting flying bats while recording their echolocation calls) that the majority of 50 kHz animals in the groves were *M. californicus.*

Another currently unresolved group includes three *Myotis* species (*M. ciliolabrum*, *M. lucifugus*, and *M. volans)* that have characteristic frequencies of 35-45 KHz. Although visual observations of body size and flight behavior can sometimes serve to distinguish these species, all three are sufficiently poorly known in California that there are many situations in which positive identification of animals in flight is also very difficult. *Myotis volans* was the only one of the three confirmed by capture to occur in the groves, but the others may be there and have eluded detection.

2.4.4. Analysis of Acoustic Data

Most acoustic data were collected with Anabat detectors (frequency division ratio of 16). Outputs were processed in real time by a zero crossing analyzer coupled to the parallel port of a battery powered laptop computer running under DOS. The signals were stored as Anabat6 files. Signal capture was either triggered manually by an active observer or passively by an adjustable call recognition algorithm in the software. The algorithm, as used, requires recognition of two bat calls to save a sequence file. Under low to moderate levels of bat activity, a file ends five seconds after the last bat call or 15 seconds after the initial call. A single file may contain two to a few hundred individual bat calls from one or more bats.

Anabat sequence files currently have a fixed maximum size, so that under intense bat activity that file size may be reached in less than 15 seconds (*e.g.*, ten sequences per minute rather than six). Thus while numbers of sequence files are a convenient measure of relative detection rates among species and localities, time duration of the sampling unit may vary with bat activity. For more detailed activity level comparisons, the program Analook can be used to display and visually count individual calls (or pulses) or the program will count calls based on user-constructed filters which include criteria for call traits (frequency, slope, duration, etc.)

For this analysis, we have visually examined and manually entered assignments to individual taxa (or multi-species acoustic categories) for all sequence files except that sequence file counts of 25, 40 and 50 kHz bats were obtained by software filters. Numerical values in subsequent comparisons are based on numbers of sequence files.

2.5. Radio-tracking Methods

Bats for radio-tracking were captured in the Mariposa Grove, and measurements taken as described above. Bats were outfitted with transmitters and followed for up to 13 days/nights between 27 July and 10 August 2001.

Figure 6. *Eptesicus fuscus* with radio transmitter

Prior to attachment, 0.48-0.6 g radio transmitters (Model B2-B, Holohil Systems) operating at 151.000-151.999 mHz were activated by soldering the power leads, sealed and allowed to run for several hours to test their condition. Transmitters were attached to bats by trimming midline dorsal hair over the scapulae and applying SkinBond® surgical adhesive to the remaining shortened hair and the under side of the transmitter. When nearly dry the transmitter was attached by gentle pressure (Figure 6).

Radio-tracking was conducted by up to five observers using telemetry receivers (Custom Electronics CE-12, Telonics TR-2, Telonics TR-4, Wildlife Materials TRX-1000S, or an AOR Limited AR8200 wide range receiver) and hand-held yagi antennas. Attempts were made each day to identify roost sites for all radio-tagged animals. GPS units (Garmin 12XL) were used to obtain coordinates (NAD27 CONUS) for located roost sites.

Although the focus was on locating roost sites, we generally monitored foraging behavior up to four hours per night. Each night, observers were assigned to monitor emergence at an identified roost tree, and then either took up a stationary position to scan for all radio-tagged bats, or moved about in the Grove looking for bats for which the signal had been lost.

2.6. Hibernation Study

In the cave-like basal hollows of giant sequoia, many crevices in which bats can hide are not readily observable, especially in winter. However, studies have shown that bats occupy hibernating sites with relatively stable temperatures a few degrees above freezing (Webb *et al.* 1996). Thus winter temperatures offer a basis for assessing the suitability of these sites for bat hibernation. To record temperature variation, we placed high-resolution two channel temperature monitors (Hobo Pro; Onset Computer) in November 2000, in nine giant sequoias (seven in the Mariposa Grove and two in the Merced Grove), and retrieved them in May 2002. Each monitor had an internal temperature sensor and a second sensor on a 1.8 m or 5.9 m extension cable. The monitor enclosures were mounted on the interior wall near a hollow entrance. The sensor extension cable was attached to a low thermal conductivity (wood and/or PVC) extension, and placed high in a crevice extending upward from the hollow (Figures 7 and 8). To obtain an

Figure 7. Installation of temperature probe inside basal hollow

Figure 8. Temperature probe installation inside basal hollow. Lower probe is visible. Interior probe is on end of pole inserted high in the hollow.

ambient temperature record for the Merced Grove, we hung a temperature monitor in an open-air location on a tree at > 2 m height. Ambient hourly temperatures for the Mariposa Grove were obtained from a permanent weather station located in the Upper Grove.

2.7. Ant Study

When it was discovered that carpenter ants (*Camponotus modoc*) were harvesting guano from our suspension traps we conducted a series of feeding trials by placing pre-measured amounts of guano in petri dishes at trees containing guano traps. In the first set of trials, we placed petri dishes with measured amounts of guano in the center of the guano traps, and measured harvest rates. In a second set of trials we placed petri dishes in various positions both within the hollow and around the perimeter of the tree, and again measured harvest rates by the ants. For those trees with basal hollows we placed 2 petri dishes on the ground inside the hollow, 3 on the ground around the tree perimeter, and 3-5 around the tree perimeter six feet above the ground. We sampled a few trees that had no basal hollow, and for those trees we placed 5 petri dishes on the ground around the perimeter, and 3-5 six feet above the ground. We placed 10 guano pellets in each dish and ran these experiments for three hours from ca. 19:30 to 22:30. We counted the number of pellets that had been harvested, and from this calculated the harvest rate by ants.

3.0 RESULTS AND DISCUSSION

3.1. Overall Bat Diversity

3.1.1. Species Assemblage

Fourteen of the 18 species known to occur in Yosemite National Park (Pierson *et al.* 2001) were detected in the giant sequoia groves. There are capture records for eight of these species; and acoustic records for six others (Table 1).

Table 2 details the capture records during this study for the three giant sequoia groves and the South Fork Merced River in Wawona. All eight species were captured in the Mariposa Grove, and seven of these were captured in more limited netting in the Merced Grove. No bats were captured in one night of netting in the Tuolumne Grove. Seven of the same species, plus an additional two species (*Lasiurus cinereus* and *Tadarida brasiliensis*) were captured at the South Fork Merced River in Wawona. Both these species, based on acoustic records, also occur in the giant sequoia groves.

There were four other species that are known to occur in Yosemite National Park, but were not detected in the giant sequoia groves: *Corynorhinus townsendii*, *Myotis ciliolabrum*, *Myotis lucifugus*, and *Nyctinomops macrotis*. *C. townsendii* is a typically cave-dwelling species that is also known to roost in basal hollows of coast redwood (Fellers and Pierson 2002, Mazurek 2004). Although maternity sites are found primarily at lower elevation, colonies have been identified up to 1,600 in the Sierra Nevada (Pierson and Fellers 1998), and up to 1,700 m in the White and Inyo Mountains (Szewczak *et al.* 1998). Its apparent absence in the Yosemite groves

Table 1. Summary of detection records for bat species in the Giant Sequoia Groves of Yosemite National Park, with summary of roosting and reproductive status.

Species	**Common Name**	**Regulatory Status**	**Roosting in Giant Sequoia**	**Pregnant / Lactating Female**
Capture Records				
Family Vespertilionidae (mouse-eared bats)				
Antrozous pallidus	Pallid bat	FSS, MSSC	YES	YES
Eptesicus fuscus	Big brown bat		YES	YES
Lasionycteris noctivagans	Silver-haired bat		Unknown	Males only
Myotis californicus	California myotis		YES	YES
Myotis evotis	Long-earred myotis	SC	YES	YES
Myotis thysanodes	Fringed myotis	MSSC*, SC	YES	YES
Myotis volans	Long-legged myotis	MSSC*, SC	YES	Males nulliparous females only
Myotis yumanensis	Yuma myotis	SC	Unknown	Males only
Acoustic Records Only				
Family Molossidae (free-tailed bats)				
Eumops perotis	Western mastiff bat	MSSC, SC		
Tadarida brasiliensis	Mexican free-tailed bat			
Family Vespertilionidae (mouse-eared bats)				
Euderma maculatum	Spotted bat	MSSC, SC		
Lasiurus blossevillii	Red bat	FSS, MSSC*		
Lasiurus cinereus	Hoary bat			
Pipistrellus hesperus	Western pipistrelle			
Possible but not Detected				
Corynorhinus townsendii	Townsend's big-eared bat	FSS, MSSC, SC		
Myotis ciliolabrum	Small-footed myotis	SC		
Myotis lucifugus	Little brown bat			
Nyctinomops macrotis	Big free-tailed bat	MSSC, SC		

Table 2. Numbers of individuals captured by species and by locality at netting sites and roost sites.

Date	Locality	*Anpa*	*Epfu*	*Lano*	*Laci*	*Myca*	*Myev*	*Myth*	*Myvo*	*Myyu*	*Tabr*	# of bats	# of spp.
Mariposa Grove													
20-Jun-01	Boardwalk, Upper Grove		2									2	2
20-Jun-01	nr. Tree 311						2		1			3	2
20-Jun-01	Tree 314						1					1	1
2-Jul-01	Sunset Loop Trail						1					1	1
3-Jul-01	Kiosk Creek		22	5		4	1	5	4			41	6
4-Jul-01	Tree 124							1				1	1
6-Jul-01	Tree 280					1						1	1
6-Jul-01	Tree 285					1						1	1
26-Jul-01	Tree 426								1			1	1
27-Jul-01	Kiosk Creek		7	1		3		10	2	1		24	6
31-Jul-01	Tree 285							1				1	1
31-Jul-01	Meadow, Upper Grove		4			2	2	1				9	4
1-Aug-01	Tree 42					1						1	1
1-Aug-01	Rattlesnake Dome		1									1	1
2-Aug-01	Loop/Wawona Pt. Jct						1					1	1
3-Aug-01	Boundary Creek	1	2			6						9	3
3-Aug-01	Kiosk Creek		8	1		2	1	2	1	1		16	7
8-Aug-01	Tree 474					2						2	1
9-Aug-01	Tree 39	1					2					3	2

Table 2. continued

Date	Locality	*Anpa*	*Epfu*	*Lano*	*Laci*	*Myca*	*Myev*	*Myth*	*Myvo*	*Myyu*	*Tabr*	# of bats	# of spp.
27-Aug-01	Kiosk Creek		11			3		1				15	3
27-Aug-01	Nr. Tree 39	2					1					3	2
28-Aug-01	Boundary Creek					5						5	1
28-Aug-01	Boardwalk, Upper Grove					1						1	1
31-Aug-01	Rattlesnake Dome					1						1	1
	Subtotals	**4**	**57**	**7**	**0**	**32**	**12**	**21**	**9**	**2**	**0**	**144**	**8**
Merced Grove													
5-Jul-01	Tree 19						1	6	1			8	3
5-Jul-01	nr. Tree 44		1			3		10	1			15	4
5-Jul-01	nr. Six Sisters					2						2	2
29-Aug-01	Creek Crossing blw					2						2	1
29-Aug-01	Nr. Tree 44		1	1		5		4		1		12	5
	Subtotals	**0**	**2**	**1**	**0**	**12**	**1**	**20**	**2**	**1**	**0**	**39**	**7**
South Fork Merced, Wawona													
25-Jul-01	River, E. End Golf Course	14	7		1	14		3	4	24		67	7
30-Aug-01	River, E. End Golf Course		1	1	1					10	1	14	5
30-Aug-01	Upstream of Campground		1	2	1	6				9	1	20	6
	Subtotals	**14**	**9**	**3**	**3**	**20**	**0**	**3**	**4**	**43**	**2**	**101**	**9**
	TOTALS	**18**	**68**	**11**	**3**	**64**	**13**	**44**	**15**	**46**	**2**	**284**	**10**

was unexpected, but its low intensity echolocation calls make it difficult to detect acoustically. It also appears to be particularly sensitive to roost disturbance and no longer forms colonies in Sierra foothill cave sites with high rates of recreational visitation. The distribution of *M. ciliolabrum* in Yosemite is poorly known. It appears to be far less common here than farther south in Sequoia and Kings Canyon National Parks. It has, however, been detected at elevations both lower (in Yosemite Valley and near Bass Lake outside the Park) and higher (Tioga Road Bridge over Yosemite Creek and Yosemite Creek Campground) than the giant sequoia groves (Pierson *et al.* 2001). Because it is thought to roost primarily in rock crevices, there may not be suitable habitat for it in the sequoia groves. There is, however, rock crevice habitat close to the Mariposa Grove at Wawona Point. The absence of *M. lucifugus* and *N. macrotis* is not surprising. *M. lucifugus* is found predominantly at elevations above 2,100 m. *N. macrotis*, a cliff-dwelling species with few records from California, is known primarily from southwestern deserts. It is a long-distance flier that is occasionally observed at locations well outside its range (as currently understood). We have obtained a few acoustic records of this species in Yosemite Valley.

3.1.2. Reproductive Patterns

Tables 3, 4, and 5 provide demographic data (age and reproductive status) for all captured individuals by species. Five of the eight species (*A. pallidus*, *E. fuscus*, *M. californicus*, *M. evotis*, and *M. thysanodes*) had reproductive populations in the groves, as assessed by the presence of lactating or near-term pregnant females. For three species (*L. noctivagans*, *M. volans*, and *M. yumanensis)* no reproductive adults were captured. Most individuals for all three species were adult males. The exceptions were one juvenile male *M. yumanensis* captured in late August in the Merced Grove, and one nulliparous female *M. volans* captured in the Merced Grove in early July.

To put these data in context, there is substantial geographic separation of the sexes during the reproductive season for a number of bat species. For some species, in mountainous areas, this separation is primarily altitudinal, with breeding females concentrated at the warmer lower elevations, and males concentrated at higher elevations (Cryan et al 2000). Data collected during this study, combined with those collected in an earlier study (Pierson *et al.* 2001), suggest that for both *M. volans* and *M. yumanensis*, there is an altitudinal separation of the sexes during the summer in Yosemite, with breeding females occurring at elevations below 1,500 m, and adult males and/or nulliparous females occurring at elevations above 1,500 m. Breeding females of both species have been found at higher elevations, however, farther south in the Sierras (e.g., *M. yumanensis* in Devils Postpile NM and *M. volans* in Kings Canyon National Park). The presence of a juvenile male *M. yumanensis* in the Merced Grove the end of August does not provide evidence that this species raises its young in the grove, since data collected in an earlier study showed that toward the end of the summer adult and juvenile male *M. yumanensis* appear together at higher elevations (Pierson *et al.* 2001).

For some migratory species, like *L. noctivagans*, the geographic separation of the sexes occurs over a larger landscape scale. There is geographic separation of the sexes for this species on the eastern and western slopes of the Oregon Cascades (M. Perkins personal communication). Both adult males and breeding females are found in the same habitat in much of northern California --

Table 3. All capture records by species by date for the Mariposa Grove, including information on age, sex, and reproductive condition when known. P3 = advanced pregnancy; Lc = lactating; Pl = post-lactating; Nl = nulliparous; Par = parous; Unk = reproductive condition not determined; M = male; F = female.

Species	Date	Mariposa Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Antrozous pallidus													
	3-Aug-01	Boundary Creek			1								1
	9-Aug-01	Tree 39					1						1
	27-Aug-01	Nr. Tree 39								1	1		2
		Subtotal	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**4**
Eptesicus fuscus													
	20-Jun-01	Boardwalk, Upper Grove	2										2
	3-Jul-01	Kiosk Creek	12		5	2	3						22
	27-Jul-01	Kiosk Creek	2			4	1						7
	31-Jul-01	Meadow, Upper Grove	3			1							4
	1-Aug-01	Rattlesnake Dome				1							1
	3-Aug-01	Boundary Creek				1		1					2
	3-Aug-01	Kiosk Creek	2			3	1			1	1		8
	27-Aug-01	Kiosk Creek	6			5							11
		Subtotal	**27**	**0**	**5**	**17**	**5**	**1**	**0**	**1**	**1**	**0**	**57**
Lasionycteris noctivagans													
	3-Jul-01	Kiosk Creek	4									1	5
	27-Jul-01	Kiosk Creek	1										1
	3-Aug-01	Kiosk Creek	1										1
		Subtotal	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**7**

Table 3 (cont'd)

Species	Date	Mariposa Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Myotis californicus													
	3-Jul-01	Kiosk Creek	3							1			4
	4-Jul-01	Tree 127*											0
	6-Jul-01	Tree 280	1										1
	6-Jul-01	Tree 285	1										1
	27-Jul-01	Kiosk Creek	2		1								3
	31-Jul-01	Meadow, Upper Grove	1								1		2
	1-Aug-01	Tree 42	1										1
	3-Aug-01	Boundary Creek	2		1	2				1			6
	3-Aug-01	Kiosk Creek			2								2
	8-Aug-01	Tree 474	1							1			2
	27-Aug-01	Kiosk Creek					2			1			3
	28-Aug-01	Boundary Creek	2							2	1		5
	28-Aug-01	Boardwalk, Upper Grove	1										1
	31-Aug-01	Rattlesnake Dome	1										1
		Subtotal	**16**	**0**	**4**	**2**	**2**	**0**	**0**	**6**	**2**	**0**	**32**

Table 3 (cont'd)

Species	Date	Mariposa Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Myotis evotis													
	20-Jun-01	Nr. Tree 311		2									2
	20-Jun-01	Tree 314		1									1
	2-Jul-01	Sunset Loop Trail	1										1
	3-Jul-01	Kiosk Creek	1										1
	31-Jul-01	Meadow, Upper Grove									2		2
	2-Aug-01	Loop/Wawona Pt. Junction									1		1
	3-Aug-01	Kiosk Creek	1										1
	9-Aug-01	Tree 39	1			1							2
	27-Aug-01	Nr. Tree 39				1							1
		Subtotal	**4**	**3**	**0**	**2**	**0**	**0**	**0**	**0**	**3**	**0**	**12**
Myotis thysanodes													
	3-Jul-01	Kiosk Creek	2		2		1						5
	4-Jul-01	Tree 124	1										1
	27-Jul-01	Kiosk Creek	1		2	4				2	1		10
	31-Jul-01	Meadow, Upper Grove	1										1
	31-Jul-01	Tree 285	1										1
	3-Aug-01	Kiosk Creek			1					1			2
	27-Aug-01	Kiosk Creek					1						1
		Subtotal	**6**	**0**	**5**	**4**	**2**	**0**	**0**	**3**	**1**	**0**	**21**

Table 3 (cont'd)

Species	Date	Mariposa Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Myotis volans													
	20-Jun-01	Nr. Tree 311	1										1
	3-Jul-01	Kiosk Creek	4										4
	26-Jul-01	Tree 426	1										1
	27-Jul-01	Kiosk Creek	2										2
	3-Aug-01	Kiosk Creek	1										1
		Subtotal	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**
Myotis yumanensis													
	27-Jul-01	Kiosk Creek	1										1
	3-Aug-01	Kiosk Creek	1										1
		Subtotal	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
		TOTALS	**70**	**3**	**15**	**25**	**10**	**1**	**0**	**11**	**8**	**1**	**144**

* Visual Observation - 7 bats in and out, identity unknown

Table 4. All capture records by species by date for the Merced Grove, including information on age, sex, and reproductive condition when known. P3 = advanced pregnancy; Lc = lactating; Pl = post-lactating; Nl = nulliparous; Par = parous; Unk = reproductive condition not determined; M = male; F = female.

Species	Date	Merced Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Eptesicus fuscus													
	5-Jul-01	Nr. Tree 44	1										1
	29-Aug-01	Nr. Tree 44					1						1
		Subtotal	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**
Lasionycteris noctivagans													
	29-Aug-01	Nr. Tree 44	1										1
		Subtotal	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Myotis californicus													
	5-Jul-01	Nr. Tree 44	1		2								3
	5-Jul-01	Six Sisters	2										2
	29-Aug-01	Creek Crossing below Grove	1				1						2
	29-Aug-01	Nr. Tree 44	1			1				2	1		5
		Subtotal	**5**	**0**	**2**	**1**	**1**	**0**	**0**	**2**	**1**	**0**	**12**
Myotis evotis													
	5-Jul-01	Tree 19			1								1
		Subtotal	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Table 4. (cont'd)

Species	Date	Merced Grove Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Myotis thysanodes													
	5-Jul-01	Nr. Tree 44	1		5		4						10
	5-Jul-01	Tree 19			5					1			6
	29-Aug-01	Nr. Tree 44	1				1			2			4
		Subtotal	**2**	**0**	**10**	**0**	**5**	**0**	**0**	**3**	**0**	**0**	**20**
Myotis volans													
	5-Jul-01	Nr. Tree 44					1						1
	5-Jul-01	Tree 19	1										1
		Subtotal	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**
Myotis yumanensis													
	29-Aug-01	Nr. Tree 44								1			1
		Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
		TOTALS	**10**	**0**	**13**	**1**	**8**	**0**	**0**	**6**	**1**	**0**	**39**

Table 5. All capture records by species by date for the South Fork Merced River in Wawona, including information on age, sex, and reproductive condition when known. P3 = advanced pregnancy; Lc = lactating; Pl = post-lactating; Nl = nulliparous; Par = parous; Unk = reproductive condition not determined; M = male; F = female.

Species	Date	South Fork Merced Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	**Lc**	**Pl**	**Nl**	**Par**	**Unk**	**M**	**F**		
Antrozous pallidus													
	25-Jul-01	River, E. end of golf course			10		1			2	1		14
		Subtotal	**0**	**0**	**10**	**0**	**1**	**0**	**0**	**2**	**1**	**0**	**14**
Eptesicus fuscus													
	25-Jul-01	River, E. end of golf course	2		3					2			7
	30-Aug-01	River, E. end of golf course					1						1
	30-Aug-01	Upstream of Campground	1										1
		Subtotal	**3**	**0**	**3**	**0**	**1**	**0**	**0**	**2**	**0**	**0**	**9**
Lasionycteris noctivagans													
	30-Aug-01	River, E. end of golf course	1										1
	30-Aug-01	Upstream of Campground	2										2
		Subtotal	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**
Lasiurus cinereus													
	25-Jul-01	River, E. end of golf course	1										1
	30-Aug-01	River, E. end of golf course	1										1
	30-Aug-01	Upstream of Campground									1		1
		Subtotal	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**3**

Table 5. Cont'd.

Species	Date	South Fork Merced Localities	Adult Males	Adult Females						Juveniles		Unk	Total
				P3	Lc	Pl	Nl	Par	Unk	M	F		
Myotis californicus													
	25-Jul-01	River, E. end of golf course	3		3	1	1			3	3		14
	30-Aug-01	Upstream of Campground				2				2	2		6
		Subtotal	3	**0**	**3**	**3**	**1**	**0**	**0**	**5**	**5**	**0**	**20**
Myotis thysanodes													
	25-Jul-01	River, E. end of golf course	1								2		3
		Subtotal	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**
Myotis volans													
	25-Jul-01	River, E. end of golf course	1							1	2		4
		Subtotal	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**4**
Myotis yumanensis													
	25-Jul-01	River, E. end of golf course	3		2	1	2			7	9		24
	30-Aug-01	River, E. end of golf course	5				2		1	2			10
	30-Aug-01	Upstream of Campground	2			2					5		9
		Subtotal	**10**	**0**	**2**	**3**	**4**	**0**	**1**	**9**	**14**	**0**	**43**
Tadarida brasiliensis													
	30-Aug-01	River, E. end of golf course									1		1
	30-Aug-01	Upstream of Campground	1										1
		Subtotal	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**
		TOTALS	**24**	**0**	**18**	**6**	**7**	**0**	**1**	**19**	**26**	**0**	**101**

e.g., the upper Sacramento River basin and the Trinity Mountains (Pierson and Rainey 1998b, Rainey and Pierson 1996). The only individuals captured in Yosemite, however, have been adult males, suggesting separation of the sexes in the central Sierra Nevada.

There are also a number of species for which adult males and breeding females are found in the same habitat (*e.g.*, *Antrozous pallidus*, *Eptesicus fuscus*, *Myotis californicus*, *Myotis evotis*, and *Myotis thysanodes*). Data regarding the summer distribution of adult males and breeding females is not well documented for many species in California, particularly some of the *Myotis* species.

3.1.3. Relative Capture Rates

Figure 9 shows the relative capture rates by species for the ten species captured either in the sequoia groves or over the South Fork Merced River during this study. The most frequently encountered species is different in each of these settings -- the big brown bat, *E. fuscus*, in the Mariposa Grove; the fringed myotis, *M. thysanodes*, in the Merced Grove; and *M. yumanensis* at the South Fork Merced River in Wawona. These results should not be over-interpreted. The high proportion of *M. thysanodes* in the Merced Grove can be partly explained by the fact that, serendipitously, our primary netting sites were adjacent to two *M. thysanodes* roosts in giant sequoia trees (#19 and #44). Nevertheless, the more open, relatively dry habitat of the Mariposa Grove (particularly the Upper Grove) is more typical for *E. fuscus*, and the more enclosed habitat

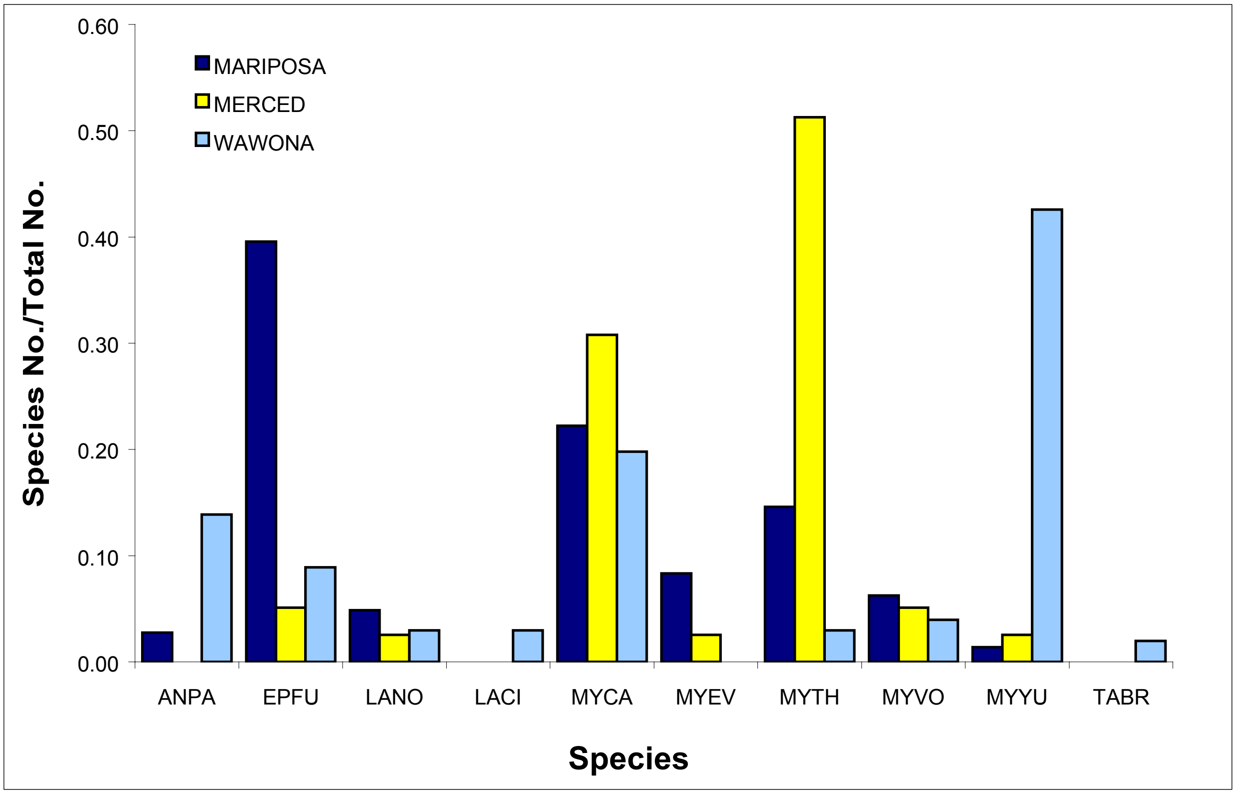


Figure 9. Bar graph showing the relative capture rates (number of individuals for particular species/total number of bats) for 10 species in the Mariposa and Merced giant sequoia groves and over the South Fork Merced River in Wawona.

with its associated stream in the Merced Grove is more typical for *M. thysanodes* in forested areas of California. The predominance of *M. yumanensis* over the South Fork Merced is not surprising given the high association between this species, which specializes on small aquatic emergent insects, and open, still or slowly moving water. While this is the species most commonly found in association with the river, this does not necessarily mean it is the most abundant species in this habitat.

3.2. Bat Use of Giant Sequoias

3.2.1. Bat Use of Basal Hollows as Assessed by Guano Traps

Guano traps were installed inside basal hollows of 27 giant sequoias in the Mariposa Grove and in 8 giant sequoias and one incense cedar in the Merced Grove (Figures 10 and 11). These traps were monitored for bat use from May through October in 2000 and 2001.

3.2.1.1. Carpenter Ant Guano Harvesting

In August 2000 we observed carpenter ants in the Mariposa Grove harvesting guano and insect parts dropped by bats from our suspended debris traps in tree cavities. To assess the rate of removal, we placed 4 cm Petri dishes filled with guano on the traps, and observed that these were emptied by ants overnight.

Subsequently, we consulted several experts on ant behavior and exclusion methods, then tested a range of trap suspension materials and structures to develop a long-term ant barrier with minimal risk to birds and other basal hollow occupants. After installing the devices in the 2001 sampling season, Petri dishes with measured amounts of guano were placed in the center of each trap to monitor barrier effectiveness. The guano loss rate was zero at most trees, but long term monitoring revealed sporadic guano loss when falling tree debris created temporary access, as well as removal by ants, which fell to the trap from the cavity walls above. Periodic examination of the barrier devices showed that few ants or other insects were trapped in the sticky barrier.

The effect of ant harvesting on guano and insect parts as an index of bat tree cavity use can be inferred by comparing the amount (mg/day) collected in 2000 before ant barriers were installed and in 2001 after the barriers were installed. If we presume that bat deposition was identical in both years, then ant harvesting had a substantial effect on results in the Mariposa Grove, with 25 of the 27 trees having more guano and insect parts recovered in 2001 than in 2000. All monitored trees had evidence of bat use in 2001, whereas a number had little or no deposition in 2000 (Figure 12).

In the Merced Grove, the guano traps were operated in the same manner (*i.e.*, ant barriers only in 2001). Students in Yosemite Institute classes removed traps at this site on several occasions in 2001 (despite labels in the trees indicating a research project was in progress), likely decreasing totals for the year. Thus while any guano recovery reliably indicated bat activity in that tree, the relative amounts (*e.g.*, more guano in three of the nine monitored trees in 2000 than in 2001) are likely altered (Figure 13).

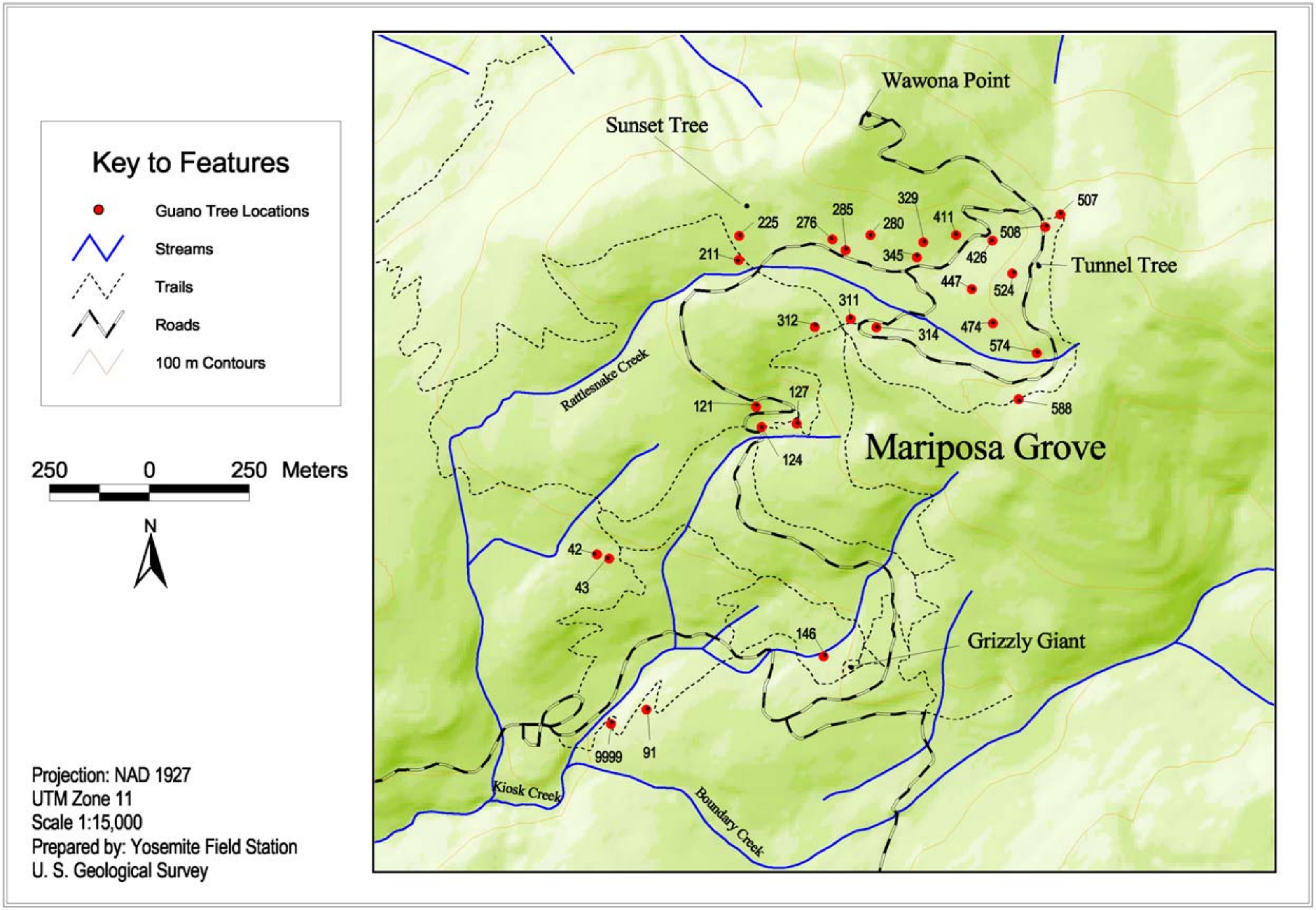


Figure 10. Map showing location of giant sequoia trees in which guano traps were installed in Mariposa Grove, Yosemite National Park, California

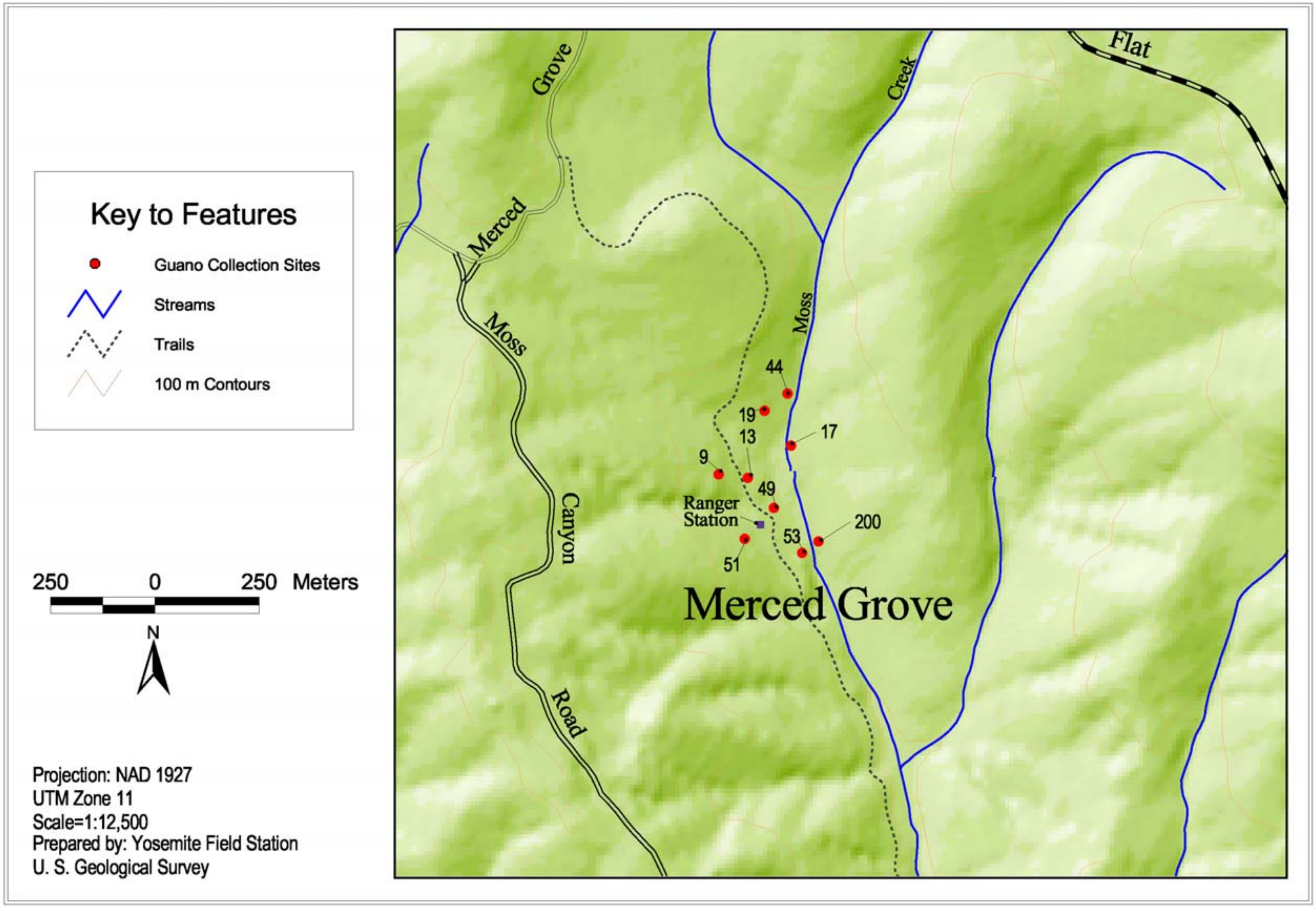


Figure 11. Map showing location of giant sequoia trees in which guano traps were installed in Merced Grove, Yosemite National Park, California

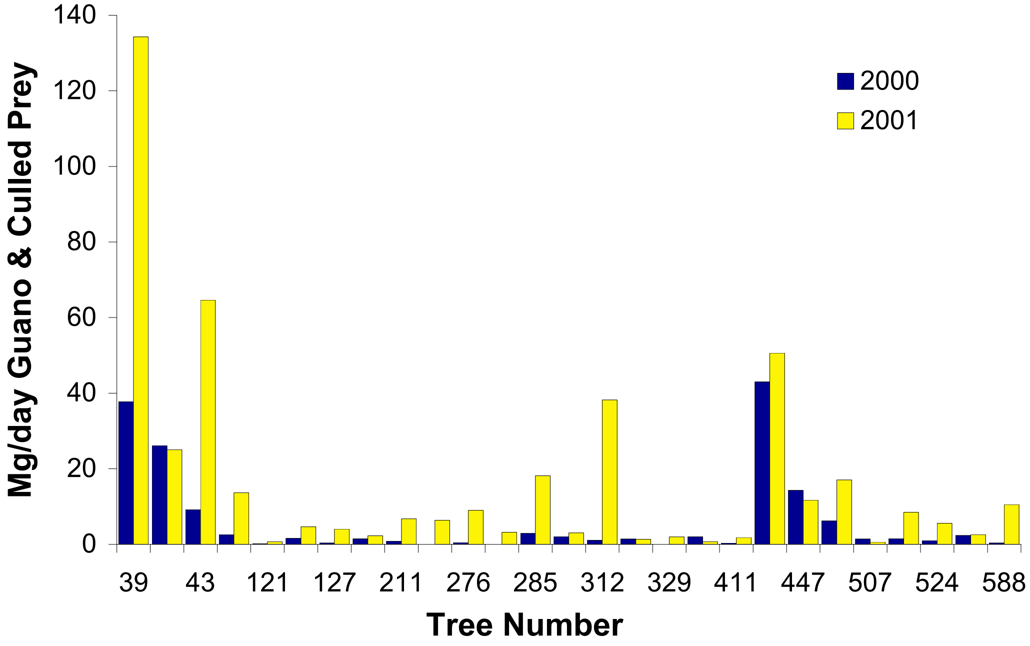


Figure 12. Bar graph showing a comparison of the annual deposition (mg/day) of guano and culled insect parts by tree in the Mariposa Grove for 2000 and 2001.

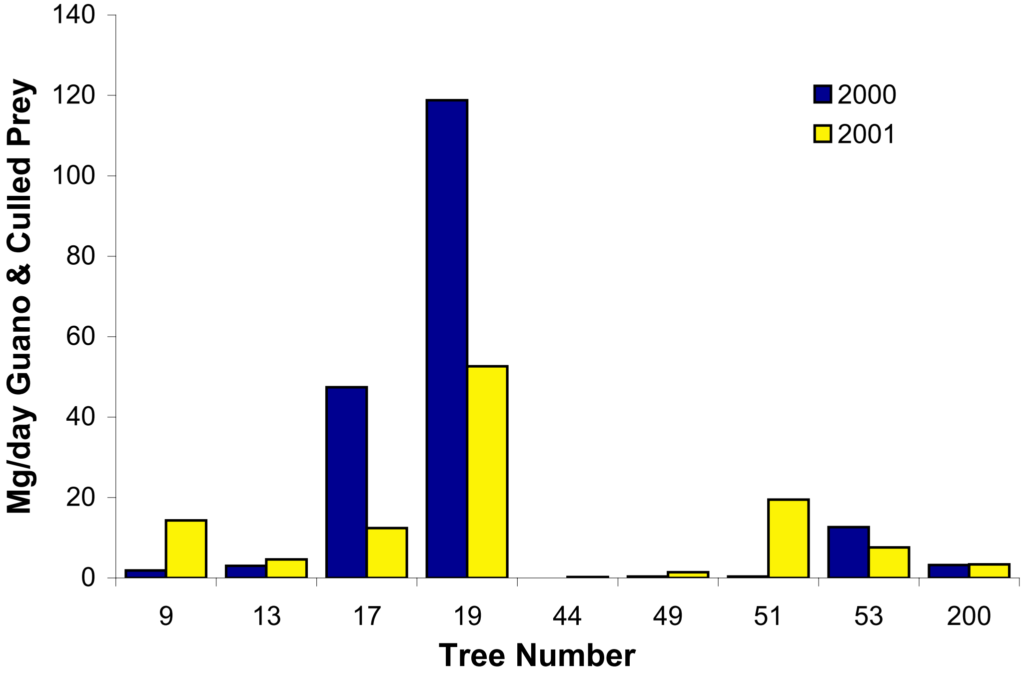


Figure 13. Bar graph showing a comparison of the annual deposition (mg/day) of guano and culled insect parts by tree in the Merced Grove for 2000 and 2001.

Observations suggested higher ant activity around study trees in the Mariposa Grove than the Merced Grove. To assess this and the spatial pattern of guano removal around cavity trees, we conducted short duration guano baiting experiments in late August and early September 2001. We placed 4 cm Petri dishes with measured amounts of guano (10 pellets per dish) on the floor inside basal hollows, externally on duff around the perimeter of the tree and on small temporary platforms on the tree bark at a height of 6 feet on 15 trees in the Mariposa Grove and 12 trees in the Merced Grove. Figure 14 shows the results as percent removed over three hours in the evening (19:00 to 23:00). In both groves, the harvest rate by ants was highest inside the basal hollows, and lowest six feet up the trunk. *Camponotus* is well known to excavate galleries in rotting wood (Hansen and Akre 1985, Holldobler and Wilson 1990), and ants were frequently observed exiting and entering subterranean tunnels both inside the basal hollows and around the base of the tree externally. The higher harvest rates observed in the Mariposa Grove suggest higher densities of carpenter ants in the Mariposa Grove.

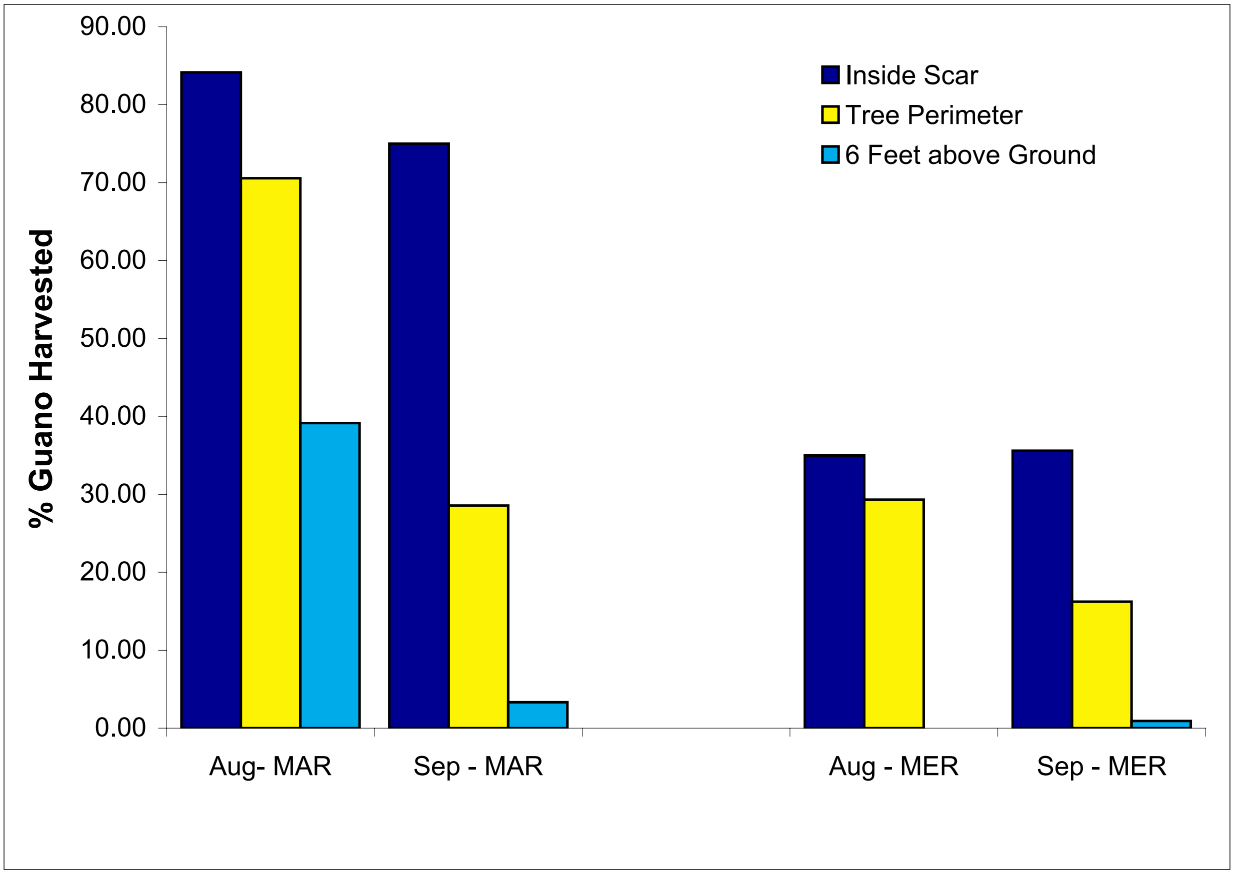


Figure 14. Bar graph showing the percent of guano harvest by ants in baiting experiments conducted in the Mariposa Grove (31 August and 10 September 2001) and the Merced Grove (29 August and 12 September 2001).

Night observation of carpenter ants on the debris traps inside tree hollows showed that they rapidly harvested bat guano, while typically not removing nearby bird droppings. Since both are a nitrogen resource, an explanation for the selectivity is not immediately obvious. Several studies report *Camponotus* species harvesting insect parts and vertebrate excrement, including bird droppings (Alsina *et al.* 1988, Grez *et al.* 1986). They actively seek nitrogen during periods of brood rearing (Cannon 1998, Cannon and Fell 2002). We found no reports of *C. modoc* harvesting bat guano, but research on ant foraging is typically conducted in daylight, so a resource only locally available and taken at night may have been missed. The primary energy source of *C. modoc* in giant sequoia forests appears to be aphid honeydew (Tilles and Wood 1982, 1986), which they transport from host trees to their nests. The aphids (*Cinara occidentalis*), which live in white fir (*Abies concolor*), appear to depend on attendance by *C. modoc* to reduce predation by other invertebrates.

The activity and perhaps the density of carpenter ants are greater in the Mariposa Grove than in the Merced Grove. In Giant Forest, a similar earlier tree hollow guano study did not reveal rapid guano removal by carpenter ants (Pierson and Heady 1996). Although the reasons for this are not known, there are several possible explanations. It may reflect vegetation differences from long-term fire suppression. Fire suppression favors the proliferation of white fir, so it is likely that white fir densities are higher in the Mariposa Grove than they would be under a natural fire regime. Piirto *et al.* (1998) examined samples of fire scarred sequoias at Giant Forest in three prescribed burn classes (1 year, 5 years, and at least 50 years since burned). They found that the proportion with carpenter ants increased significantly with time since burning (37% after 1 year, 60% after 5 years, 87% greater than 50 years). While the quantitative significance at the scale of the entire grove is not likely to be large, human visitor activity in the Mariposa Grove locally contributes to the nitrogen budget of carpenter ants. The sheltered sides and basal hollows of trees near paths serve as informal latrines, and we frequently observed ants aggregated around patches of urine.

3.2.1.2. Deposition of Guano and Culled Prey

The guano trap experiments revealed that all monitored trees in both the Mariposa and Merced Groves were used by bats, although the extent of use and seasonal patterns of use varied greatly among the trees. Figures 15 and 16 show the cumulative dry weight of guano collected from trees in the Mariposa and Merced groves in 2001. Two features of these graphs are notable. First, certain trees appear to be highly preferred by the bats. Tree #39 in the Mariposa Grove received far more bat use than any other. This tree is at the lowest elevation of any tree we monitored, suggesting that temperatures in the vicinity would generally be warmer than many other areas in the grove. Also, this tree is very close to Kiosk Creek, and is closer to perennial water than any other monitored tree. Additionally, this tree has multiple entrances to its very large basal hollow, offering abundant roosting habitat (although there were a number of the monitored trees that shared this feature). Possible explanations for the preferred use of Tree #19 in the Merced Grove are less clear. All trees in that grove are close to a flowing stream, and others have what appear to be equally suitable interior roosting space. We know from mist netting that this tree was used for day-roosting by at least three species, and contained reproductive females of two species (*Myotis thysanodes* and *Myotis evotis*).

The other striking feature of guano deposition patterns in both groves is that the periods of most intense use vary from tree to tree, and do not follow a similar seasonal pattern. In the Mariposa Grove, for example, the interval with the greatest guano accumulation occurred in June for Tree #426, July for Tree #43, August for Tree #447, and October for Trees #39 and #312. The trees in the Merced Grove show comparable variability.

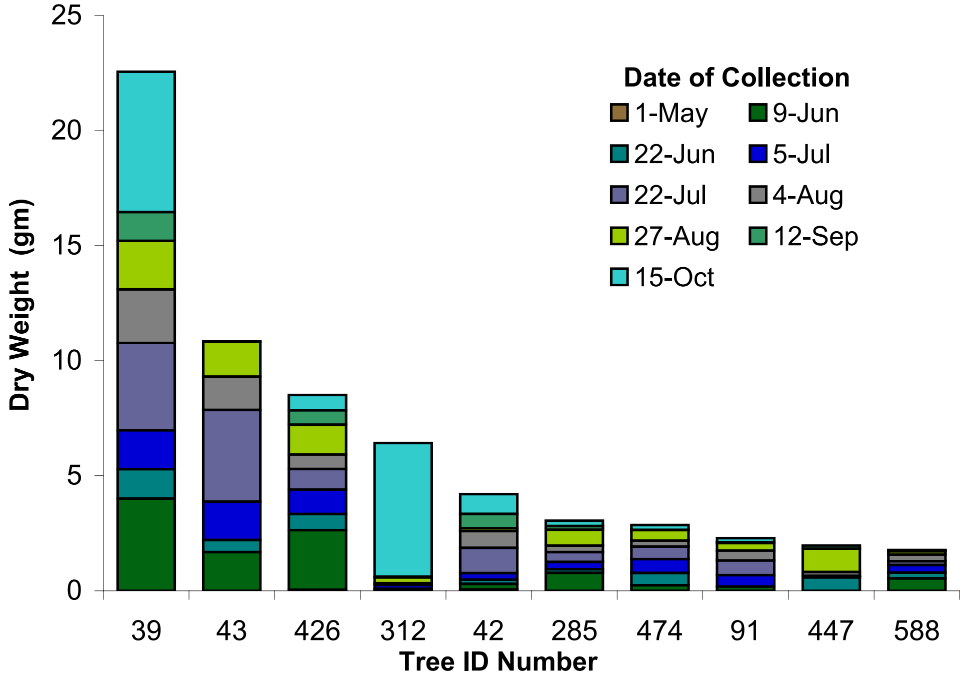


Figure 15. Bar graph showing cumulative dry wt of guano for the ten most heavily used trees in the Mariposa Grove in 2001.

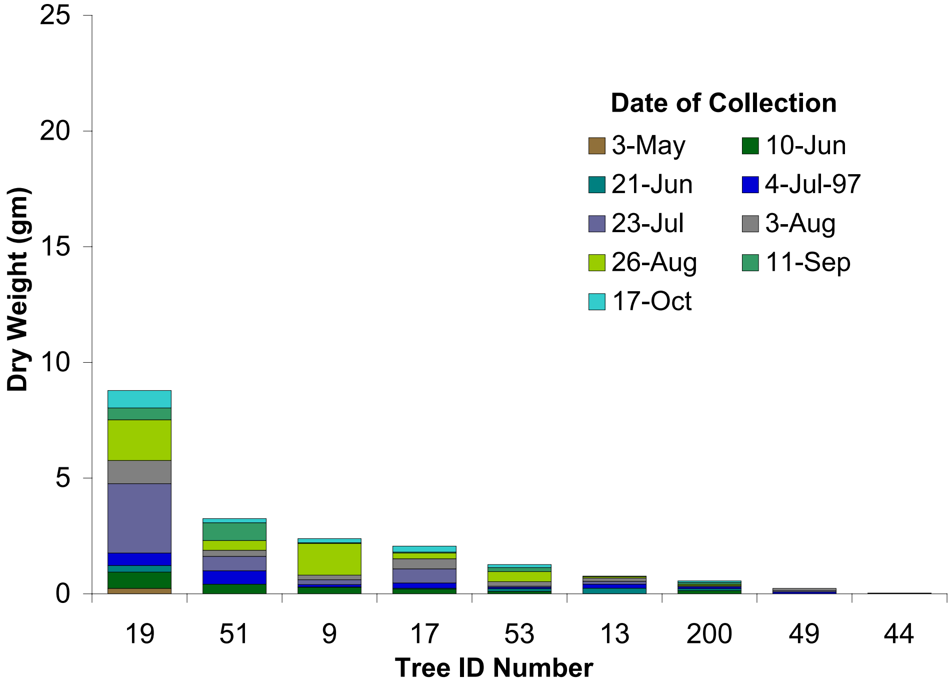


Figure 16. Bar graph showing cumulative dry wt of guano for all monitored trees in the Merced Grove in 2001.

Figures 17 and 18 show the seasonal patterns of guano accumulation for the ten most active trees in the Mariposa Grove and the five most active trees in the Merced Grove, and illustrate both the within tree, and tree to tree variability. Despite the differences among trees, there was an overall seasonal pattern to use of the basal hollows as indicated by the mean per day deposition of guano and culled prey across the sampling period. Figure 19 shows that the mean amount of deposition per day was comparable in the two groves. Using guano deposition as an index of bat activity, our data suggest that bat use of the trees increased from early June to late July in both groves, and then declined in both groves through the end of September. The peak activity in late July coincides with the time that newly flying young are entering the population. The most obvious difference between the two groves is the notable increase in bat use of some tree hollows between September and October in the Mariposa Grove and not in the Merced Grove. The reasons for this are unclear, although these results would be consistent with bats moving into the Mariposa Grove in preparation to hibernate there (see Section 3.2.3. below).

The size and shape of guano pellets provide some indication of which species were using the trees. At time of collection the guano pellets present in an individual tree were identified as "small," which would indicate use by one or more of the *Myotis* species, "large," which would indicate use by *E. fuscus* and/or *A. pallidus*, or "mixed," which would suggest that species in both categories had used the tree during that collection interval. Figure 20 shows the temporal distribution of guano by size category in the Mariposa Grove for the 2001 sampling season. Although there is considerable variation from one sampling session to the next, for all but two sampling periods there were more trees with small size guano than with mixed or large guano, suggesting extensive use of the trees by *Myotis* species. Guano collected in the Merced Grove is even more heavily dominated by "small" guano (Figure 21).

Arthropod parts, found in association with the guano and deposited by feeding bats, were collected at the same time as guano. Fifteen orders of insects and other arthropods were identified (see Appendix V). Although in most cases it is not possible to identify the bat species from its prey item, there are two ground-dwelling arthropods (Jerusalem crickets, *Stenopelmatus fuscus*, and scorpions) that are thought to be highly specific prey items for pallid bats.

We screened all the culled insect parts for Jerusalem crickets and/or scorpions and found that over the course of the study 16 of the 27 monitored trees were used by pallid bats. Figure 22 depicts, for the 27 monitored trees in the Mariposa Grove, the temporal distribution of use by pallid bats in 2001. Use, as indicated by Jerusalem cricket and/or scorpion parts, appeared to be heaviest in late August and early September, with as many as 10 trees used in any one sampling period. Figure 23 shows for each of the monitored trees the proportion of samples that contained pallid bat prey. The trees receiving the heaviest use by pallid bats, in descending order, were #42 in the Middle Grove, #39 in the Lower Grove, and #508 in the Upper Grove. A dead pallid bat was found in #508 on 10 June 2001.

The results for the Merced Grove were strikingly different. We found no culled parts for either Jerusalem crickets or scorpions in this grove. Large guano was found far less frequently, and none looked like pallid bat guano. We did find cerambycid (long-horned) beetle parts in six out of nine trees at some point during the two years of sampling. While we know that pallid bats favor cerambycid beetles, we do not know to what extent other bat species consume these

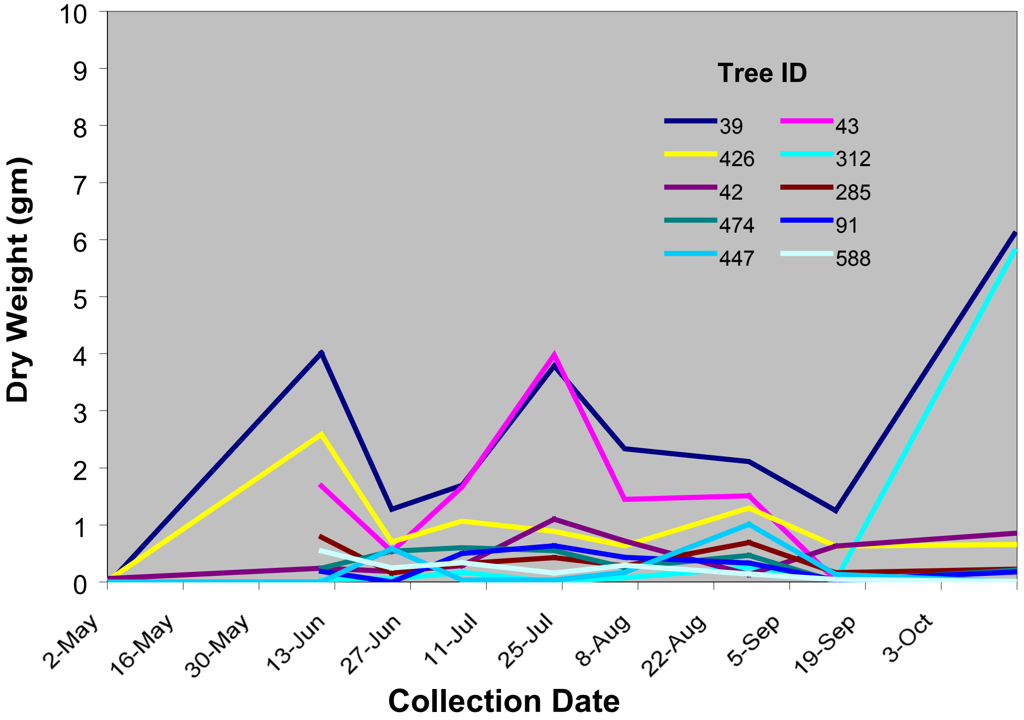


Figure 17. Seasonal patterns of guano accumulation for the ten most active trees in the Mariposa Grove in 2001.

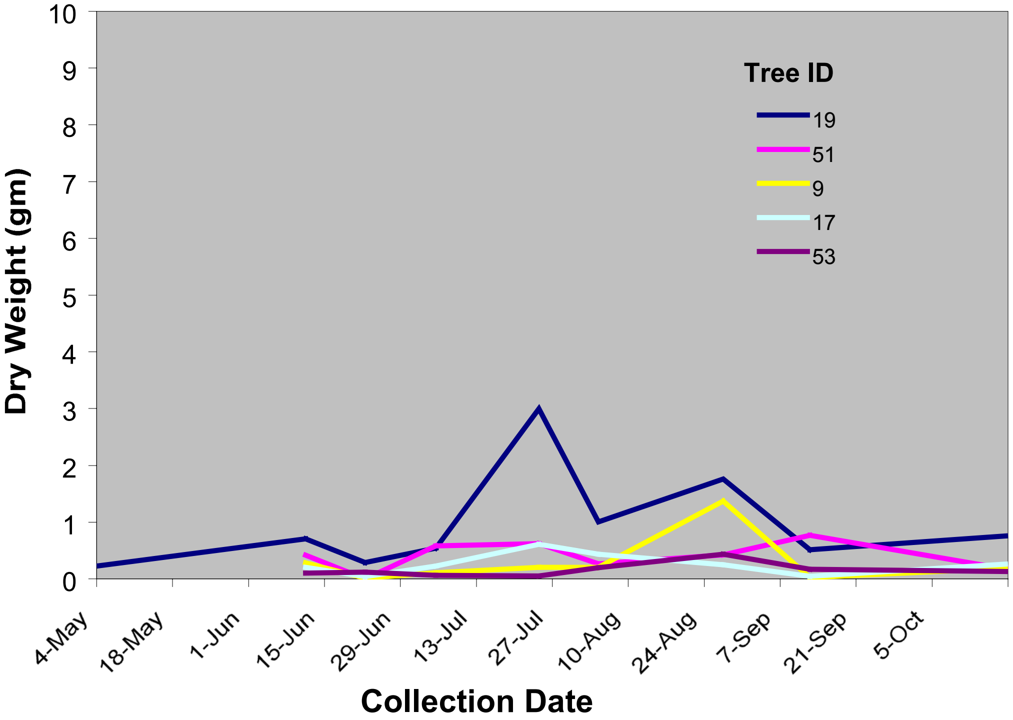


Figure 18. Seasonal patterns of guano accumulation for the five most active trees in the Merced Grove in 2001.

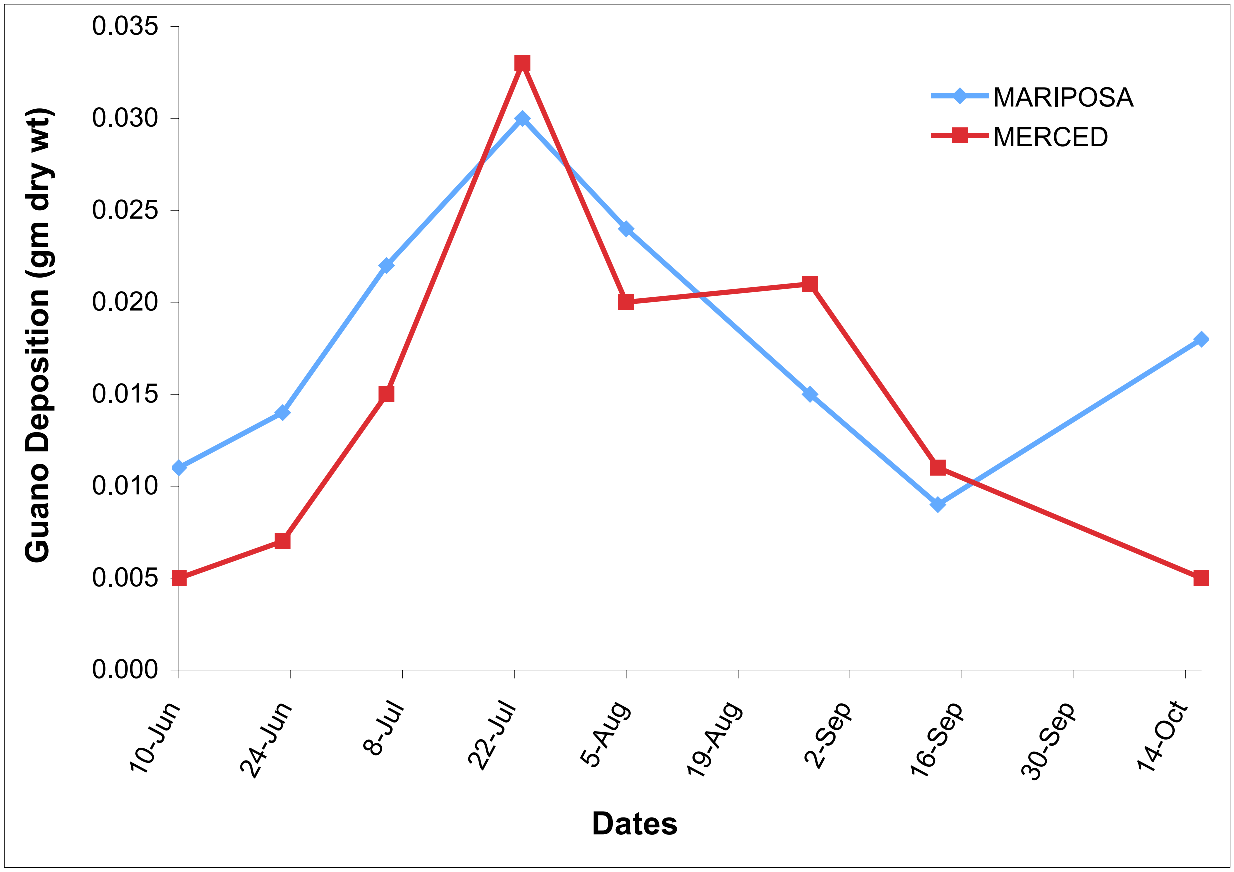


Figure 19. Line graph comparing mean guano deposition (gm dry wt) per day across sampling period in the Mariposa and Merced groves in 2001.

beetles, particularly those (*e.g.*, *E. fuscus* and *M. thysanodes*) thought to be beetle specialists. Cerambycid beetle parts were also prevalent in the Mariposa Grove, being found in many trees known to be used by pallid bats, plus five additional trees not identified by any other criteria as pallid bat trees.

3.2.2. Bat Use of Basal Hollows as Assessed by Observation and Capture

While the guano traps provided documentation that bats were using all the basal hollows, it was not clear to what extent these sites were being used as night roosts for foraging bats or as daytime refugia. To assess daytime use we monitored 22 trees (19 in the Mariposa Grove and 3 in the Merced Grove) at emergence time (sunset to one hour after sunset) by observing the entrance with night vision equipment and/or setting nets over the entrance. We identified two trees being used as day roosts by colonies of bats (Tree #132, the Clothespin Tree, in the Mariposa Grove and Tree 19 in the Merced Grove) and three others (#39 and #42 in the Mariposa Grove and Tree #44 in the Merced Grove) that likely had colonies at some point during the season. Three trees had one to three individual bats roosting at the time of observation. Six species were identified as using the basal hollows (Table 6), and two *(M. evotis* and *M. thysanodes*) were identified as using basal hollows as nursery sites.

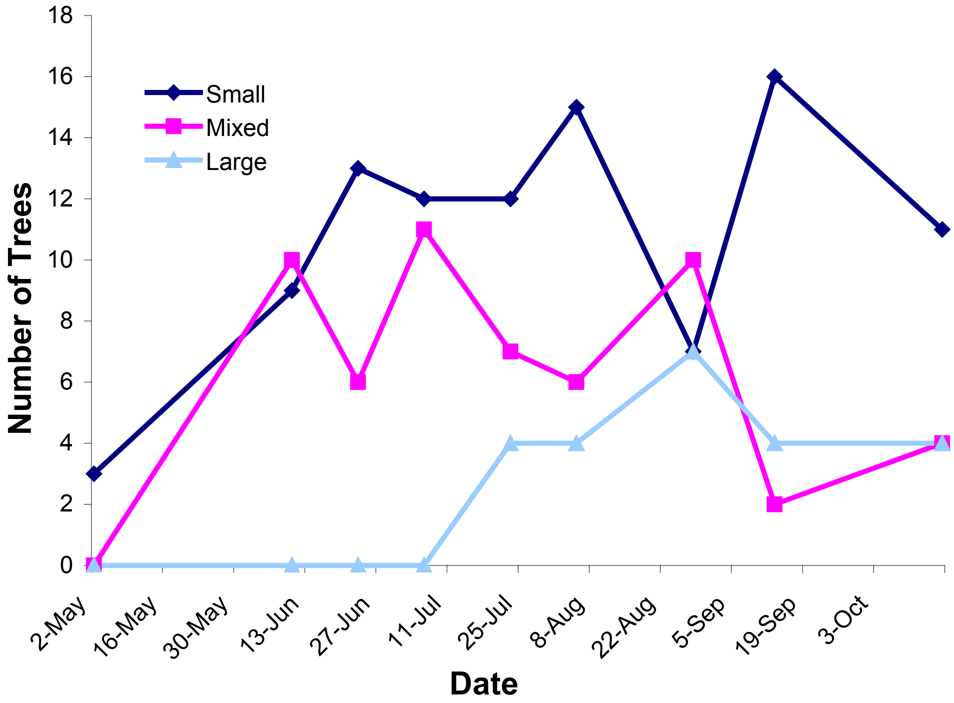


Figure 20. Temporal distribution of guano by size classes (large, medium and small) in Mariposa Grove in 2001.

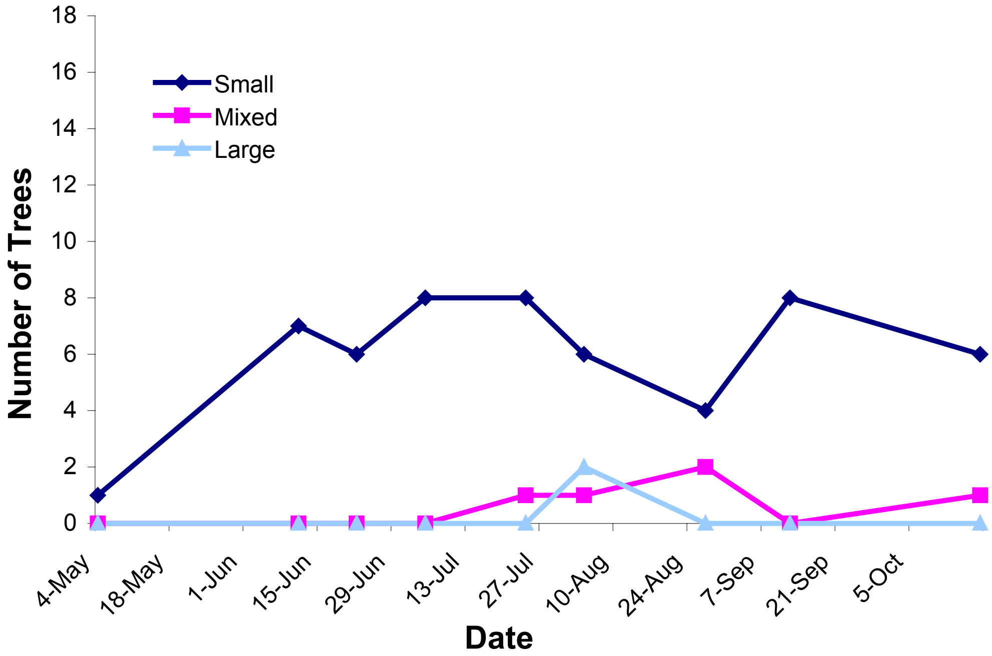


Figure 21. Temporal distribution of guano by size classes (large, medium and small) in Merced Grove in 2001.

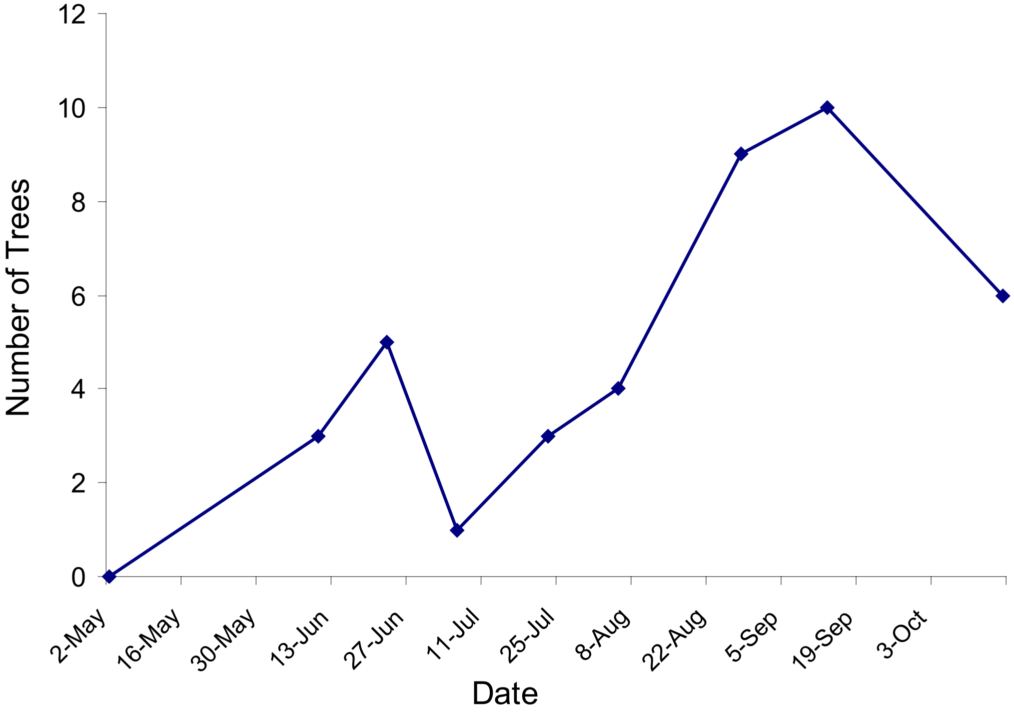


Figure 22. Temporal distribution of use of monitored trees by pallid bats in Mariposa Grove in 2001.

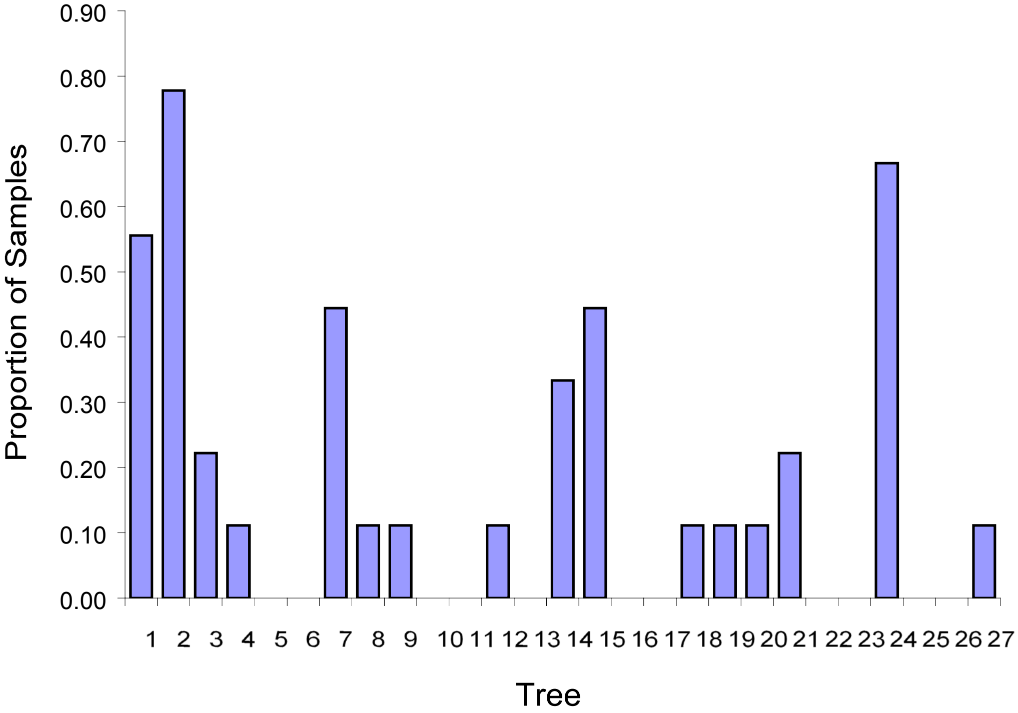


Figure 23. Proportion of use attributable to pallid bats for all monitored trees in Mariposa Grove in 2001.

Table 6. Bat species identified by mist-netting, or night vision/acoustic monitoring as using specific basal hollows.

Species	Mariposa Grove Tree ID	Merced Grove Tree ID
Antrozous pallidus	39, 42	
Eptesicus fuscus		44
Myotis californicus	42, 280, 285, 474	44
Myotis evotis	39, 132, 311, 312, 314	19, 44
Myotis thysanodes	124, 285	19, 44
Myotis volans	311, 426	19, 44

3.2.3. Winter Use of Giant Sequoias

Table 7 provides data on the nine giant sequoia trees that were monitored as potential hibernation sites. Temperature monitors were installed inside basal hollows, with one sensor placed on the interior wall just above the hollow entrance at 2.4-6.3 m, and the other on a cable inside a ceiling crevice (2.4-7.4 m above the ground). Seven of the nine temperature monitors yielded data on retrieval after two winters. One was missing altogether; rodents had chewed others. In some cases the cables had been cut by the rodent bites, typically in the second winter.

Figure 24a & b shows temperature records comparing ambient and internal temperatures for five trees in the Mariposa Grove and two in the Merced Grove. Ambient temperature, (plotted with Tree #124 in the Mariposa Grove and Tree #19 in the Merced Grove) fluctuates widely on a daily basis, and in the winter months often drops as low as -10°C. For all the trees, the sensor that was mounted on the interior wall of the basal hollow (= logger int) just above the entrance was more stable than ambient, but also fluctuated daily. The sensor mounted on a cable (= cable sens), and inserted 1.7 –5.8 m into a crevice extending upward from the basal hollow varied slowly, showing substantial lag as changes in the average external temperature propagated through the tree.

The DBH of trees yielding data ranged from 268 to 624 cm and the amount of wood insulating the extension probe from exterior air at ambient temperature varied considerably. Despite that variation, temperature in crevices remained above freezing throughout the winter. The typical temperature range in these crevices during the hibernation season, October to April, was between 3° and 10°C, matching the temperature range reported for hibernation by a number of bat species (Webb *et al*. 1996). This group includes *Eptesicus fuscus* (Beer and Richards 1956), one of the species most likely to be using the giant sequoias for hibernation. Because the temperature range of the hollows matches documented temperatures of hibernacula, we hypothesize that the giant sequoia hollows are used as hibernating sites by bats.

Table 7. Data on the seven trees in the Mariposa Grove and two trees in the Merced Grove in which temperature probes were installed to monitor for winter temperatures.

Grove	**Tree Number**	**Logger Number**	**Date Installed**	**Date Collected**	**DBH (cm)**	**External Opening (m)**	**Scar Type**	**Logger/Sensor #1 Height (m)**	**Lead/Sensor #2 Length (m)**	**Condition**
Mariposa	42	8	01-Nov-00	31-May-02	339	7.4	Catface	3.0	1.8	chewed
Mariposa	124	1	01-Nov-00	31-May-02	268	2.8	Core	2.4	1.8	intact
Mariposa	311	4	01-Nov-00	31-May-02	590	5.8	Core	6.1	1.7	intact
Mariposa	474	3	01-Nov-00	31-May-02	607	2.5	Core	7.4	1.7	chewed
Mariposa	588	2	01-Nov-00	31-May-02	624	5.5	Catface	5.6	1.7	Missing
Mariposa	285	9	15-Nov-00	31-May-02	471	5.6	Core	6.3	5.8	chewed
Mariposa	524	7	15-Nov-00	31-May-02	451	3.6	Core	4.9	1.7	intact
Mariposa	Ambient*									
Merced	19	6	16-Nov-00	30-May-02	451	5.0	Core	6.3	5.9	chewed
Merced	53	5	16-Nov-00	30-May-02	508	2.5	Core	3.7	4.5	chewed
Merced	Ambient		16-Nov-00	30-May-02				3.5		

* California Department of Forestry permanent weather station

Figure 24a. Temperature profiles for five trees in the Mariposa Grove monitored as potential hibernating sites. Local ambient temperature is shown in conjunction with the profile for Tree #124.

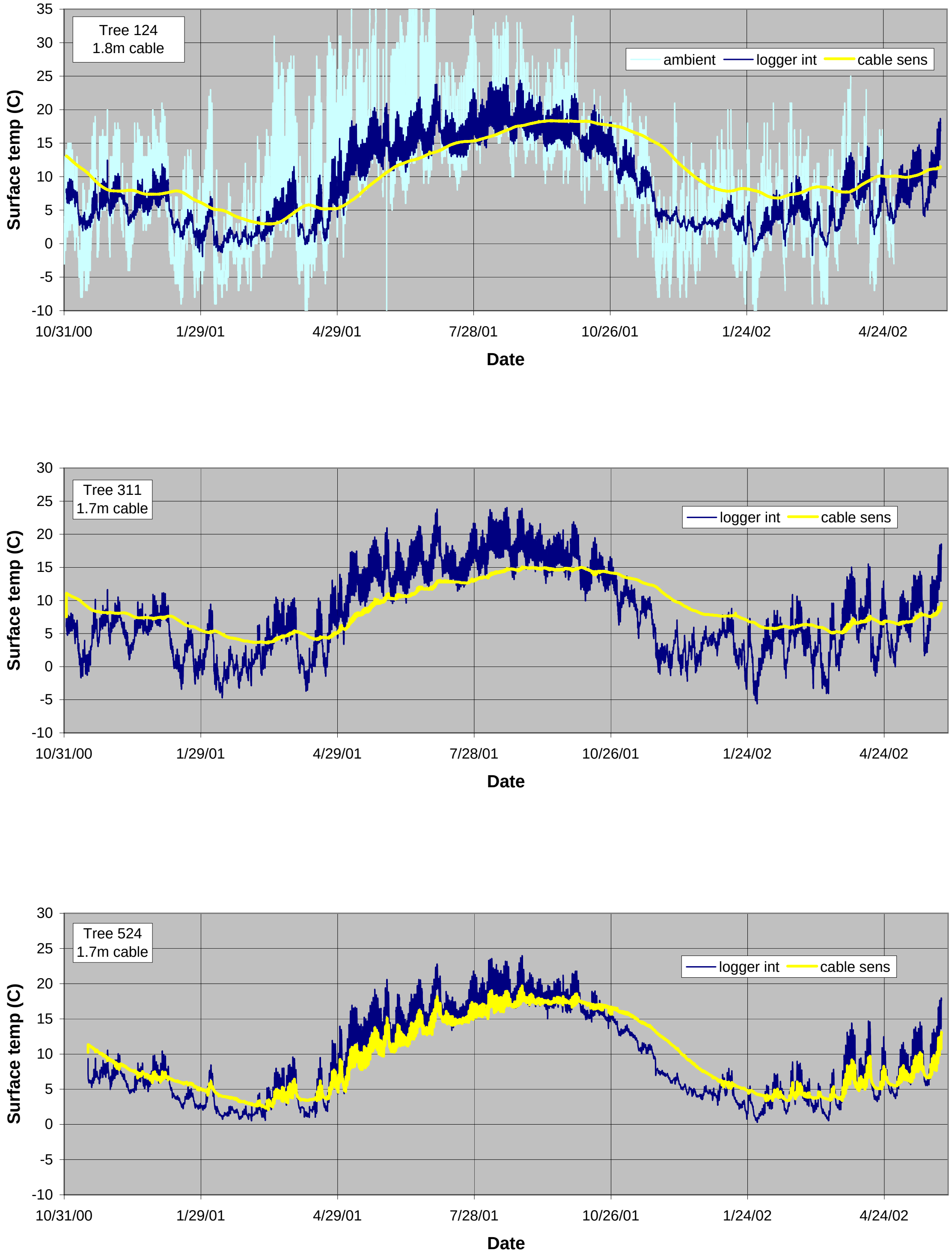
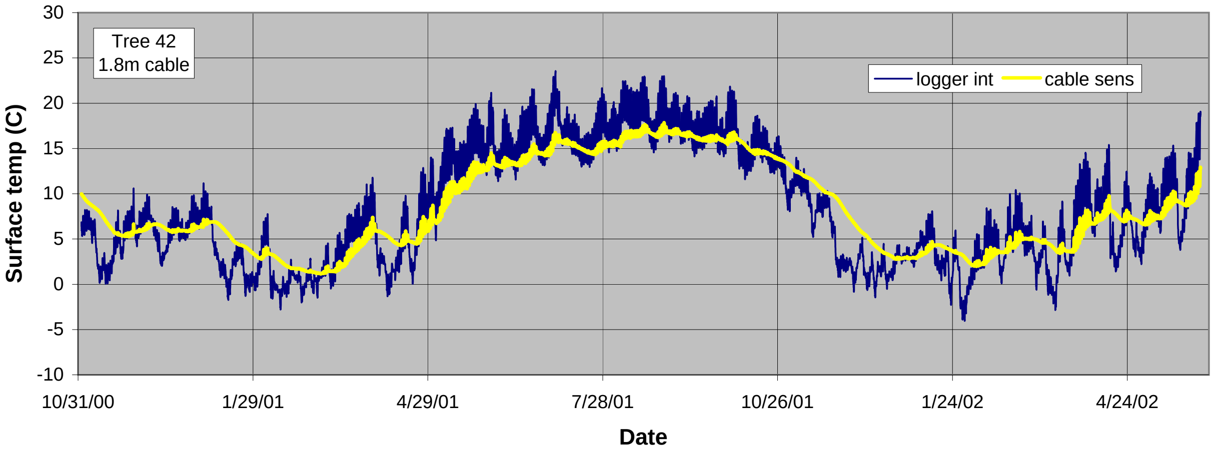


Figure 24a (cont'd.)



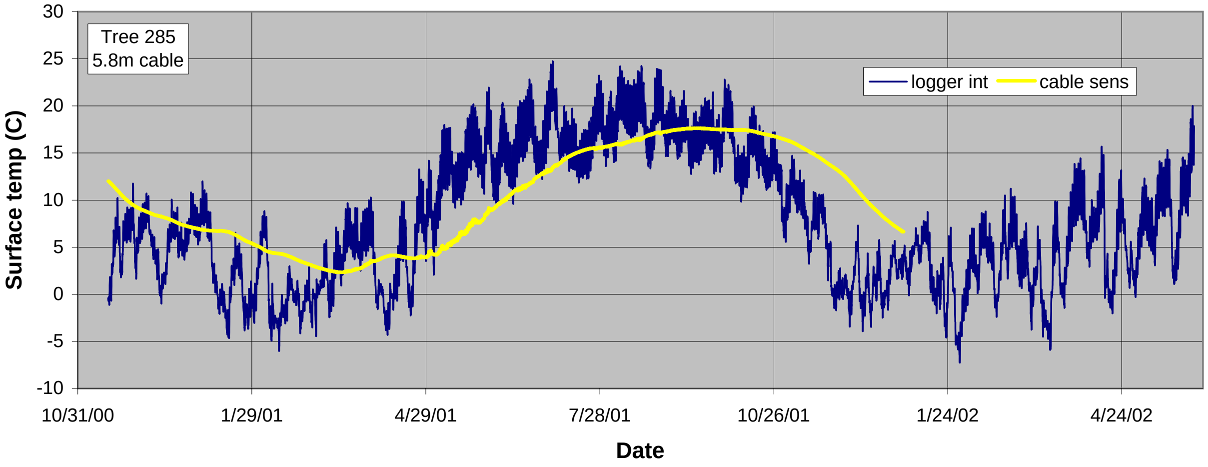
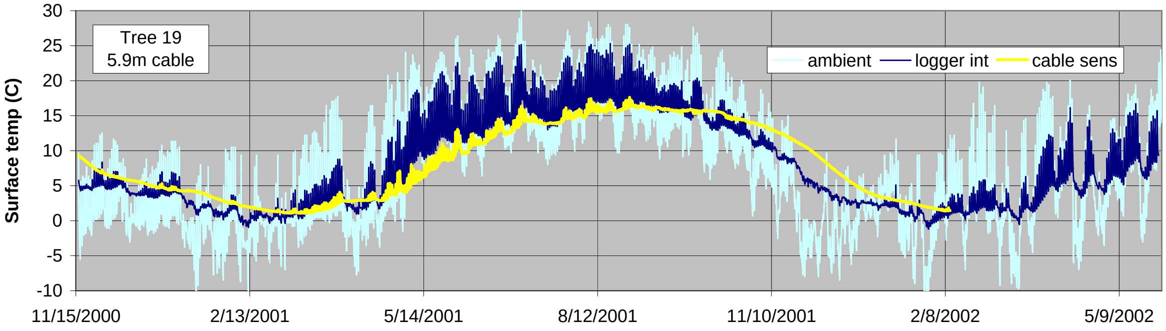
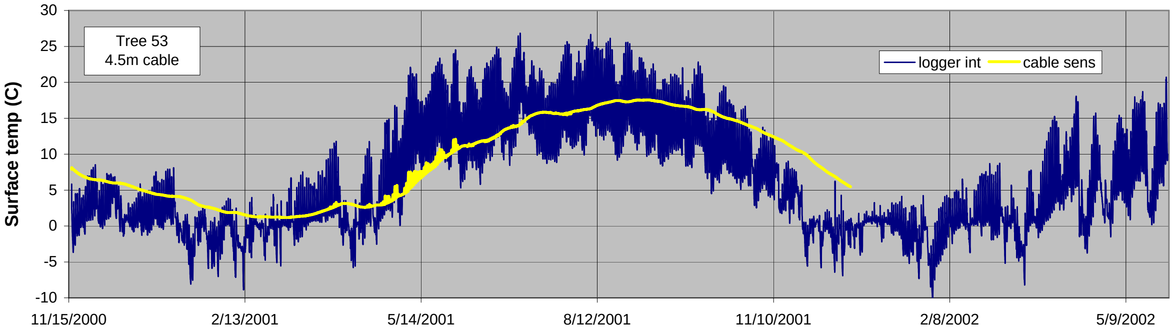


Figure 24b. Temperature profiles for two trees in the Merced Grove monitored as potential hibernating sites. Local ambient temperature is shown in conjunction with the profile for Tree #19.





Bats arouse periodically during hibernation, and are briefly active at intervals of several days (Brack and Twente 1985, Thomas and Geiser 1997). Several western North American species (*e.g., A. pallidus*, *E. maculatum*, *P. hesperus*, *E. fuscus*) have been observed flying in winter at air temperatures close to freezing (Lausen 2005, O'Farrell and Bradley 1970, Ruffner *et al.* 1979). To sample winter bat activity, we conducted overnight acoustic sampling at five stations between 29 December 2000 and 02 January 2001, when snow levels were low enough for vehicle access to transport equipment to the Mariposa Grove. The data are summarized in Table 8. We obtained multiple acoustic detections at all stations, with the records dominated by a 50 kHz *Myotis* (most likely *M. californicus*) and bats echolocating at 25 kHz, predominantly *E. fuscus*. Although records were distributed throughout the night, the majority were at dusk, suggesting that the echolocating bats were roosting in the vicinity of the detectors, in areas where trees offered the only roosting options. Improvements in acoustic monitoring technology would now make it possible to monitor activity through the winter in the groves.

Table 8. Winter acoustic detections for bats in the Mariposa Grove, 29-30 December 2000 and 02 January 2001.

Date	**Locality**	**Q25**	**M50**	**Eupe**	**Totals**
12/29/00	Kiosk Creek	31	1		32
12/30/00	nr. Tree 484	7	35		42
	nr. Tree #426	20	2	4	26
1/2/01	Sunset Rock	7	4	2	13
	Three Graces	4			4

3.2.4. Bat Foraging near the Canopy of Giant Sequoias

On three occasions, 31 August 2000, 3 July 2001, and 26 July 2001, we launched a radio linked bat detector 67 m above the forest floor via a helium balloon to sample for bat activity from dusk to midnight near the canopy of the giant sequoias. Maximum heights in the canopy of adjacent trees (measured with a laser range finder) were 78 and 82m. Figure 25 summarizes the results and suggests several patterns. First, simultaneous sampling at the canopy and ground levels showed different levels of bat activity and different species. On two nights, activity at the canopy exceeded that on the ground, and on the third night it was the reverse. Also, although the number of species detected each night was comparable at the two heights (8 from the balloon, 7 from the ground), only four were the same. Some species detected in the canopy were among those that we generally associate with foraging relatively low over the ground – *e.g.*, *Myotis evotis, Myotis thysanodes*, and *Lasiurus blossevillii*. More extensive acoustic monitoring from dedicated canopy access structures in the U.S. Pacific Northwest and Canada has also shown differences in activity with height and changes in the height of peak activity with time of night (Hayes and Gruver 2000, Kalcounis *et al.* 1999) Like other forest edges, the irregular interface at the top of the canopy is an important foraging zone for fast flying bats, such as *L. cinereus* (Kalcounis *et al.* 1999). In our experience balloon position was very sensitive to small shifts in wind speed and

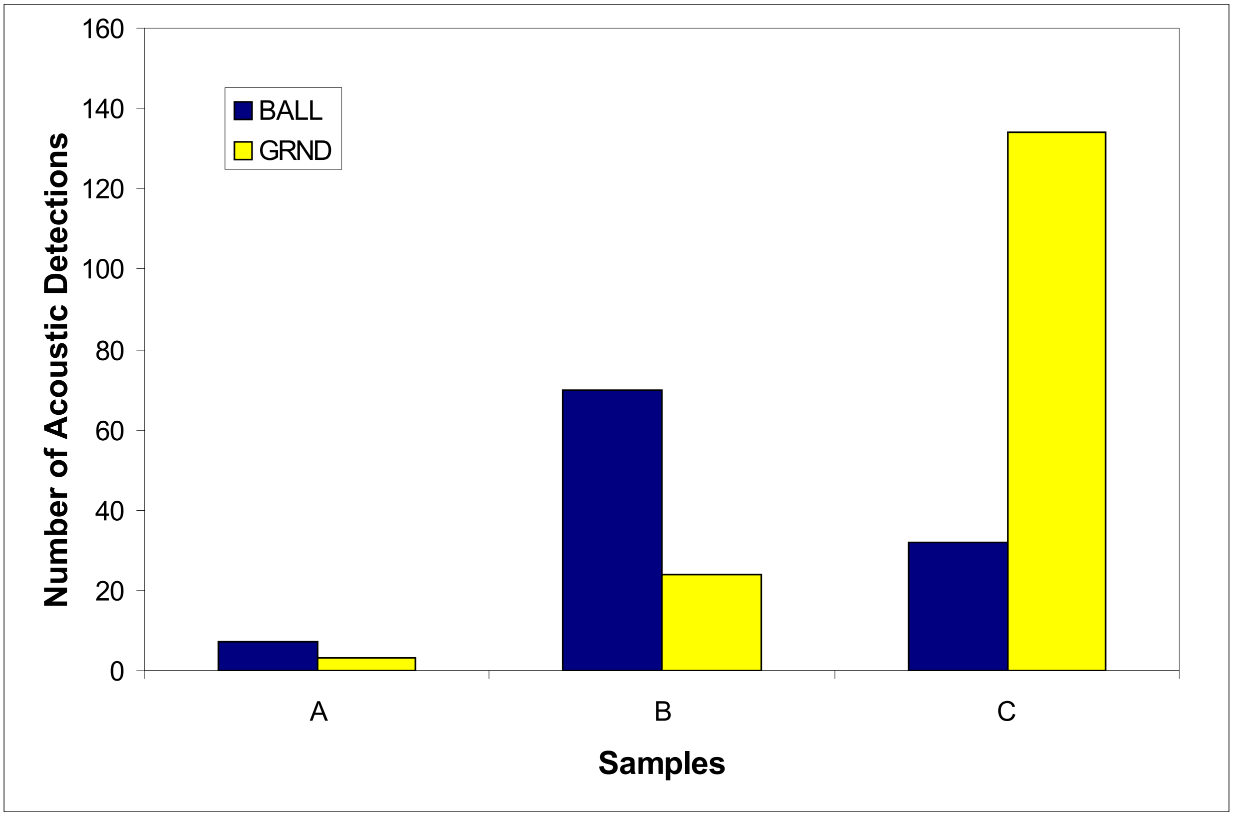


Figure 25. Comparison of number of acoustic detections obtained during simultaneous sampling at canopy level from a balloon (BALL) and on the ground (GRND).

direction even at very low wind speeds and lift was affected by dew condensation as temperatures fell, so the system had to be monitored closely by several operator/observers. The system offered a highly portable method for short-term exploration in low wind conditions, but longer duration sampling would seem to favor a temporary rigid structure or short-term attachments on natural features.

During a trial with the balloon radio detector in an open area of Wawona Meadow, we observed in natural light at dusk and subsequently by spotlight, that bats of a number of species, including *L. noctivagans L. cinereus*, *T. brasiliensis, M. evotis*, *E. perotis* and a 40 kHz *Myotis*, closely approached the balloon or the tether lines and produced echolocation sequences resembling feeding buzzes. *L. cinereus* appeared to strike the lines. *E. maculatum* were frequently recorded from the ground during the balloon flight, but were not observed to respond to the balloon.

Touching the tether lines from the balloon revealed that they were vibrating under tension. These brief observations do not resolve what caused the equipment to attract an ecologically diverse array of bats (*e.g.*, a large novel object in foraging area; lines vibrating perhaps near the wingbeat frequencies of insects). At least in this locale, while balloon monitoring offered information on bats in the vicinity, the rapid intensification of local activity indicated that, over a few hours, the system could be an attractant rather than a passive platform for observation of bat activity at selected heights above the ground.

3.3. Radio telemetry Study in the Mariposa Grove

We radio-tracked 16 bats of five species (10 *Eptesicus fuscus*, 2 *Lasionycteris noctivagans*, 2 *Myotis volans,* 1 *Myotis thysanodes*, 1 *Antrozous pallidus*) in late summer 2001. These individuals were captured in five different netting sessions, conducted between 27 July and 3 August, and outfitted with Holohil transmitters. The weight of the transmitters was within the recommended limit of 5.0 % of body weight (Aldridge and Brigham 1988) for all except two individuals (the *M. thysanodes* and one *M. volans*) (Table 9).

We attempted to locate the roost of every radio-tagged animal, every day from July 28 through August 10. Additionally, two to six observers followed animals for the first three to four hours of foraging on every night except the four nights (27 and 31 July 27, 1 and 3 August) when all available personnel were involved in capturing and tagging animals.

3.3.1. Roost Sites

3.3.1.1. Overview

We located a total of 32 roosts for 15 individuals. The 32 roost sites were distributed among four tree species trees (six in ponderosa pines, thirteen in sugar pines, seven in giant sequoias, three in white firs) and three roosts in the rock-outcrop area below Wawona Point (Table 10). The only tree that was used by more than one radio-tagged individual was the giant sequoia known as the Sunset Tree (Figure 26). This tree was used by three individuals. Thus the seven giant sequoia roosts were distributed among five trees, all of which were located in the Sunset area, near the Sunset Tree or in trees adjacent to the meadow on the south side of the road.

Of the 29 tree roosts, 21 were in snags, four were in live giant sequoias, one was in a live ponderosa pine, and three occurred in a single live giant sequoia with a dead top (Tree #219, the Sunset Tree). There were 13 roosts identified under flaking bark, three in bark crevices, three in tree cracks or holes, two in top hollows, and three in rock crevices. The roost trees were an average of 1.32 times the height of the surrounding canopy (range 1.00-2.50, n = 18). Twenty of the 27 trees used as roosts were in a relatively advanced decay stage (IV or V, dead with loose bark, or dead with most bark missing respectively). Figure 27 provides a photograph of one of the identified roost trees, typical of many of the roosts in its size and stage of decay.

3.3.1.2. Roost Selection

The relative abundance and size distribution of the five dominant tree species in the Mariposa Grove (*Abies concolor*, *Calocedrus decurrens*, *Pinus lambertiana*, *Pinus ponderosa*, and *Sequoiadendron giganteum*) were compiled from data for 11 prescribed fire monitoring plots (FABCO1T08-09, FABCO1T08-10, FABCO1T08-11, FABCO1T08-12, FABCO1T08-13, FABCO1T08-14, FSEGI1T08-01, FSEGI1T08-02, FSEGI1T08-03, FSEGI1T08-04, FSEGI1T08-05), provided to us by park staff (Monica Buhler, Fire Ecologist, Ecology and Fuels, Yosemite NP). Only trees with a DBH >20 cm were included in the analysis. Figure 28 shows the distribution of these plots within the Mariposa Grove.

Table 9. Capture data for bats mist-netted in the Mariposa Grove (July & August 2001) and outfitted with radio-transmitters.

Date	Locality	Species	Sex	Age	Reproductive Condition	Forearm (mm)	Wt (g)	Transmitter ID
27-Jul-2001	Kiosk Creek (N.37.50026 W119.60944, 1684 m)							
		Eptesicus fuscus	F	A	Post-Lactating	46.92	21.96	151.632
		Lasionycteris noctivagans	M	A		41.75	11.55	151.592
		Myotis thysanodes	F	A	Post-Lactating	38.83	6.77	151.574
		Myotis volans	M	A		39.84	8.74	151.610
31-Jul-2001	Meadow, Upper Grove (N37.51558 W119.60184, 2002 m)							
		Eptesicus fuscus	F	A	Post-Lactating	45.54	21.36	151.652
		Eptesicus fuscus	M	A	Scrotal	46.97	18.34	151.670
		Eptesicus fuscus	M	A	Scrotal	46.09	16.55	151.611
1-Aug-2001	Rattlesnake Dome (N37.51441 W119.60571, 1950 m)							
		Eptesicus fuscus	F	A	Post-Lactating	45.02	20.47	151.203
3-Aug-2001	Boundary Creek (N37.49952 W119.59823, 1806 m)							
		Antrozous pallidus	F	A	Lactating	55.53	20.65	151.954
		Eptesicus fuscus	F	A	Post-Lactating	45.63	19.15	151.934
3-Aug-2001	Kiosk Creek (N.37.50026 W119.60944, 1684 m)							
		Eptesicus fuscus	F	A	Post-Lactating	46.83	18.51	151.244
		Eptesicus fuscus	F	J		45.57	14.21	151.260
		Eptesicus fuscus	F	A	Post-Lactating	48.47	18.23	151.103
		Eptesicus fuscus	F	A	Post-Lactating	48.61	21.04	151.119
		Lasionycteris noctivagans	M	A		39.84	10.01	151.043
		Myotis volans	M	A		39.80	6.74	151.022

Table 10. Summary of day roosts indicating tree species used as roost, condition of tree, roost type, DBH, tree height, Tree Height/Canopy Height, and the coordinates (NAD27 CONUS). ND = No data, NA = Not applicable. * = same general area as 632A&B; mgs = mean giant sequoias.

Roost I.D.	Bat Species	Tree Species	Condition	Decay Stage	Roost Type	DBH (cm)	tree ht (m)	tree ht/ canopy ht	Latitude	Longitude
203A	*E.fuscus*	giant sequoia #219	live/dead top	2	unknown	652	68	mgs	37N51605	119W60377
632E	*E.fuscus*	giant sequoia #216	live	1	unknown	443.5	57	mgs	37N51663	119W60347
632F	*E.fuscus*	giant sequoia #219	live/dead top	2	top hollow	652	68	mgs	37N51605	119W60377
670B	*E.fuscus*	giant sequoia #219	live/dead top	2	unknown	652	68	mgs	37N51605	119W60377
670A	*E.fuscus*	giant sequoia #222	live	2	unknown	815	74	mgs	37N51973	119W60313
652D	*E.fuscus*	giant sequoia #245	live	1	bark crevice	480	82	mgs	37N51487	119W00160
652C	*E.fuscus*	giant sequoia #282	live	2	flaking bark	645	77	mgs	37N51487	119W60108
652A	*E.fuscus*	ponderosa pine	dead	4	flaking bark	152.5	45	2.50	37N51141	119W60516
592A	*L.noctivagans*	ponderosa pine	live	1	unknown	144	44/66	1.36	37N50619	119W60425
592B	*L.noctivagans*	ponderosa pine	dead	5	flaking bark	132.5	47	1.57	37N50796	119W60463
574A	*M.thysanodes*	ponderosa pine	dead	5	flaking bark	151	52	1.38	37N50196	119W60340
574B	*M.thysanodes*	ponderosa pine	dead	4	unknown	164.5	28/69	1.90	37N50316	119W60360
610A	*M.volans*	ponderosa pine	dead	4	bark crevice	148	50	1.00	37N50536	119W60255
103A	*E.fuscus*	sugar pine	dead	5	unknown	150	70	1.64	37N504320	119W612680
103B	*E.fuscus*	sugar pine	dead	5	flaking bark	165	49	1.15	37N50326	119W61303
119A	*E.fuscus*	sugar pine	dead	5	crack/hole	169	61	1.48	37N50084	119W61010
244A	*E.fuscus*	sugar pine	dead	5	flaking bark	135	61	ND	37N50144	119W60925
632C	*E.fuscus*	sugar pine	dead	4	flaking bark	152.5	55	1.38	37N51705	119W60212
652B	*E.fuscus*	sugar pine	dead	5	crack/hole	132.5	41	1.06	37N51140	119W60419
934A	*E.fuscus*	sugar pine	dead	4	flaking bark	149	48	ND	37N49839	119W59584
43A	*L.noctivagans*	sugar pine	dead	4	flaking bark	143	50	1.08	37N50928	119W60167
43B	*L.noctivagans*	sugar pine	dead	4	crack/hole	126	48	1.96	37N50776	119W60023

Table 10. cont'd.

Roost I.D.	Bat Species	Tree Species	Condition	Decay Stage	Roost Type	DBH (cm)	tree ht (m)	tree ht/ canopy ht	Latitude	Longitude
574C	*M.thysanodes*	sugar pine	dead	4	flaking bark	236	26/60	1.52	37N50162	119W60571
574D	*M.thysanodes*	sugar pine	dead	6	top hollow	108	ND	ND	37N49590	119W61050
22A	*M.volans*	sugar pine	dead	4	flaking bark	143	43	ND	37N51536	119W58855
610B	*M.volans*	sugar pine	dead	4	flaking bark	149	54	1.35	37N50273	119W60183
260A	*E.fuscus*	white fir	dead	5	flaking bark	84.5	43	ND	37N50175	119W62014
611A	*E.fuscus*	white fir	dead	4	flaking bark	105.5	44	1.38	37N51515	119W60527
670C	*E.fuscus*	white fir	dead	4	unknown	83	19	ND	37N51533	119W60331
632A	*E.fuscus*	rock		NA	crack	NA	NA	NA	37N51759	119W60181
632B	*E.fuscus*	rock		NA	crack	NA	NA	NA	37N51769	119W60195
632D	*E.fuscus*	rock		NA	rock	NA	NA	NA	ND*	ND*

Decay Stages

1 Live, healthy; no decay; no obvious defects
2 Live, usually unhealthy; obvious defects
3 Recently dead; dead needles present; little decay
4 Dead; no needles, few twigs; top often broken; <50% branches lost; bark loose
5 Dead; most branches and bark lost; top broken
6 Dead; no branches or bark; broken off along mid-trunk

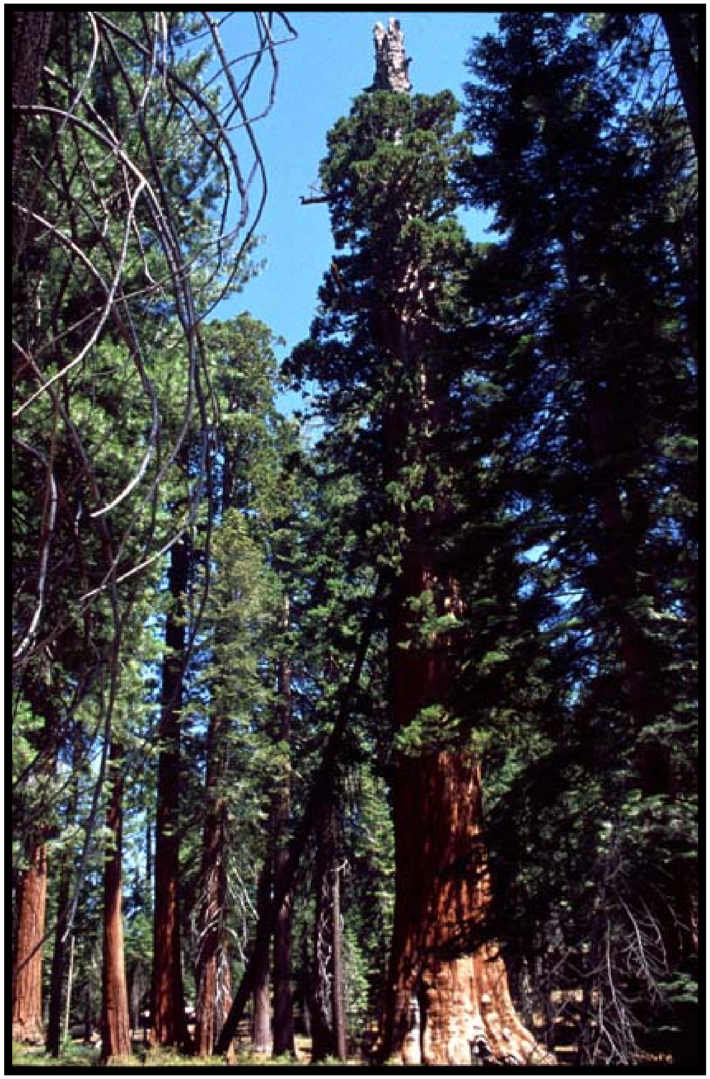


Figure 26. Photograph of Sunset Tree, used as a roost by three radio-tagged *E. fuscus*. The most likely roosting area is the lightning scar at the top of the tree.

Figure 27. Photograph of a sugar pine, used as a roost tree by *Lasionycteris noctivagans* #43.

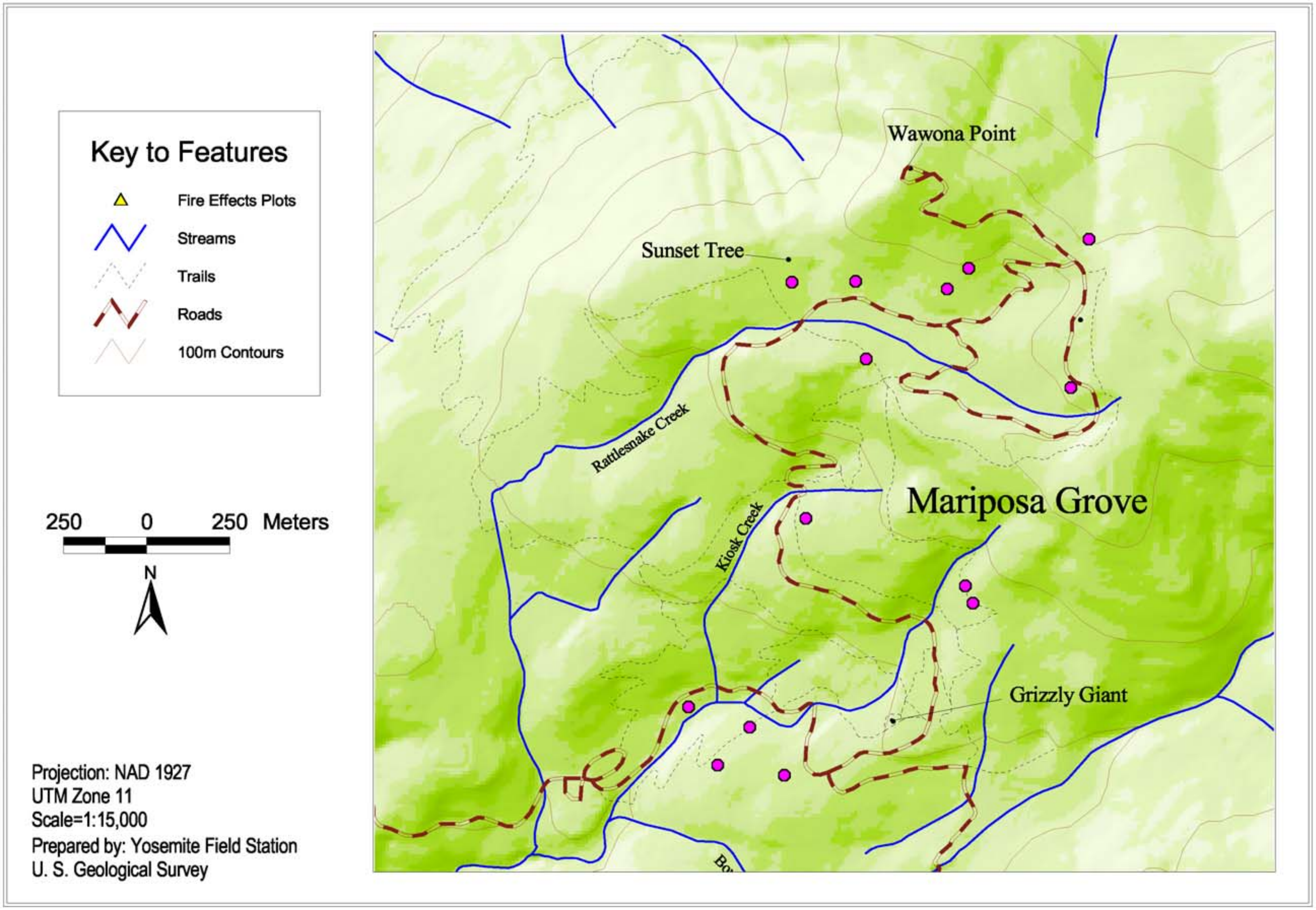


Figure 28. Map showing distribution of fire plots within the Mariposa Grove, Yosemite National Park, California

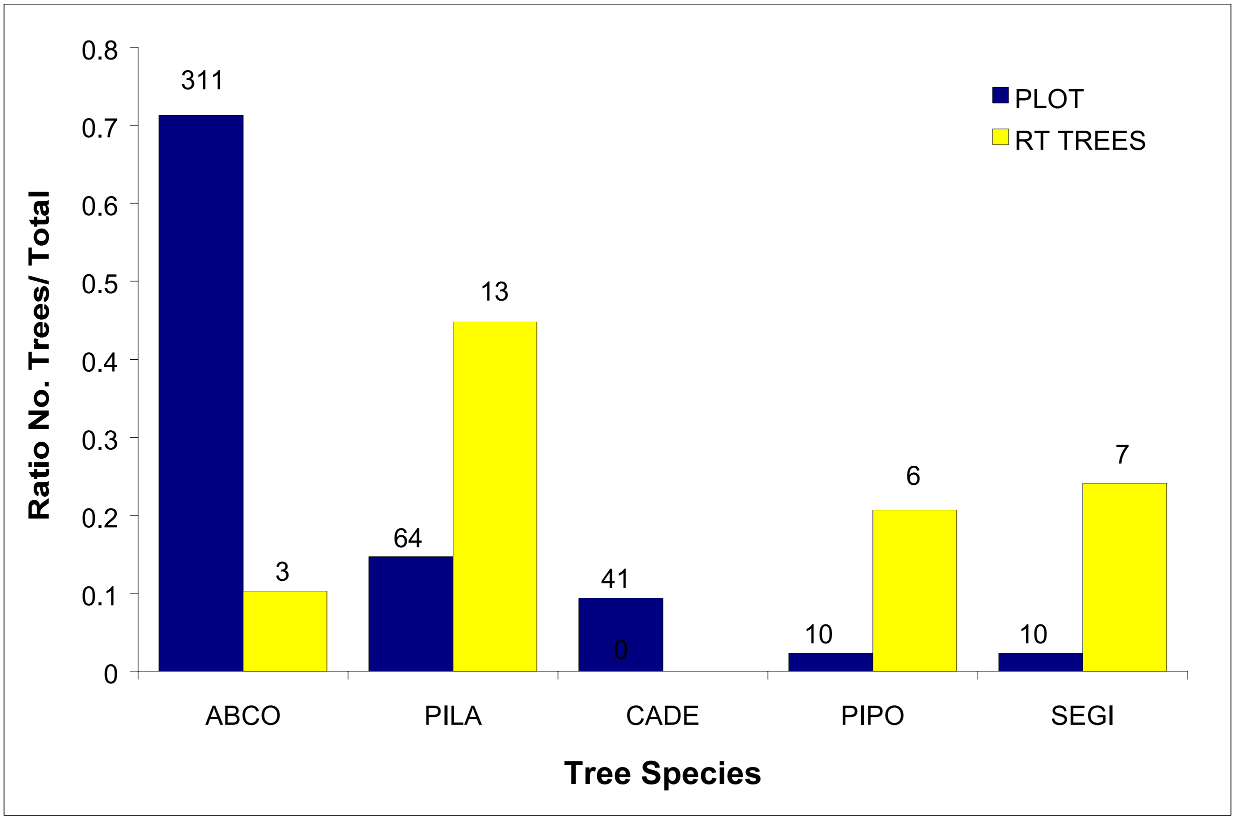


Figure 29. Relative abundance of five tree species – fire plots and roost trees compared. ABCO = *Abies concolor*, PILA = *Pinus lambertiana*, CADE = *Calocedrus decurrens*, PIPO = *Pinus ponderosa*, and SEGI = *Sequoia giganteum*

Figure 29 compares the relative abundance of the five tree species in the eleven fire plots with that of trees used as bat roosts. Although white fir, *A. concolor*, is numerically dominant in the grove (over 70 % of plot trees), this species is only 10% of the bat roost tree sample. There were no roosts detected in incense cedar (*C. decurrens*), the third most abundant tree species in the grove. For the four tree species with some roost observations (*A. concolor*, *P. lambertiana*, *P. ponderosa*, and *S. giganteum*), the frequency of roosts by tree species differs significantly from the frequency of trees on the plots (Chi-square=84.3,d=3, p<0.001)

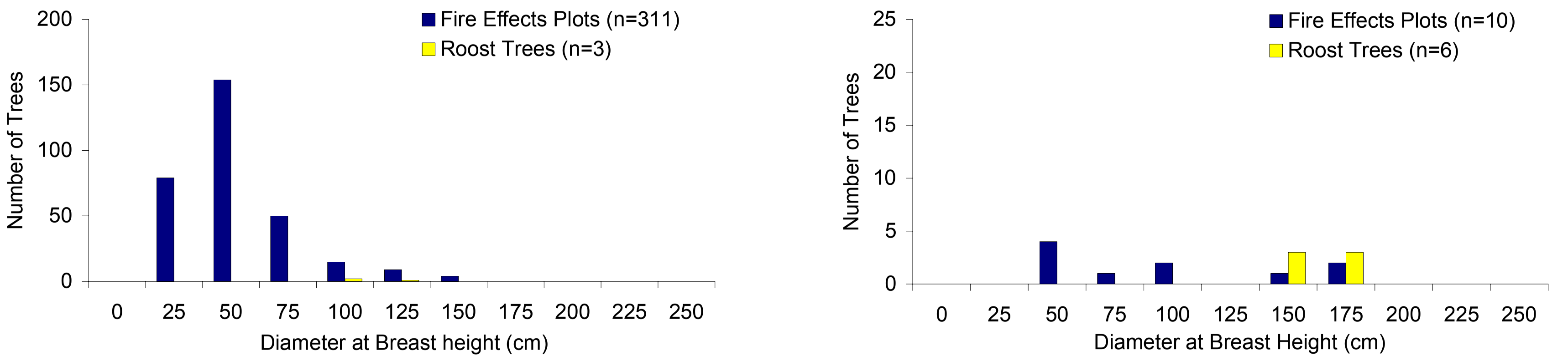
Figure 30 (a,b,c,d) shows the distribution of fire plot trees and roost trees by DBH size class for the four tree species used by the bats. In all cases, the trees selected as roosts by the bats fall at the large end of the size class spectrum.

3.3.2. Roosting and Foraging Behavior by Species

3.3.2.1. Overview

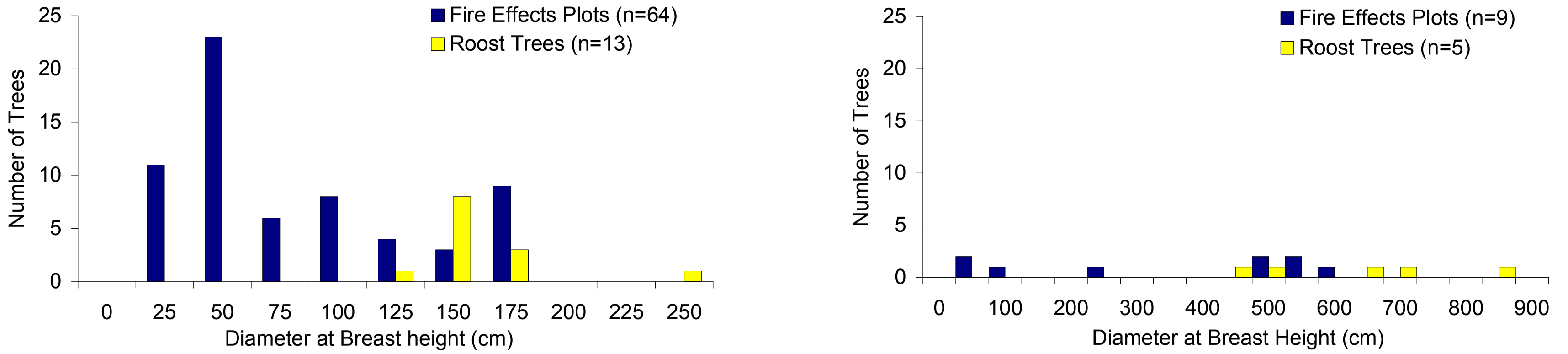
The temporal pattern of roost use is provided in Table 11 and Figure 31. Roost switching occurred for the four species for which we identified roosts. The degree of roost switching was extremely variable among individuals. On average bats spent 2.15 +/- 0.35 days in a roost (range 1-10, *n* = 32) and the average number of roosts per bat was 2.06 +/- 0.37 (range 1-6, *n* = 16).

Figure 30. Distribution by DBH of trees, by species, in fire effects monitoring plots compared with roost trees (note scale differences in *y axis* and *x axis* for white fir and giant sequoia, respectively).



a. white fir, *Abies concolor*

b. ponderosa pine, *Pinus ponderosa*



c. sugar pine, *Pinus lambertiana*

d. giant sequoia, *Sequoiadendron giganteum*

Table 11. Summary of bats radio tracked, including species, sex, age, reproductive condition, as well as the number of days radio tracked, number of roosts located, and average days per roost.

Bat I.D.	**Species**	**Sex**	**Age**	**Reproductive Condition**	**Days Tracked**	**Roosts Located**	**Av. Days per Roost**
954	*A.pallidus*	F	A	lactating	7	0	
103	*E.fuscus*	F	A	post-lactating	6	2	1.0
119	*E.fuscus*	F	A	post-lactating	6	1	3.0
203	*E.fuscus*	F	A	post-lactating	2	1	2.0
244	*E.fuscus*	F	A	post-lactating	7	1	7.0
632	*E.fuscus*	F	A	post-lactating	14	6	2.0
652	*E.fuscus*	F	A	post-lactating	11	4	2.5
934	*E.fuscus*	F	A	post-lactating	8	1	3.0
260	*E.fuscus*	F	J	non-lactating	6	1	1.0
611	*E.fuscus*	M	A	scrotal	10	1	10.0
670	*E.fuscus*	M	A	scrotal	11	3	2.3
43	*L.noctivagans*	M	A	non-lactating	3	2	1.0
592	*L.noctivagans*	M	A	non-lactating	3	2	1.0
574	*M.thysanodes*	F	A	post-lactating	5	4	1.0
22	*M.volans*	M	A	non-lactating	2	1	1.0
610	*M.volans*	M	A	non-lactating	4	2	1.5

Figure 31. Flow chart showing the roosting patterns by capture site, date and identified roosts for all radio-tagged bats.

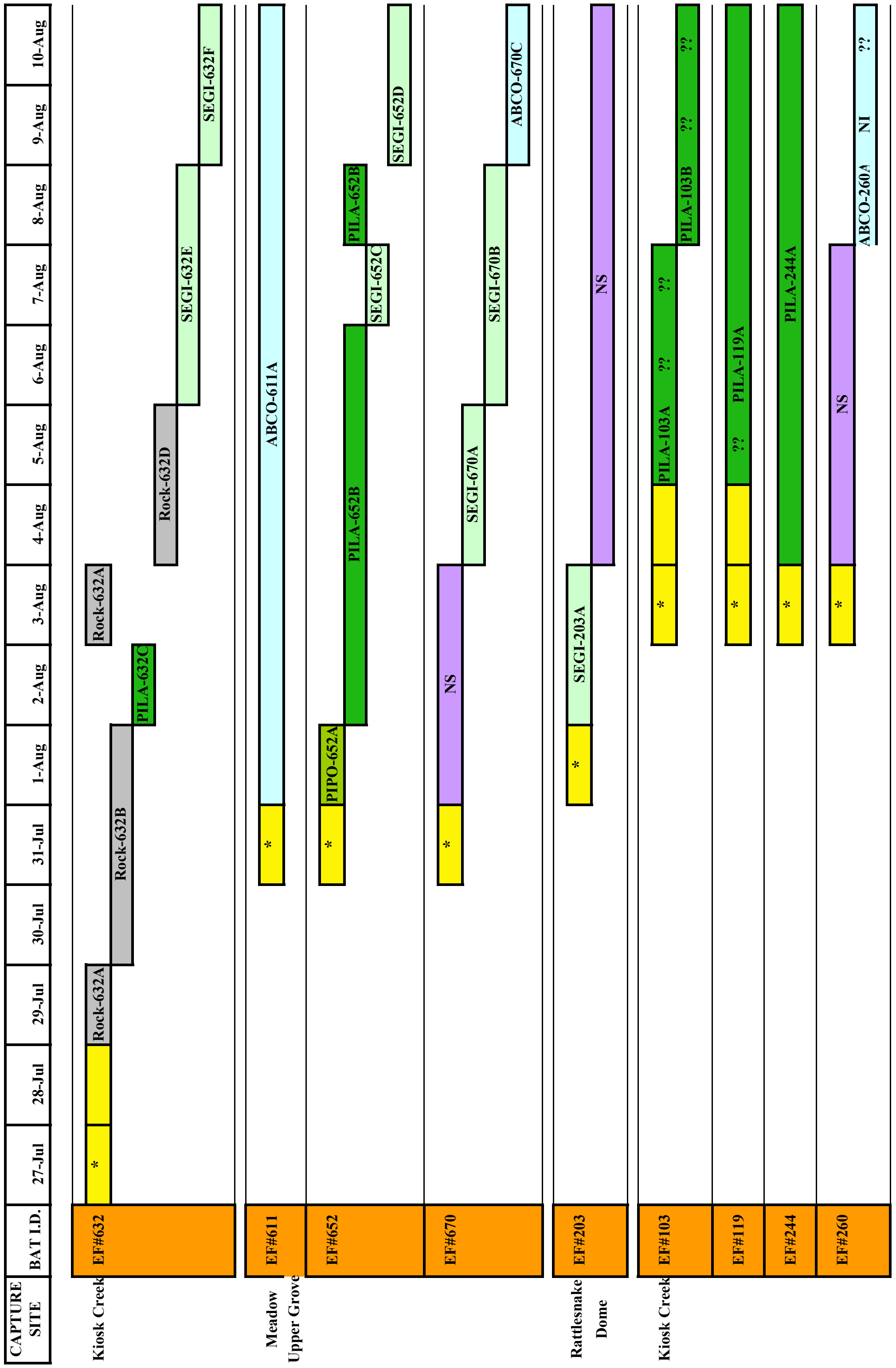
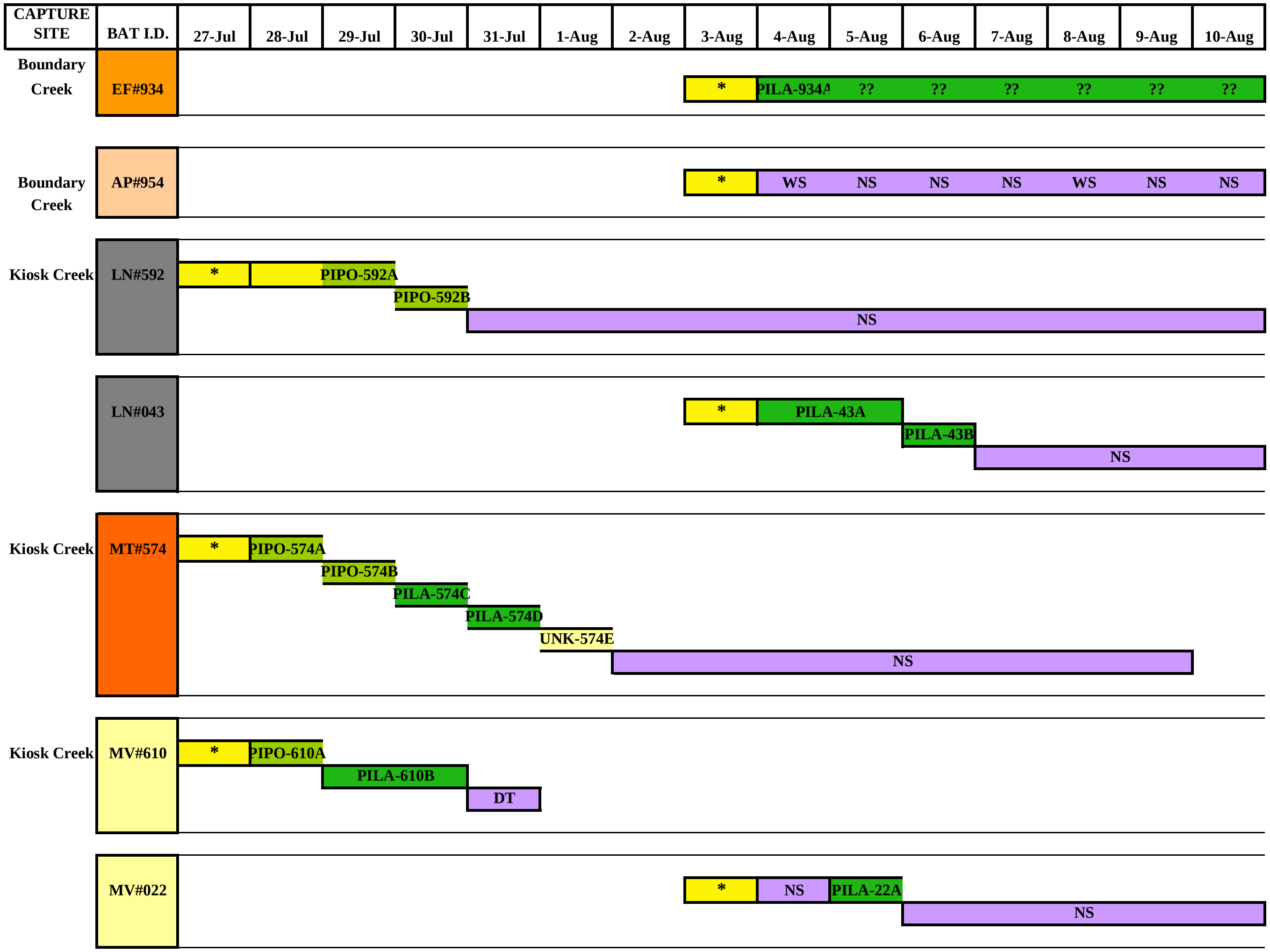


Figure 31. Cont'd.



DT = Dropped transmitter; located
NS = No signal
?? = Signal obtained; consistent with being same roost; roost not checked
NI = No information
WS =Weak signal; roost not located

Six bats used only one roost; nine bats changed roosts between one and seven times. In general, when a bat changed roosts, it selected a roost that was within an average of 0.19 km of its previous roost (range = 0.02-0.78 km, *n* =17).

The focus of this study was on locating roost sites. We did, however, follow as many individuals as possible during foraging for two to four hours after emergence for nine nights. We were able to identify the foraging areas of most bats for which we had known roost localities. There were some individuals that we were able to identify foraging in the grove on nights when we had been unable to locate their roosts during the day (see species specific discussion below). For most individuals, however, once we could no longer locate their roosts, we also failed to detect them foraging. These animals most likely moved outside our detection radius, although it is also possible that their transmitters failed or were dropped.

Ten of the sixteen radio-tagged bats were reproductive females, five were adult males, and one was a juvenile female (Table 9). We were able to tag reproductive females for three species *(A. pallidus*, *E. fuscus*, and *M. thysanodes*). Knowing that all three species form nursery colonies, we expected to discover colonial roost sites for all of them. We monitored 24 of the roosts at emergence on the day the roost was discovered; three roosts were monitored two times during the course of the radio-tracking study. Only one colonial roost (for *M. thysanodes*) was found.

3.3.2.2. Antrozous pallidus

The single, lactating *A. pallidus*, captured on 3 August at Boundary Creek, was the most elusive animal. Although signals were obtained on two days for roost sites, none were located despite extensive efforts by two investigators. The weak and bouncing signals suggested that the roost was located on a steep, inaccessible and perhaps rocky slope or gully, northwest of the grove. Signals were obtained during foraging on four nights in the general vicinity of her capture site. We had no detections for a roost or foraging on the last two days/nights of the study.

3.3.2.3. Eptesicus fuscus

Our most complete data were obtained for *E. fuscus*. We radio-tracked ten individuals -- seven post-lactating females, one juvenile female, and two adult males – captured at five localities on four different nights (Table 9 and Figure 31). Five were captured in the Lower Grove at Kiosk Creek (on 27 July and 3 August), one in the Middle Grove at the Boundary Creek crossing (on 3 August), and four in the Upper Grove (three in the meadow just south of the Sunset area on 31 July, and one at Rattlesnake Dome on 1 August).

We were able to locate roosts, or get signals for roosts, every day for seven of the ten individuals. We obtained no signal for two individuals for two to three days after the transmitters were applied, but roosts were later located for both animals (#670 and #260). One of them, Bat #260, was detected in the Grove during evening foraging bouts on nights when her roost was not located during the day. Only one individual, Bat #203, was lost after two days of tracking, and not heard from again during day or evening tracking sessions.

Of the ten radio-tagged individuals, six used only a single roost; the other four animals switched roosts between one and six times (Table 9 and Figure 31). The distribution of these roosts is shown in Figures 32 and 33. For those animals using multiple roosts, the mean distance between roosts was 0.12 km (range = 0.02-0.47 km, *n*= 11). With the exception of one individual (Bat #632), all the *E. fuscus* roosted and foraged in the vicinity of their capture sites. Thus those individuals captured at Kiosk Creek appeared to confine their roosting and foraging activities to the vicinity of the Lower Grove; those captured in the Sunset area, roosted and foraged there. The mean distance from the capture site to roost sites was 0.69 km (Range = 0.12-2.04 km, n = 10).

Fifteen of 21 roosts were monitored at emergence, and the most bats observed exiting from a single tree was three. The only tree that was used by multiple radio-tagged animals, but never on the same night, was the Sunset Tree. The roost location, in the lightning scar at the top of that tree, was too far away for observation. Thus, it is possible that this tree served as a colonial roost site that went undetected.

E. fuscus captured at Kiosk Creek:
Bat #632. This post-lactating female, captured on 27 July, roosted in six different roosts, two giant sequoias, one sugar pine snag, and three rock crevices, all located between the Sunset area in the Upper Grove and Wawona Point. She was one of three individuals identified as roosting in the Sunset Tree. This *E. fuscus* moved farther, and was less predictable in her foraging behavior, than any other radio-tagged individual. She was detected sometimes foraging in the Upper Grove, and at other times in the Lower Grove. For example, on the night of August 6 she fed in the Upper Grove all evening, and on August 7 and 8 she was followed foraging in a small area between the grove parking and the Fallen Monarch.

Bat #103. This post-lactating female, captured on 3 August, roosted in at least two different sugar pine snags up Rattlesnake Creek. She foraged every night in a limited area between the capture site and her roost sites.

Bat #119. This post-lactating female, captured on 3 August, roosted throughout the study in a sugar pine snag about 50 m up-slope on the south side of Kiosk Creek. She foraged every night in the vicinity of her capture site.

Bat #244. This post-lactating female, captured on 3 August, roosted throughout the study in a single sugar pine snag near the tram parking. She foraged every night in the vicinity of her capture site.

Bat #260. This juvenile female, captured on 3 August, roosted in a white fir snag located to the west of the grove. She foraged every night to the east of the capture site, in the vicinity of the Grizzly Giant.

E. fuscus captured at Boundary Creek:
Bat #934. This post-lactating female, captured on 3 August, roosted up-slope just south of the creek. She foraged every night in the vicinity of her capture site.

E. fuscus captured at Rattlesnake Dome:
Bat #203: This post-lactating female, captured on 1 August, roosted for two days in the Sunset Tree and then disappeared. She was never detected foraging.

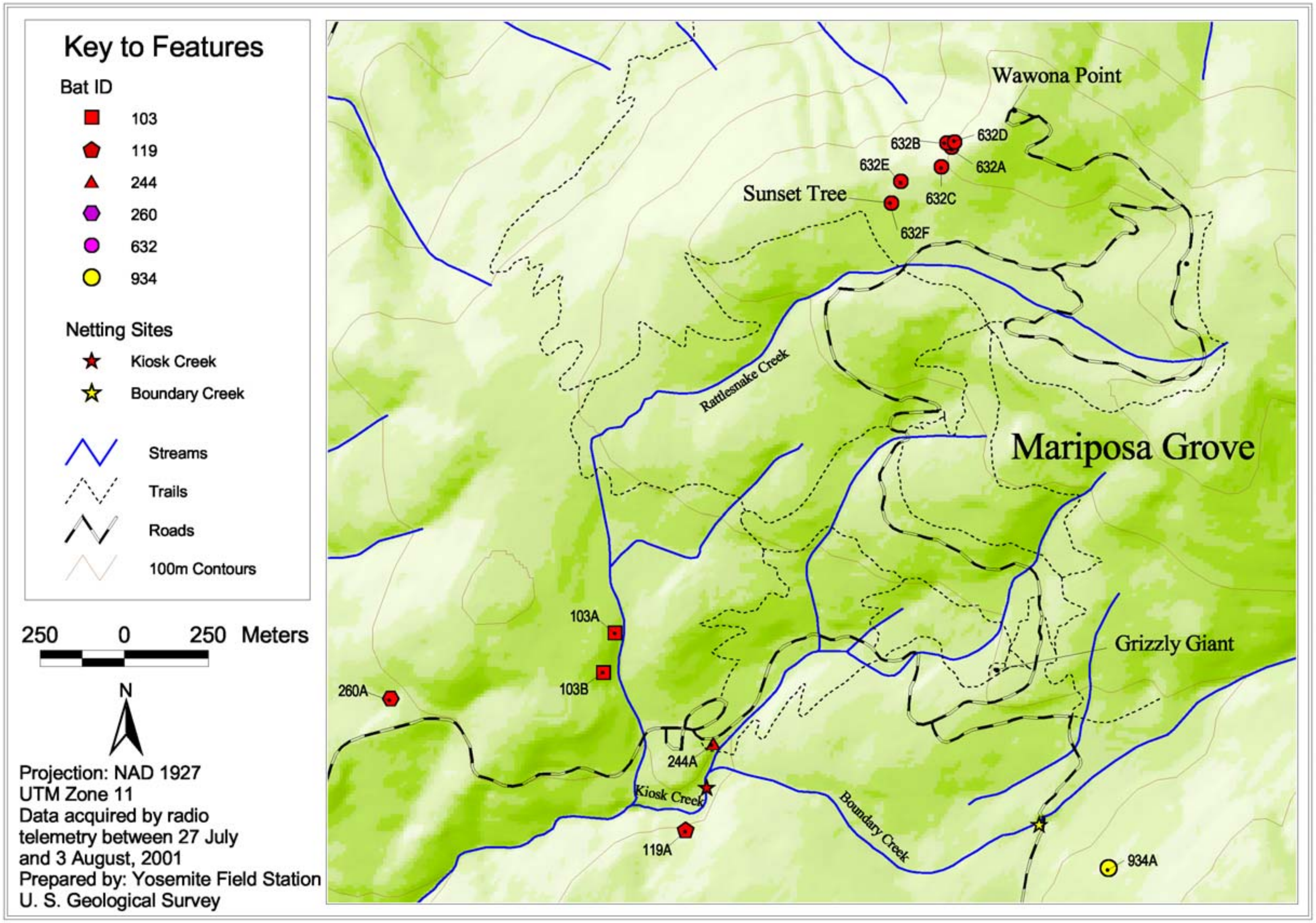


Figure 32. Roost locations and netting sites for big brown bats (Eptesicus fuscus) captured in the Lower or Middle Mariposa Grove, Yosemite National Park, California

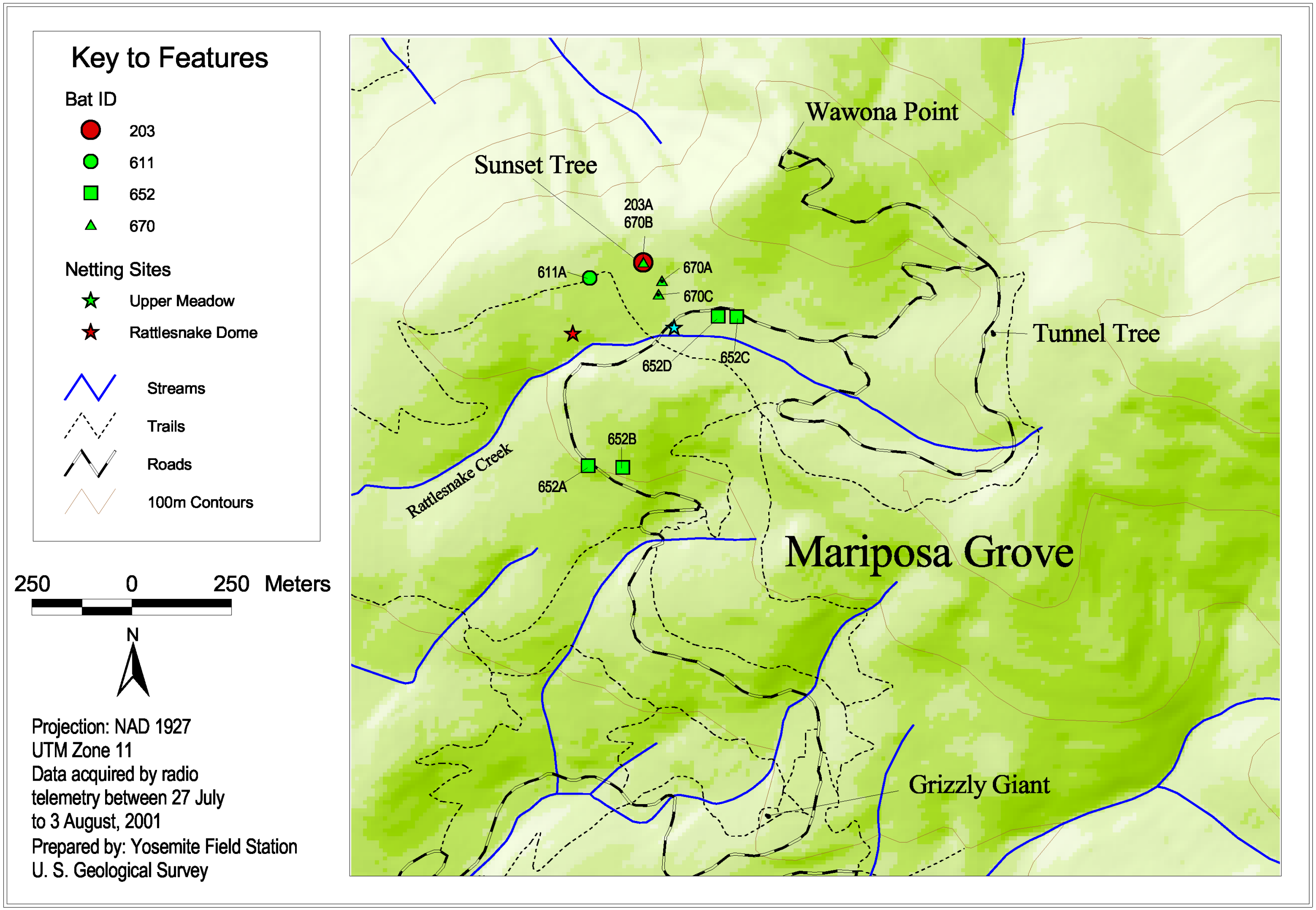


Figure 33. Roost locations and netting sites for big brown bats (Eptesicus fuscus) captured in the Upper Mariposa Grove, Yosemite National Park, California

E. fuscus captured in the Upper Grove:
Bat #611. This adult scrotal male, captured on 31 July, roosted for 10 consecutive days in a white fir snag located in the Sunset area. He did not emerge to forage every night. When he did, he was detected foraging in the Upper Grove, close to his roost site.

Bat #652. This post-lactating female, captured on 31 July, roosted in four different trees (two giant sequoias, one ponderosa pine snag and one sugar pine snag). She foraged every night in the upper meadow where she was captured.

Bat #670. This adult scrotal male, captured on 31 July, roosted in three trees (two giant sequoias and one white fir snag), including the Sunset Tree. All roosts were in the Sunset area. He foraged in the vicinity of the Upper Meadow every night.

This bat was observed by one of us (CJC) perched at night on the side of a white fir, in the vicinity of the Sunset Tree, “static calling”. This behavior, first detected acoustically, was observed for *E. fuscus* at two localities in the Grove (Rainey and Corben 2001). It is not known at this time whether this behavior is related to foraging (a sit and wait, sallying mode of foraging) or a form of social signaling, possibly related to mating.

3.3.2.4. Lasionycteris noctivagans

We radio-tracked two adult male *L. noctivagans*. Both were captured at Kiosk Creek, one on the first capture effort on 27 July, and the other on 3 August. These individuals disappeared after two and three days respectively, and were never detected again day or evening (Table 9 and Figure 31).

We located four roosts, two each, for the two radio-tagged animals (Figure 34). All four roosts were observed at emergence and had between one and three bats each, emerging from different areas of the trees. One radio-tagged individual used flaking bark at both trees; the other one used flaking bark at one tree, and a crack/bole cavity in the other. The mean distance between roosts was 0.41 km (range = 0.2-0.21, n = 2), and the mean distance from the capture site was 1.01 km (range = 0.8-1.21 km, n = 2).

Bat #592: This *L. noctivagans*, captured on 28 July, roosted in two ponderosa pines, one snag and one living tree, in the Middle Grove. We were able to follow it all evening for the first two nights, foraging in the Middle Grove. On the third night it disappeared to the southeast of its roost area and was never heard again.

Bat #043: This *L. noctivagans*, captured on 3 August, roosted in two sugar pine snags in the Middle Grove, south east of the Clothespin Tree. It was observed on one night at emergence foraging for about 20 minutes in the vicinity of its roost. On the second night it was detected foraging in the grove for approximately the first hour after emergence. It then disappeared and was never detected again in a roost or foraging area.

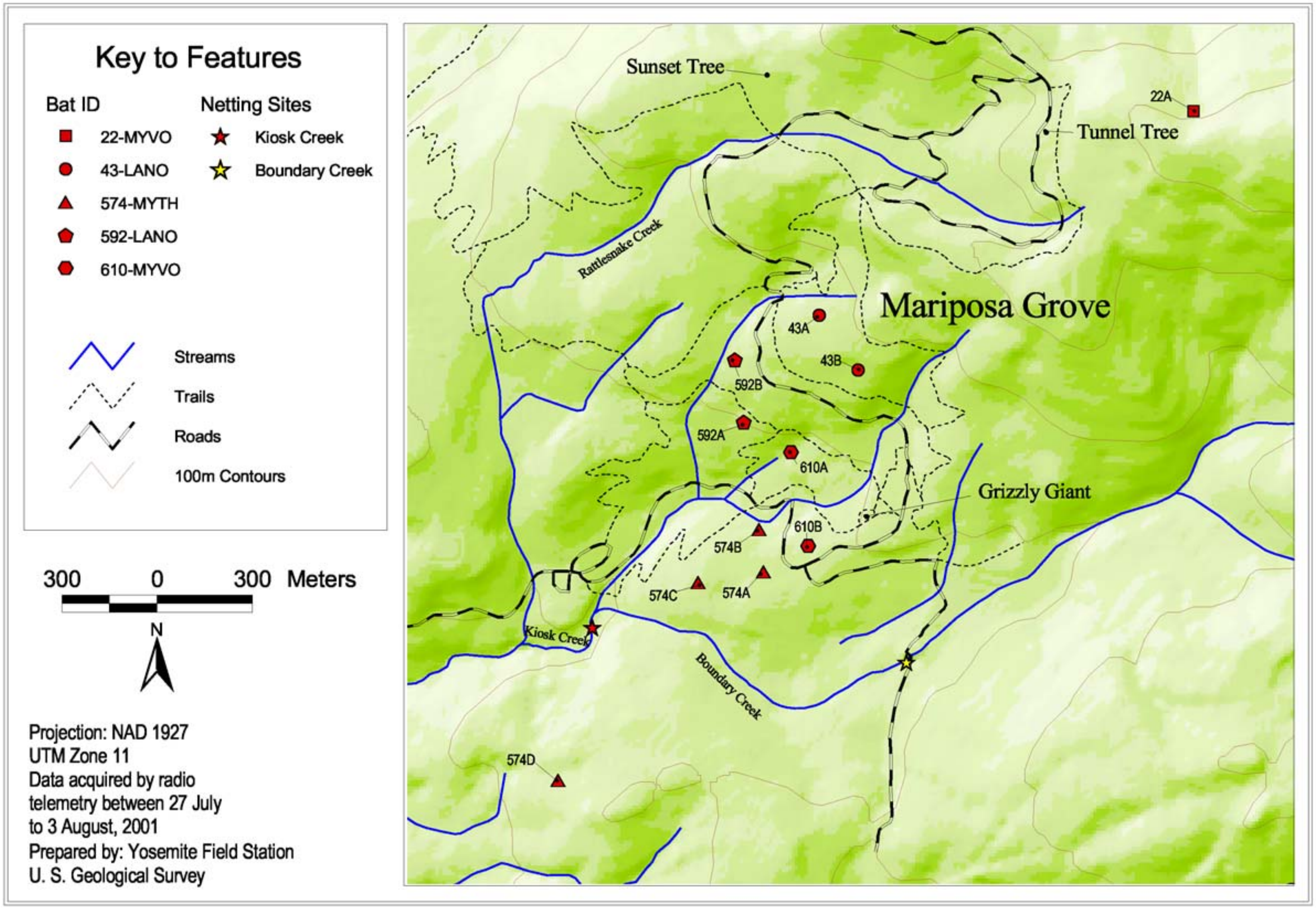


Figure 34. Locations of roost trees and capture sites for species other than E. fuscus. All animals were captured at Kiosk Creek in the Lower Mariposa Grove. This assemblage includes Lasionycteris noctivagans, Myotis thysanodes and Myotis volans.

3.3.2.5. Myotis thysanodes

One post-lactating *M. thysanodes* was captured at Kiosk Creek, and tracked for five days and nights before she disappeared (Table 9 and Figure 31). She moved every day for the five days she was followed, and roosted in a different roost each day (Figure 34). Three of the four identified tree roosts were monitored at emergence. Two of the trees were being used on the night of observation by one to seven bats. A third tree (#574B) was a colonial roost site in a large *P. ponderosa*. On 29 July twenty-nine bats emerged from the roost; on 30 July ten animals emerged. The mean distance between roosts was 1.16 km (range = 0.13-0.78 km, n = 3), and the distance from the capture site to the first roost was 0.57 km.

We had difficulty obtaining foraging information for this individual. During the three nights she was followed, she was detected either at emergence or during the first hour after emergence, and then lost until she returned to her roosting area at ca. midnight. It is likely she foraged at least part of the time outside the grove.

For four sequential nights, August 30-September 2, after the radiotracking study was completed, the colonial roost was observed using acoustic, night vision and/or infrared video devices. Additionally, the roost was observed at dawn on September 1 and 2. The number of bats using the roost varied day to day from 24 to 44 individuals. The animals alternated between two roost sites on the same tree, both under flaking bark, located ca. 5 to 10 m above the ground.

3.3.2.6. Myotis volans

We radio-tracked two adult male *M. volans*. Both were captured at Kiosk Creek, one on 27 July, the other on 3 August. One *M. volans* was tracked for three days before dropping its transmitter (which was recovered); the other individual disappeared after two days (Table 9 and Figure 31).

We located one roost for one *M. volans*, and two for the other (Figure 34). The single roost located for one bat was not observed at emergence, but was determined to be under flaking bark. The two roosts for the other individual were both observed at emergence, with one bat emerging from one tree and five (four of which were *E. fuscus*) from the other. The radio-tagged bat was roosting in a bark crevice in one tree and under flaking bark in the other. The distance between the two roosts for Bat #610 was 0.3 km, and the mean distance from the capture site for the two bats was 1.66 km (range = 0.83-2.49, n = 2).

Bat #610: This *M. volans*, captured on 28 July, roosted in one ponderosa pine snag and one sugar pine snag in the Middle Grove. We were able to follow it all evening on the second night, foraging in the general vicinity of the roost. On the third night it was heard also in the vicinity of its roost until 22:22. On the fourth day, its dropped transmitter was found near the base of its second roost (#610B).

Bat #022: This *M. volans*, captured on 3 August, roosted in a sugar pine, along the ridge to the east of the Upper Grove. It was detected on the night of 4 August foraging northeast of the Clothespin Tree, and then never heard from again.

3.3.3. Our Study Compared to Other Studies of Tree Dwelling Bats

Radio-tracking studies have repeatedly shown an association between bats and large live and dead trees (>50cm DBH) (Betts 1998a, Campbell *et al.* 1996, Erickson and West 2003, Ormsbee and McComb 1998). The features most frequently used are bole cavities (*e.g.*, either natural or excavated by woodpeckers), fire scars (*e.g.*, lightning strikes or basal hollows of the kind most typically found in giant sequoias and coast redwoods), loose bark (as is typically found on mid-stage ponderosa and sugar pine snags), or crevices created by broken limbs. Tree-roosting has been documented by radiotracking in other habitats for all eight species we captured in the giant sequoia groves: *Antrozous pallidus* (Pierson and Heady 1996, Rainey and Pierson 1996), *Eptesicus fuscus* (Agosta 2002, Betts 1996, Kalcounis and Brigham 1998, Rabe *et al.* 1998, Rainey and Pierson 1996, Vonhof 1996, Vonhof and Barclay 1996), *Lasionycteris noctivagans* (Barclay *et al.* 1998, Betts 1996 & 1998, Campbell *et al.*, 1996, Crampton and Barclay 1998, Rainey and Pierson 1996, Vonhof 1996, Vonhof and Barclay 1996), *Myotis californicus* (Brigham *et al.* 1997), *Myotis evotis* (Chung MacCoubrey 1996 & 2001, Pierson and Rainey 1997, Vonhof and Barclay 1996), *Myotis thysanodes* (Chung MacCoubrey 1996 & 2001, Weller and Zabel 2001), *Myotis volans* (Chung MacCoubrey 1996 & 2001, Ormsbee and McComb 1998, Vonhof and Barclay 1996, Waldein at al. 2000), and *Myotis yumanensis* (Pierson and Rainey 1997).

The roosting behavior we documented in this study for *E. fuscus*, *L. noctivagans*, *M. thysanodes*, and *M. volans* was consistent with that observed in other studies. This study and other radio-tracking studies have shown that roost trees differ from random snags in a number of variables (Jung *et al.* 2004). Bats tend to select the tallest available snags (Betts 1998, Weller and Zabel 2001), preferring those that are higher than surrounding canopy (Betts 1998, Campbell *et al.* 1996, Jung *et al.* 2004, Vonhof and Barclay 1996, Weller and Zabel 2001). These are also trees that tend to be larger in diameter than surrounding trees, and in an intermediate stage of decay (*e.g.*, Betts 1998, Brigham and Barclay 1996, Campbell *et al.* 1996, Jung *et al.* 2004,Vonhof and Barclay 1996, Weller and Zabel 2001). Several studies have shown that a decline in the number of snags has resulted in a decline in roosting habitat for bats (Crampton and Barclay 1998, Lunney et al 1988, Thomas and West 1991). Correlatively, bats are more frequently detected in stands with abundant large trees (Erickson and West 2003).

Although giant sequoias do not frequently form snags, as do most conifers, these ancient trees have a number of defects/features that provide roosting habitat (*e.g.*, dead tops from lightning strikes, fire-scar basal hollows, crevices and sometimes cave–like cavities associated with broken limbs, deep bark crevices). Certainly for the variables of DBH and height above the surrounding canopy they exceed any other trees in the forest, and thus would be expected to be favored by bats.

While high roost fidelity is characteristic of bats that roost in highly permanent structures such as caves and has often been observed for colonies occupying human-made structures such as buildings, mines, and bridges, low roost fidelity is characteristic of tree-dwelling bats (Lewis 1995). Frequent roost switching, as we observed in this study, has been documented repeatedly for tree-dwelling bats (*e.g.*, Menzel *et al.* 2002, Vonhof and Barclay 1996, Weller and Zabel 2001).

3.4. Acoustic Surveys of Bat Foraging Activity in the Mariposa Grove

3.4.1. Overall Diversity

Tables 12,13,14 and Figures 35-37 show the distribution of acoustic records by taxon for all acoustic sampling in the three giant sequoia groves.

4.4.1.1. Mariposa Grove

We sampled a total of 41 different sites in 195 sampling sessions in the Mariposa Grove (Figure 35, Table 12).

Almost 68% of the 32,068 acoustic files are attributable to bats echolocating at 25 kHz, an assemblage comprised of *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Tadarida brasiliensis*. Repeated behavioral observations in conjunction with acoustic sampling, plus capture results, suggest that, while all three species are present in the grove, *Eptesicus fuscus* is by far the most abundant. The second most frequently detected group is the 50 kHz *Myotis*, which could be either *Myotis californicus* or *Myotis yumanensis*. Again, behavioral observations and capture records suggest that this assemblage is comprised predominantly of *M. californicus*. The third most abundant group is the 40 kHz *Myotis*. While there are three *Myotis* species that occur in Yosemite National Park and echolocate at 40 kHz (*M. ciliolabrum*, *M. lucifugus*, and *M. volans*), we obtained no evidence that either *M. ciliolabrum* or *M. lucifugus* occur in the giant sequoia groves. We thus conclude that the majority of the 40 kHz *Myotis* we detected were *M. volans*. These three most frequently detected taxa – 25 kHz species, 50 kHz species, and 40 kHz species – were also widely distributed, being detected at 87.8-92.7% of the sampling sites.

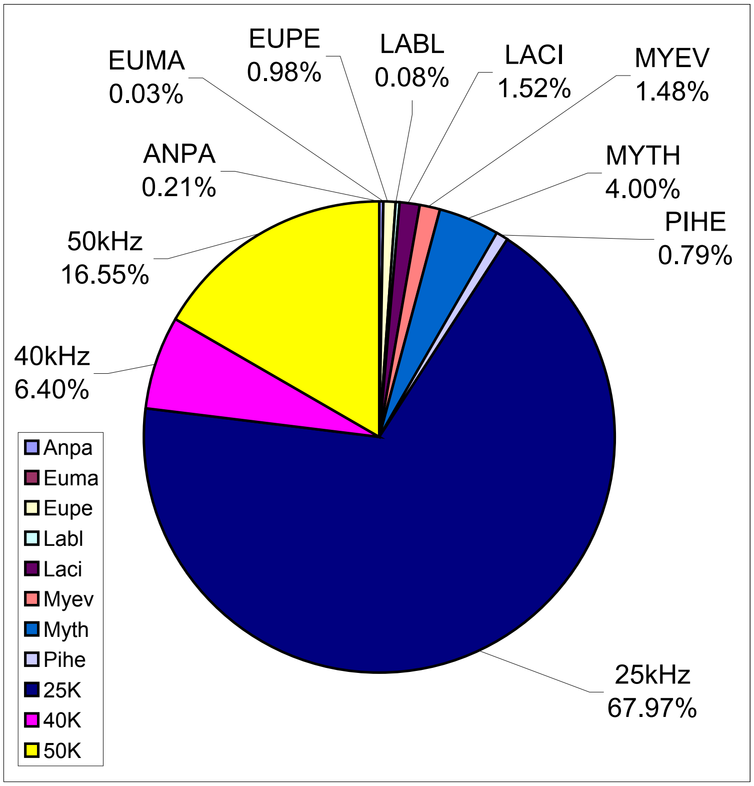


Figure 35. Pie graph showing distribution by species of acoustic detections in the Mariposa Grove.

Table 12. Acousitc activity for bats in the Mariposa Grove. For each species or species group the following information is provided: total number of acoustic detections, the percentage of total detections; the number of sampling sessions in which species was detected; the percentage of sampling sessions (n = 195) in which the species was detected; the number of sites (n = 41) at which the species was detected; and the percentage of sites at which it was detected.

Species	# Acoustic Detections	% Total Detections All Species	# Sampling Sessions (n=195)	% Total Sessions Detected	# Sites Detected (n=41)	% Total Sites Detected
Antrozous pallidus	66	0.206	37	18.974	12	29.268
Euderma maculatum	11	0.034	9	4.615	5	12.195
Eumops perotis	315	0.982	91	46.667	21	51.220
Lasiurus blossevillii	25	0.078	22	11.282	12	29.268
Lasiurus cinereus	486	1.516	94	48.205	17	41.463
Myotis evotis	475	1.481	125	64.103	26	63.415
Myotis thysanodes	1,281	3.995	108	55.385	26	63.415
Pipistrellus hesperus	253	0.789	26	13.333	8	19.512
25 kHz	19,162	59.754	183	93.846	38	92.683
Eptesicus fuscus	2,222	6.929				
Lasionycteris noctivagans	154	0.480				
Tadarida brasiliensis	258	0.805				
Myotis - 40 kHz	1,948	6.075	170	87.179	36	87.805
Myotis volans	105	0.327				
Myotis - 50 kHz	5,307	16.549	181	92.821	38	92.683
Myotis californicus/yumanensis						
TOTALS	32,068	100.000				

All other species are relatively rare by comparison. Nevertheless, *Myotis thysanodes* was more commonly detected here than in any other habitat we have surveyed in the Park. This species is generally rare. The fact this species was detected at 63.4% of the sampling sites suggests it is widely distributed in the Mariposa Grove. The acoustic data almost certainly under-represent the distribution of *Antrozous pallidus*. For this species, only a subset of their echolocation calls is diagnostic. They also frequently forage using visual and auditory cues, so might not be detected acoustically. The data from the guano traps (see Section 3.2.1.2 above) document a significant presence of this species in the groves.

3.4.1.2. Merced Grove

In the Merced Grove, we sampled 9 different sites, in 25 sampling sessions distributed over six nights. We obtained 2,854 acoustic files (Figure 36, Table 13).

The most frequently detected taxon was 50 kHz *Myotis*, presumed (based on capture records, visual observations and habitat characteristics) to be primarily *M. californicus*. It was detected in all sessions at all sites, and represented 38.6% of all detections. The second most frequently detected group were the bats echolocating at 25 kHz, almost certainly primarily *E. fuscus*. These bats were detected at all sites, and during 96% of all sampling sessions, representing 26.9% of all detections. Both *M. thysanodes* and *M. volans* were also relatively common and widespread in this grove. The perennial creek and the associated riparian vegetation appear to provide particularly suitable habitat for *M. thysanodes*.

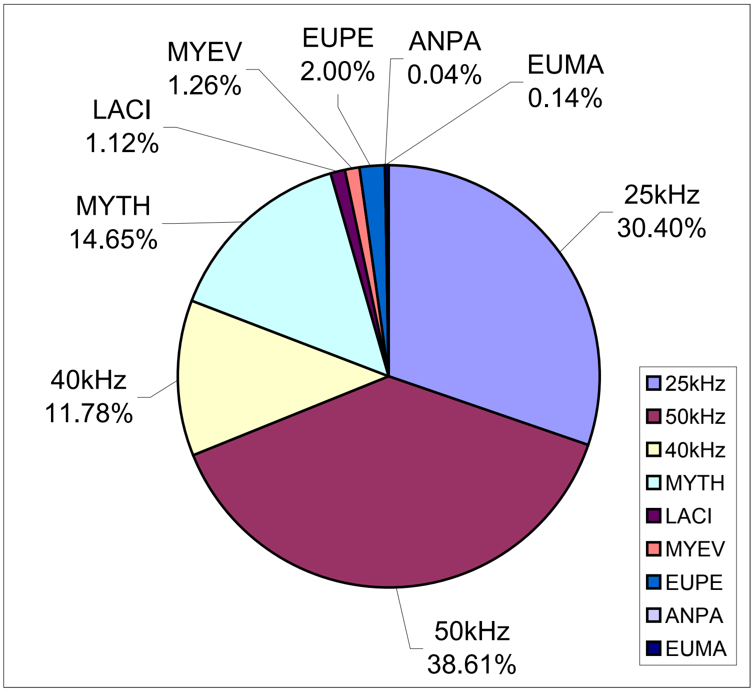


Figure 36. Pie graph showing distribution by species of acoustic detections in the Merced Grove.

E. perotis was detected at all sites and during 64.0% of all sessions, but the number of detections was relatively few, representing 2.0% of all detections. *L. cinereus* was detected at 77.8% of the sites, and during 48% of the sessions, but the total number of detections was relatively few, representing 1.12 % of all detections. *M. evotis*, which is sometimes not easily identified acoustically, is likely more widespread and common in this grove than the acoustic records suggest. It was detected at 55.6% of the sites, during 36% of the sessions, representing 1.26% of all detections. *A. pallidus* and *E. maculatum* appeared to be rare, and two species detected in the Mariposa Grove were not detected here: *L. blossevillii* and *P. hesperus*.

Table 13. Acousitc activity for bats in the Merced Grove. For each species or species group the following information is provided: total number of acoustic detections, the percentage of total detections; the number of sampling sessions in which species was detected; the percentage of sampling sessions (n = 25) in which the species was detected; the number of sites (n = 9) at which the species was detected; and the percentage of sites at which it was detected.

Species	# Acoustic Detections	% Total Detections All Species	# Sampling Sessions (n=25)	% Total Sessions Detected	# Sites Detected (n=9)	% Total Sites Detected
Antrozous pallidus	1	0.04	1	4.00	1	11.11
Euderma maculatum	4	0.14	1	4.00	1	11.11
Eumops perotis	57	2.00	16	64.00	9	100.00
Lasiurus blossevillii	0	0.00	0	0.00	0	0.00
Lasiurus cinereus	32	1.12	12	48.00	7	77.78
Myotis evotis	36	1.26	9	36.00	5	55.56
Myotis thysanodes	418	14.65	21	84.00	8	88.89
Pipistrellus hesperus	0	0.00	0	0.00	0	0.00
25 kHz	767	26.87	24	96.00	9	100.00
Eptesicus fuscus	85	2.98				
Lasionycteris noctivagans	0	0.00				
Tadarida brasiliensis	16	0.56				
Myotis - 40 kHz	327	11.46	22	88.00	9	100.00
Myotis volans	9	0.32				
Myotis - 50 kHz	1,102	38.61	25	100.00	9	100.00
Myotis californicus/yumanensis						
TOTALS	2,854	100.00				

3.4.1.3. Tuolumne Grove

In the Tuolumne Grove, we sampled 4 different sites, in 12 sampling sessions distributed over 3 nights. Thus the same four sites were repeat-sampled three times. We obtained a total of 822 acoustic detections. (Figure 37, Table 14).

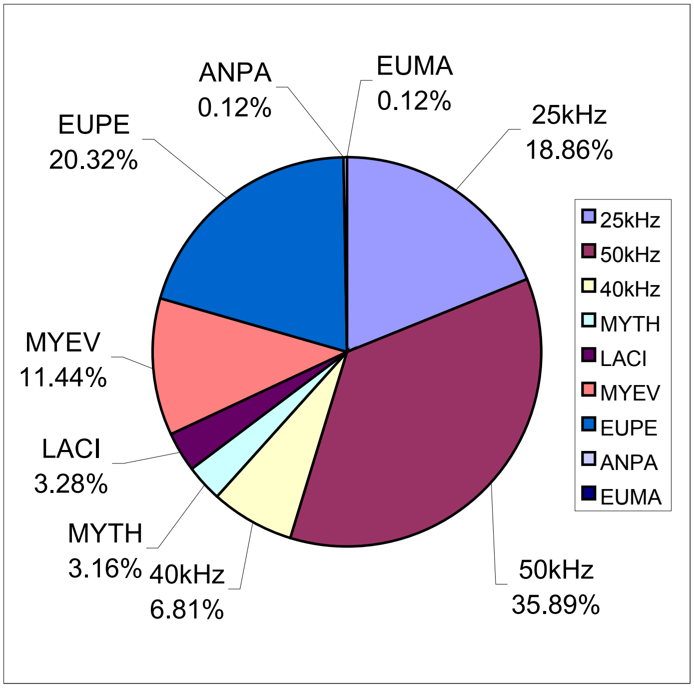


Figure 37. Pie graph showing distribution by species of acoustic detections in the Tuolumne Grove.

As in the other two groves, the 25 KHz and 50 kHz bats, predominantly *E. fuscus* and *M. californicus*, are dominant taxa in the assemblage. What is strikingly different is the relatively large number of detections of *Eumops perotis*, which is the second most frequently detected taxon. Since this species is thought to be an obligate cliff-dweller in Yosemite, and is also known to travel large distances to forage (Pierson and Rainey 1996b), we presume that the Crane Creek drainage is in a foraging flyway for this species. Also, the relatively open habitat of the Tuolumne Grove would make this area more suitable for foraging by this open-air forager, and also would make it more likely that bats echolocating high above the ground would be detected.

3.4.1.4. Comparison of the Three Groves

In summary, there are some striking differences in the bat assemblages in the three groves. The western pipistrelle, *Pipistrellus hesperus*, and the western red bat, *Lasiurus blossevillii*, were found only in the Mariposa Grove. The presence of pipistrelles in this grove, and neither of the others, is most likely attributable to the rock roosting habitat used by this species at nearby Wawona Point, located in close proximity to wet meadows used for foraging within the grove. The detection of red bats only in the Mariposa Grove may be a consequence of more intensive sampling in this grove. This species was extremely rare in the Mariposa Grove. Based on its occurrence in Redwood Creek in Kings Canyon National Park (E.D. Pierson and W.E. Rainey, personal observation), in a habitat very similar to that in the Merced Grove (*i.e.*, a perennial stream running through a giant sequoia grove), it is likely that red bats do occur, if rarely, in the Merced Grove. The apparent greater abundance of *Myotis thysanodes* in the Merced Grove relative to the other groves is consistent with findings elsewhere of a high association with secondary streams in primary forest habitat (Weller and Zabel 2001). Nevertheless, it appears to be more common in general in giant sequoia habitat than other areas of the park that have been sampled, and should be considered a relatively rare and sensitive species that is highly associated with giant sequoia forest.

Table 14. Acousitc activity for bats in the Tuolumne Grove. For each species or species group the following information is provided: total number of acoustic detections, the percentage of total detections; the number of sampling sessions in which species was detected; the percentage of sampling sessions (n = 12) in which the species was detected; the number of sites (n = 4) at which the species was detected; and the percentage of sites at which it was detected.

Species	# Acoustic Detections	% Total Detections All	# Sampling Sessions (n=25)	% Total Sessions Detected	# Sites Detected (n=9)	% Total Sites Detected
Antrozous pallidus	1	0.12	1	4.00	1	11.11
Euderma maculatum	1	0.12	1	4.00	1	11.11
Eumops perotis	167	20.32	16	64.00	9	100.00
Lasiurus blossevillii	0	0.00	0	0.00	0	0.00
Lasiurus cinereus	27	3.28	12	48.00	7	77.78
Myotis evotis	94	11.44	9	36.00	5	55.56
Myotis thysanodes	26	3.16	21	84.00	8	88.89
Pipistrellus hesperus	0	0.00	0	0.00	0	0.00
25 kHz	151	18.37	24	96.00	9	100.00
Eptesicus fuscus	4	0.49				
Lasionycteris noctivagans	0	0.00				
Tadarida brasiliensis	0	0.00				
***Myotis* - 40 kHz**	54	6.57	22	88.00	9	100.00
Myotis volans	2	0.24				
***Myotis* - 50 kHz**	295	35.89	25	100.00	9	100.00
Myotis californicus/yumanensis						
Total	822	100.000				

The prevalence of *Eumops perotis* in the Tuolumne Grove is more likely explained by features of geography and landscape patterns of activity for this species than by any specific association with giant sequoia habitat.

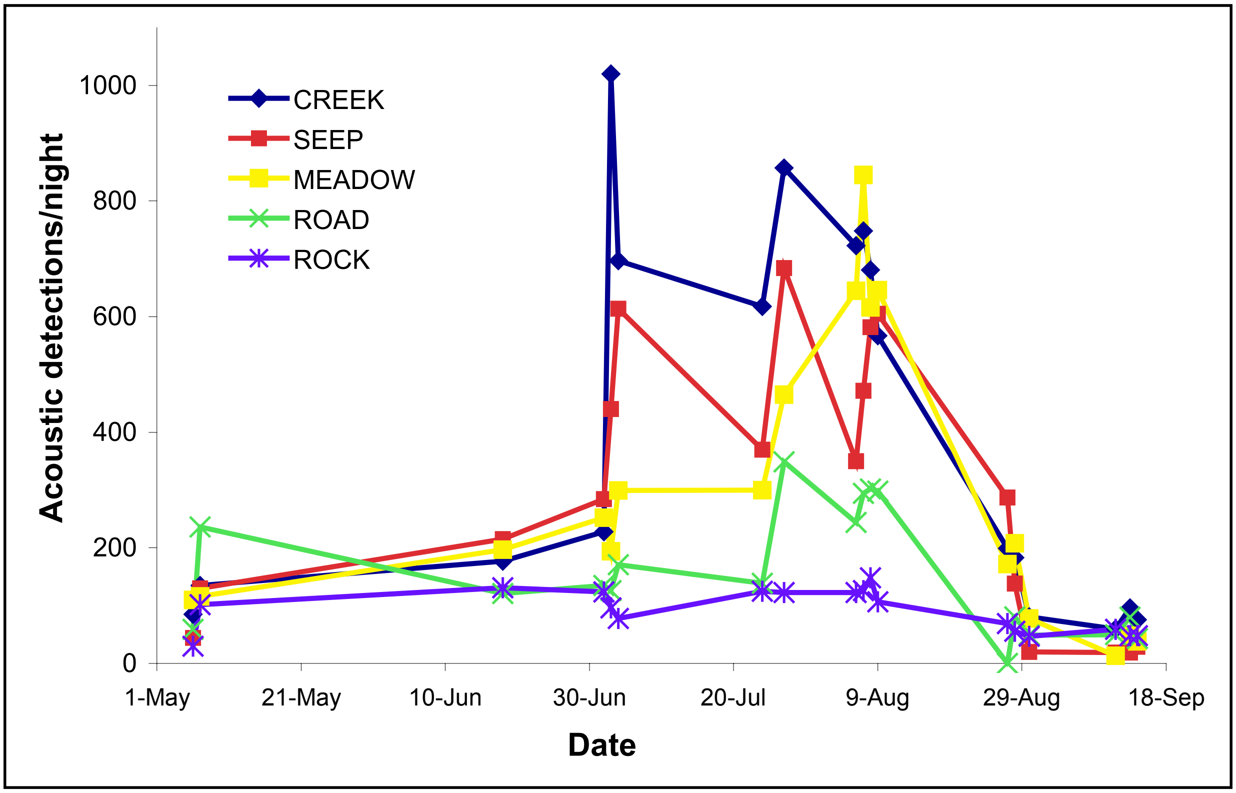


Figure 38. Line graph depicting the number of acoustic files per night at five sites, representing five habitat types, sampled simultaneously for 18 nights between May and September 2001.

3.4.2. Bat Diversity and Relative Abundance in Different Habitats

3.4.2.1. Repeat Sampling at Five Sites Representing Five Different Habitats

Between 6 May and 14 September 2001, we repeat sampled five sites, representing five different habitats, simultaneously 18 times. For each sampling session, the detectors were installed prior to dark and picked up after dawn. Appendix IV identifies the sampling site for each habitat type.

There were significant differences among sites in the amount of bat activity per night (Figure 38), with the most activity at the creek and the least at the rock outcrop. This finding is consistent with studies conducted elsewhere that have shown bat activity is greater at water sites than terrestrial sites (Grindal et al 1999; Pierson *et al.* 2001).

What is most interesting about these data, however, is not the expected result of more bat activity in association with water, but rather some informative differences in where particular species, especially the rarer species, were most likely to be detected. The 25 kHz, 50 kHz and 40 kHz bats were the most abundant taxa in all five habitat types. For all the remaining species the pattern of activity in the different habitats is variable. For example, *Lasiurus cinereus*, *Pipistrellus hesperus*, and *Euderma maculatum* were all encountered most frequently at the meadow site, *Eumops perotis* and *Lasiurus blossevillii* at the rock outcrop; *Antrozous pallidus* and *Myotis evotis* on the road; *Myotis thysanodes* at the creek. The pattern for each of these rarer species is discussed in more detail in the species accounts below (Section 3.5).

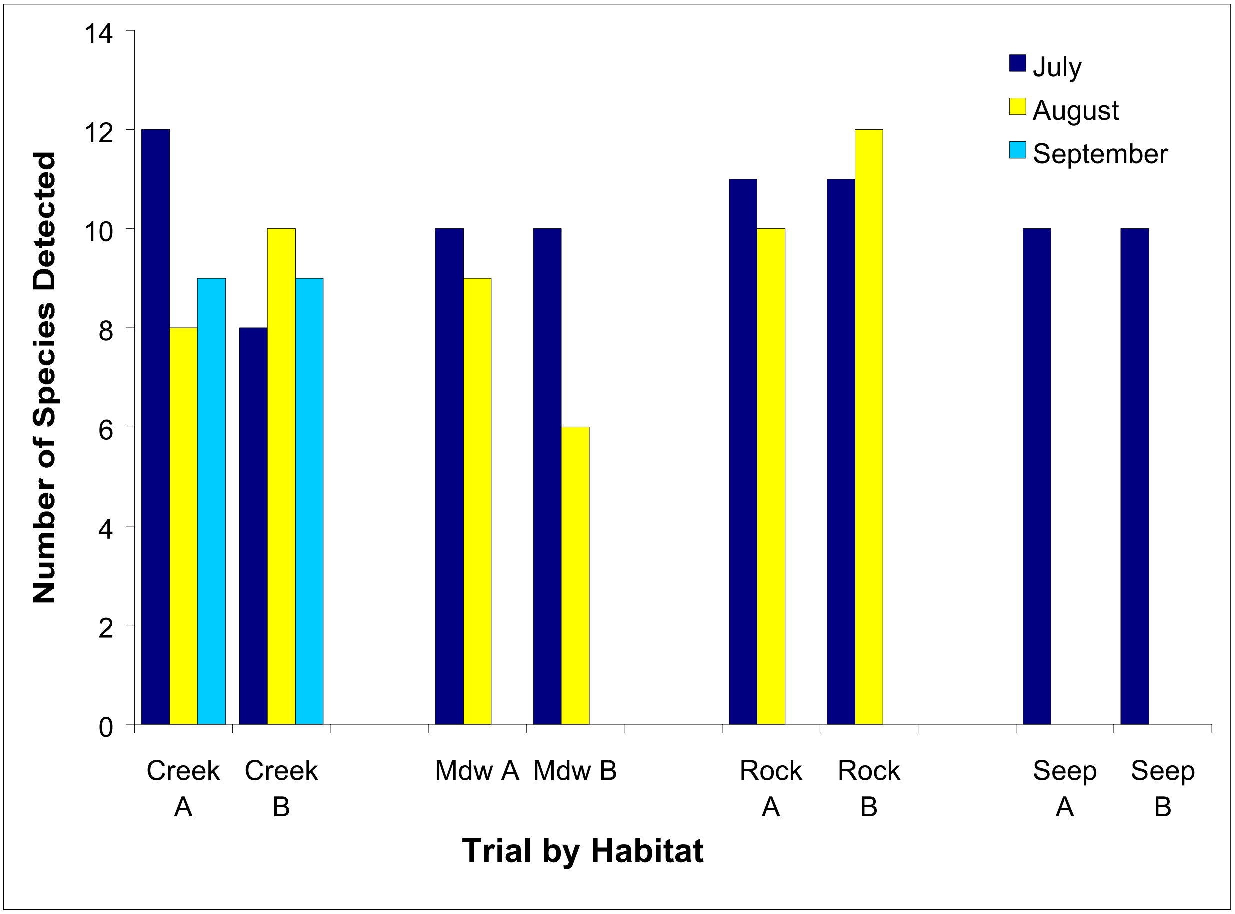


Figure 39. Bar graph depicting the number of species detected at a single site, where sampling was repeated for 3-4 consecutive nights ("A" category) versus the number of species detected at multiple sites ("B" category).

3.4.2.2. Comparison of Repeat Sites with Other Sites in Same Habitat Category

In eight separate trials we compared the number of species detected acoustically at a single site sampled for 3 or 4 sequential nights with the number of species detected on a single night at 3 or four different sites within the same habitat category. In all comparisons of single versus multiple sites, the number of multiple sites matched the number of nights a single site was sampled. Thus, if the number of multiple sites was three, then three nights of data for a single site were used. The single site was sampled on three or four sequential nights, and on one of those nights two or three additional sites within the same habitat category were also sampled.

It is generally assumed that when sampling for species diversity, it is preferable to sample multiple sites rather than repeat sample a single site. This is almost certainly true for capture sites, where capture success declines with repeat sampling, presumably because the animals learn and become net averse (Kunz and Kurta 1988). Acoustic surveys do not have the same investigator bias. The results of our comparisons, as depicted in Figure 39, suggest that there is no significant difference for number of taxa detected between the two approaches – repeat samples taken at a single site versus single samples taken at multiple sites.

Nevertheless, our samples may be biased by the fact that when selecting our repeat sampling sites, we selected those we thought most likely to yield high diversity in our study area. Also, the data do suggest that if your target is a rare species, and your sampling time is limited, you are more likely to detect this species by sampling multiple sites. Also, sampling multiple sites provides information regarding distribution within the study area.

3.5. Species Accounts

Eighteen species of bats have been identified in Yosemite National Park; fourteen of these were identified as occurring in the giant sequoia groves. Below are species accounts for each species, providing background information on its distribution and ecology, a summary of what is known regarding its distribution in Yosemite National Park, and a discussion of our findings in this study.

3.5.1. *Antrozous pallidus*, Pallid Bat

Background

Antrozous pallidus is distributed from southern British Columbia and Montana to central Mexico, and east to Texas, Oklahoma and Kansas. An isolated population also occurs on Cuba (Hermanson and O'Shea 1983). *A. pallidus* occurs in a number of habitats ranging form rocky arid deserts to grasslands into higher elevation coniferous forests. They are most abundant in the arid Sonoran life zones below 2,000 m, but have been found up to 3,400 m in the Sierra Nevada (Barbour and Davis 1969; Record from Chagoopa Plateau, Sequoia National Park). It shows an association with oak habitat (both low elevation oak savannah and mid-elevation black oak) (Rainey and Pierson 1996), mixed deciduous forest (*e.g.*, documented populations in Yosemite Valley and Wawona), and both coast redwood and giant sequoia habitat (Pierson and Heady 1996, Rainey *et al.* 1992).

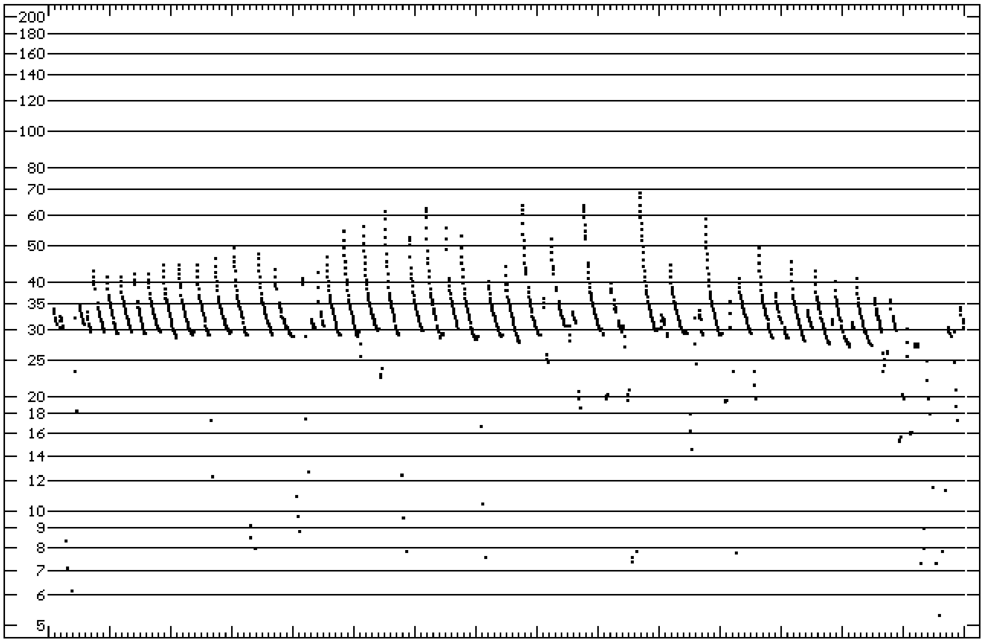
This species is quite versatile in its choice of roosting sites, and has been documented using tree hollows (both oak and ponderosa pine), rock crevices, caves, abandoned mines, and other anthropogenic structures such as buildings and bridges (Barbour and Davis 1969, Hermanson and O'Shea 1983, Lewis 1996, Orr 1954, Pierson *et al.* 1996, Pierson *et al.* 2001, E.D. Pierson and W.E. Rainey unpublished data). This species is gregarious, and roosts in nursery colonies of typically between 30 and several hundred individuals.

A. pallidus feeds primarily on large, ground-dwelling prey -- flightless arthropods such as scorpions, Jerusalem crickets, cicadas, wolf spiders and centipedes. Large cerambycid beetles, particularly *Prionus californicus*, and ten-lined June beetles (*Polyphylla decemlineata*) are also major prey items (Johnston and Fenton 2001, Orr 1954, Pierson *et al.* 2004).

This species is morphologically distinctive. It is a relatively large bat with a forearm of 48-60 mm. It is pale (blonde to tan) with large ears, a blunt pig-like snout, and a characteristic skunk-like odor. It has a distinctive echolocation call that allows it to be identified acoustically (Figure 40a). Particularly diagnostic is the social "directive" call (Figure 40b).

Records from Yosemite Prior to This Study

There are 8 museum specimens for pallid bats for Yosemite National Park, all from Yosemite Valley (MVZ, YNP), collected between 1934 and 1940. More recent studies conducted in Yosemite National Park and along Rte. 120 indicate that pallid bats occur from the Central Valley to at least 1,890 m in the Park (Pierson and Rainey 1993 & 1995, Pierson *et al.* 2001, Pierson and Rainey unpublished data).



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Tape:   ABpassiv Date: 01/07/02  Loc: CA;Mariposa;YNP;UpprGrv;Wawona Jct
Sp: aAP                                                 Spec:
Note:   37N..... 119W..... ....m;EDP;2032-AM PDT;B;1080R 8.4gn lmk;wx:clear,calm,
hot
B7022036.01#    Div 16      Type  132   2001/07/02 2036:01
TOT 375ms TK 25ms  f6 COMP St 2      FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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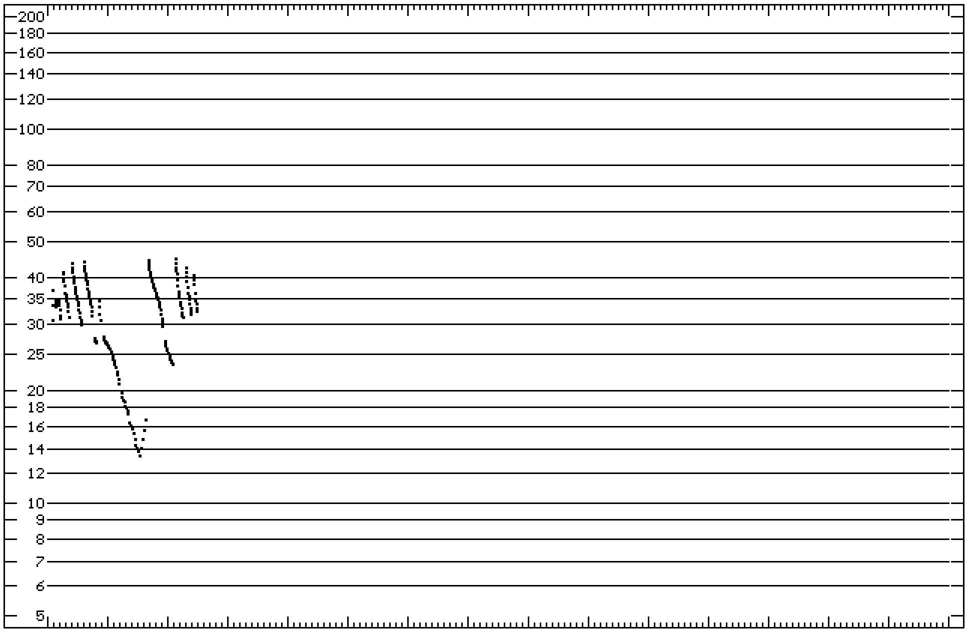
Figure40a. Echolocation call of pallid bat, Upper Mariposa Grove, 02 July 2001.



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Tape:   ABpassiv Date: 01/08/29  Loc: CA;Mariposa;YNP;TuolGv;trail/1st seq
Sp: aAP                                                 Spec:
Note:   37N....., 119W....., ....m;WFF;1955-2300PDT;B1327 8.3gn lmk;wx:clr,clm,
warm;at first tree in grove facing over trail. as bfr in june
B8292054.15#    Div 16      Type  132   2001/08/29 2054:15
TOT 375ms TK 25ms  f6 COMP St 2      FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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Figure 40b. Diagnostic directive call of pallid bat, Tuolumne Grove, 28 August 2001.

This Study

Data (both guano and culled prey) collected from the suspension traps documented that the giant sequoias provided important refugia for pallid bats in the Mariposa Grove. They used 63% (17 out of 27) of the basal fire scars we monitored. Additionally, our data suggested that they used at least three giant sequoia trees as colonial roost sites -- #39 in the Lower Grove, near the tram parking, and #42 and #43, a pair of adjacent trees in the Middle Grove, west of the Grizzly Giant.

They were detected acoustically during 19% of the acoustic sampling sessions, and at 29% of the acoustic stations. Because this species often forages close to the ground, and frequently uses visual and auditory cues (as opposed to echolocation) for prey detection (Bell 1982), the acoustic data likely under-represent the relative abundance of this species in the Mariposa Grove. The largest number of detections was along trails or in the relatively open seeps and rock outcrops with the fewest detections along the creek and in the meadow (Figure 41).

Four individuals were captured – three of them, including two juveniles, in association with Tree #39. The fourth individual, a lactating female, was captured at Boundary Creek and outfitted with a radio-transmitter. Although her roost was never specifically located, it was thought to be on a steep, rocky slope northwest of the Mariposa Grove.

Sampling in the Merced and Tuolumne Groves was too limited to be conclusive. We obtained one acoustic record for pallid bats in the Merced Grove, in association with Tree #44 (a giant sequoia near Moss Creek, with a large basal hollow). Four to five stations were sampled on six

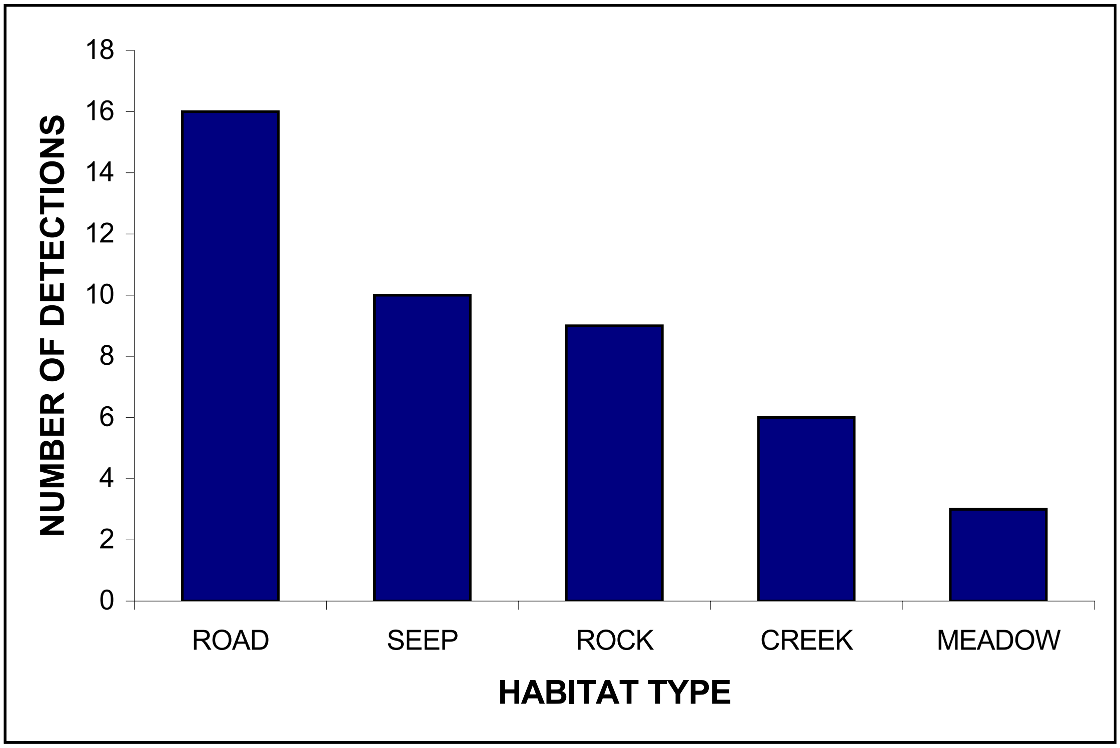


Figure 41. Acoustic activity (number of detections) for pallid bats by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

different nights between June and October. Although we found no culled prey (Jerusalem crickets or scorpions) diagnostic for pallid bats in our suspension traps in the Merced Grove, we did find long-horned beetle parts in six of the nine monitored trees (in 7 % of the samples taken in 2000, and 15% of the samples taken in 2001). While cerambycid beetles could be consumed by other bat species, it is a favored prey item for pallid bats. We also have a July 2004 capture record for a lactating female pallid bat from the vicinity of Crane Flat Campground, upslope a few kilometers from the Merced Grove.

We obtained 1 record for pallid bats in three nights of acoustic sampling (12 stations).

Comparative mist-netting efforts conducted at the South Fork Merced River in Wawona yielded 14 pallid bats in one night, including ten lactating females and three juveniles. It is highly likely that there is a pallid bat maternity roost located near this capture site.

3.5.2. *Eptesicus fuscus*, Big Brown Bat

Background

E. fuscus, is one of the most widely distributed species in the Western Hemisphere, occurring from western South America to northern Canada, and throughout the United States (Hall 1981). It is found in almost all habitats in California, from sea level to high elevation (Barbour and Davis 1969), although maternity colonies may be concentrated at lower elevations (Pierson *et al.* 2001).

It is primarily a crevice roosting species. Common diurnal roost sites are trees (particularly snags), old buildings, bridges, rock crevices, caves, and mines (Barbour and Davis 1969, Brigham 1991, Kurta and Baker 1990). Big brown bats are colonial, with a typical colony containing 25-75 adults, although colonies up to 700 have been found (Kurta and Baker 1990). Big brown bats are foraging habitat generalists, feeding aerially over both water and land, in forested and edge situations. They often emerge early (prior to dark) and can be seen foraging very high (up to 50 m above the ground), descending later in the evening to 10-15 m (Whitaker *et al.* 1977). In some habitats they feed predominantly on beetles (Coleoptera), including important agricultural pests (Whitaker 1995). In other localities they may feed primarily on aquatic insects, such as caddisflies (Trichoptera) (Brigham 1991, Verts *et al.* 1999), and have been known to consume a variety of other insect groups (*e.g.*, Hemiptera, Hymenoptera, Diptera, Plecoptera, a few Lepidoptera). In northern California, radio-tracking and netting data suggest individuals follow watercourses to forage, often flying above canopy level, and not traveling more than a few kilometers from their roosts. They feed over both open river corridors and in much more cluttered settings beneath the riparian canopy of small streams (Rainey and Pierson 1996, E.D. Pierson and W.E. Rainey unpubl. data).

E. fuscus is a relatively large bat (forearm of 42-51 mm), with glossy deep brown fur and a blunt tragus (which distinguishes it from all *Myotis* species), broad wings, and a keeled calcar (Barbour and Davis 1969). It typically echolocates at ca. 25 kHz, and whereas some of its calls are distinctive, many are not distinguishable from other 25 kHz species (most typically, *Lasionycteris noctivagans* and *Tadarida brasiliensis*).

Records from Yosemite Prior to This Study

There are 38 museum records for this species from Yosemite National Park (CM, KU, MCZ, MVZ, YNP -- 17 from Yosemite Valley, seven from Merced Lake, with additional records from Hetch Hetchy, Tuolumne Meadows, Miguel Meadow, upper Yosemite Creek, Benson Lake and Arch Rock). Collection dates range from 1880 to 1957. More recent studies conducted in Yosemite National Park and along Rte. 120 indicate that big brown bats are one of the most abundant species in the Sierra Nevada, occurring from the floor of the Central Valley to at least 3,000 m (Pierson and Rainey 1993 & 1995, Pierson *et al.* 2001).

This Study

E. fuscus was by far the most frequently encountered bat species in the Mariposa Grove – both in net captures and in acoustic surveys. Capture surveys documented that the species had reproductive populations in the Mariposa Grove. We radio-tracked 10 individuals of this species, and found that they roosted predominantly in live giant sequoias, and very large, dead ponderosa and sugar pines. To a lesser extent they roosted in white fir snags, and one individual used four different rock crevice roosts at Wawona Point. The majority of these individuals foraged within the grove, within a few km radius of their roost sites.

Based on both capture and acoustic surveys this species was somewhat less common in the Merced Grove. It was, nevertheless, still one of the dominant taxa. Based on acoustic data alone (*i.e.*, number of acoustic detections for 25 kHz bats), it was also relatively common in the Tuolumne Grove.

3.5.3. *Euderma maculatum*, Spotted Bat

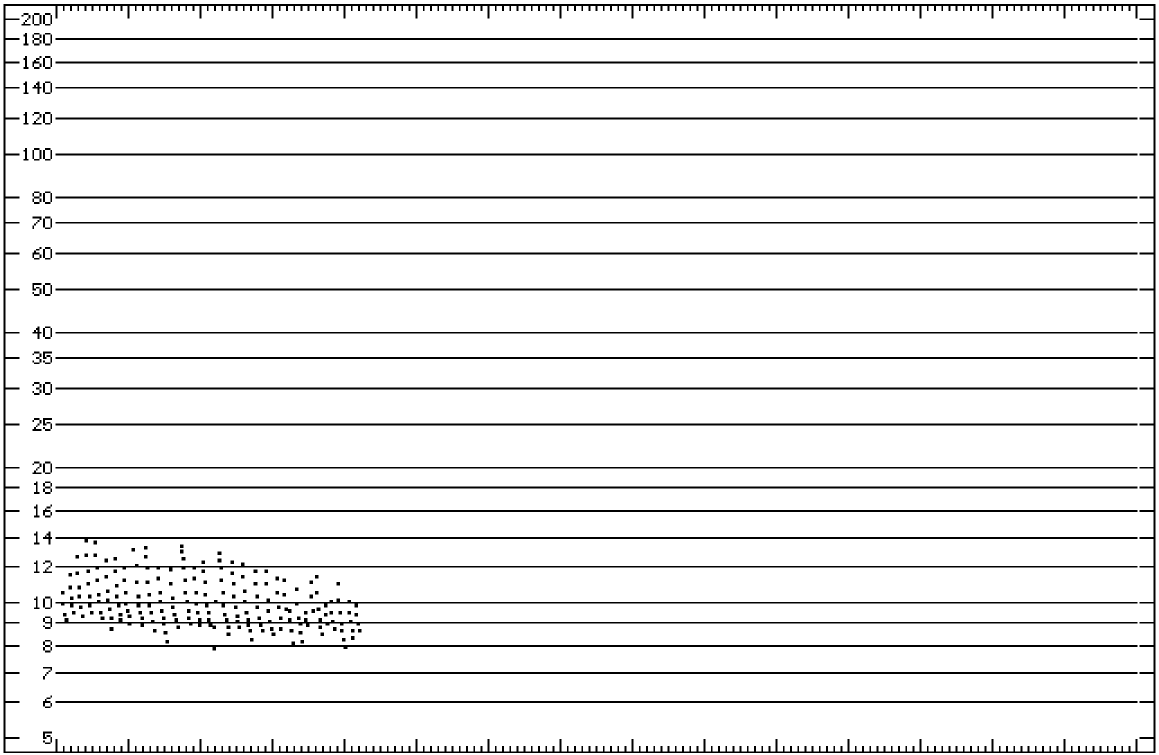
This species is distributed throughout much of the western U.S., with its range extending as far north as southern British Columbia, and as far south as Durango, Mexico. The widely used distribution map from Hall (1981) does not reflect more recent range extensions. There are now records for western Colorado, Oregon, and the Klamath Mountains of northwest California. Its distribution in California has recently been reviewed by Pierson and Rainey (1998c).

Although the majority of museum records are from low elevation, it is now known to be widely distributed in the Sierra Nevada, with acoustic records up to >3,000 m. It has been collected most often in dry, rough desert terrain, but occurs in habitats ranging from desert scrub to montane coniferous forest. Within this overall range, the species' distribution appears to be patchy and geomorphically determined, limited to areas with appropriate roosting habitat (Pierson and Rainey 1998c).

Limited information suggests that spotted bats roost non-colonially, predominantly in crevices in high cliff faces (Wai-Ping and Fenton 1989). Surveys in the Sierra Nevada suggest that they are most abundant in areas with fractured rock (Pierson and Rainey 1996b, 1998a & c). Spotted bats feed primarily on large (5-12 mm) moths (most likely noctuids). Most observations suggest spotted bats forage alone (Wai-Ping and Fenton 1989), sometimes maintaining exclusive feeding areas (Leonard and Fenton 1983), and other times using a “trapline” strategy (Woodsworth *et al.* 1981). Individuals generally forage 5-15 m off the ground in large elliptical paths, with axes of 200-300 m (Wai-Ping and Fenton 1989, Navo *et al.* 1992, Pierson and Rainey 1996b). Recent radio-tracking studies in Arizona have documented this species traveling one-way distances from the roost site of up to 40 km each night (Chambers *et al.* 2005).

This is a highly distinctive species morphologically. It is a relatively large bat (forearm of 48-51 mm), with very striking coloration. Its dorsal fur is black, with three large white spots, one on the rump and one on each shoulder. Its ears are pink, and larger than those of any other North American bat species (Barbour and Davis 1969). If captured alive or found as an intact specimen, it could not be mistaken for any other species.

It is also distinctive acoustically (Figure 42). Its echolocation call, with a characteristic frequency of 5-7 kHz, is generally audible, and distinguishable from the other audible species in Yosemite (*Eumops perotis*) by the more rapid cadence (shorter inter-pulse intervals) of its calls. In addition to its search phase echolocation call, it often emits a social call ("trill") that appears to be used to claim foraging territory from alert conspecifics (personal observation).



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;wx:clr,calm, warm;same loc as bfr on log below balloon
B7270006.58#   Div 8      Type  132   2001/07/27 0006:58
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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Figure 42. Echolocation call of spotted bat, Upper Mariposa Grove, 27 July 2001.

<u>Records from Yosemite Prior to This Study</u>

There are two museum records for this species from Yosemite National Park, both from Yosemite Valley (MVZ), collected in 1931 and 1951. More recent studies conducted in Yosemite National Park have documented that spotted bats are relatively abundant in many areas of Yosemite National Park, where suitable cliff-roosting habitat is prevalent. The majority of records are from relatively open foraging settings (*e.g.*, wet meadows) at lower elevations (*e.g.*, Yosemite Valley and Wawona). We have records, however, from a number of sites up to >3,000 m (Pierson and Rainey 1993,1995 & 1996b, Pierson *et al.* 2001).

This Study

Spotted bats were very rare in the Mariposa Grove. They were detected only acoustically. We had eleven detections during nine out of 175 sampling sessions (Figure 43). The majority of detections were in the wet meadow area in the Upper Grove. This species was also detected acoustically in the Merced Grove and the Tuolumne Grove. We had four detections at one station on one night (one out of 25 sampling sessions) in the Merced Grove, and one detection in the Tuolumne Grove (one out of twelve sampling sessions).

Because this species is thought to be an obligate cliff-dweller, and is known to travel large distances from its roost sites to forage, it is highly unlikely that it was roosting in any of the giant sequoia groves.

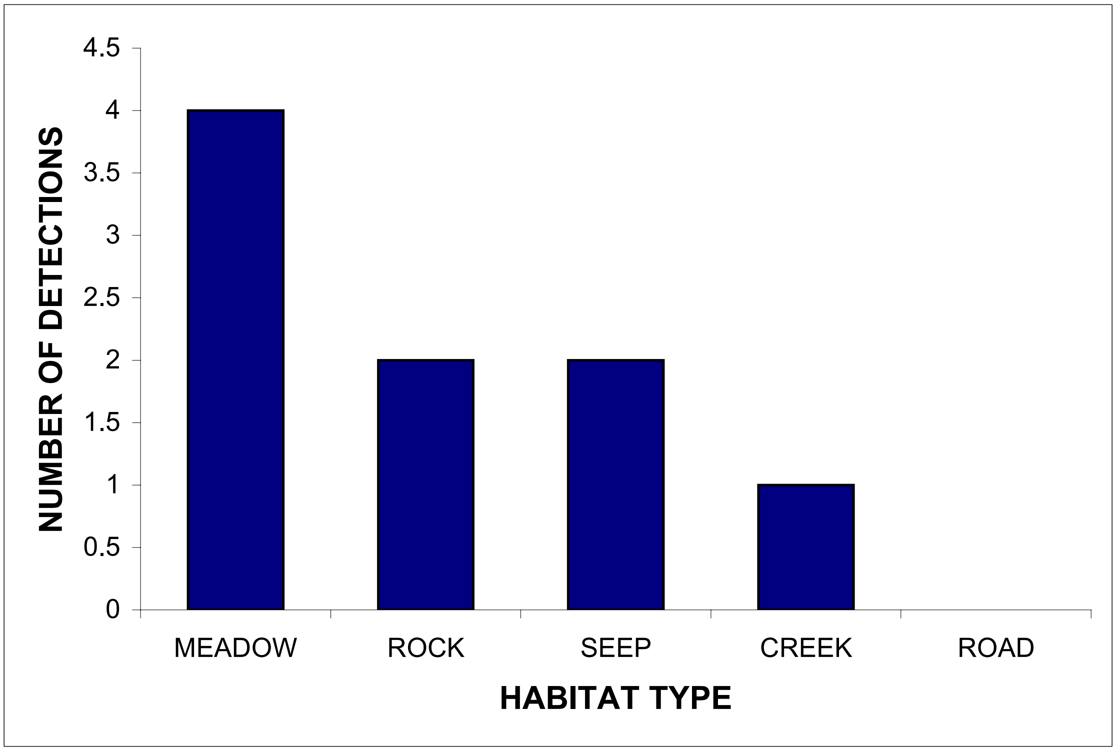


Figure 43. Acoustic activity (number of detections) by habitat type for spotted bats in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

3.5.4. *Eumops perotis*, Western Mastiff Bat

Eumops perotis has a disjunct distribution, with two subspecies confined to South America. The subspecies that occurs in North America, *E. p. californicus*, ranges from central Mexico across the southwestern United States (parts of California, southern Nevada, Arizona, southern New

Mexico and western Texas) (Eger 1977, Bradley and O'Farrell 1967). Although generally regarded as a desert bat, recent surveys have documented a distribution in California that is far broader than was previously realized (Pierson and Rainey 1996b & 1998a, Rainey and Pierson 1996). Once thought to occur primarily in southern California, it is now known to occur almost as far north as the Oregon border (Pierson *et al.* 1996, Rainey and Pierson 1996), with roosts in the Sierra Nevada up to 1,400 m, and foraging animals at >3,000 m. The distribution of *E. perotis* is likely geomorphically determined, with the species being present only where there are significant rock features offering suitable roosting habitat. It is, however, found in a variety of habitats, from desert scrub to chaparral to oak woodland and into the ponderosa pine belt.

This species roosts in moderate size colonies, mostly in cliffs -- particularly under slabs of exfoliating granite or crevices in basaltic columns. Building roosts have also been identified in the Los Angeles basin. As fast-flying aerial foragers, individuals can travel large distances per night (up to 25 km one-way distance from the roost). Focused studies on this species in Yosemite National Park have documented that the distribution of this species is geomorphically limited, and highly associated with both the granite features of the Sierra Nevada and the basaltic tablelands of the foothills. While this species is rare in many parts of the state, it is relatively abundant in the central Sierra Nevada wherever there are granite cliffs.

E. perotis is morphologically distinctive. It is North America's largest bat, with a forearm of 72-82 mm and a wingspan of up to 570 mm. The distal half of the tail is free from the tail membrane, and its large, forward leaning ears are joined at the mid-line (Barbour and Davis 1969). It has a highly distinctive and generally audible echolocation call at ca. 8-12 kHz. It can be distinguished from the other audible species (*Euderma maculatum*) by the much longer (up to one second) inter-pulse interval (Figure 44).

Records from Yosemite Prior to This Study

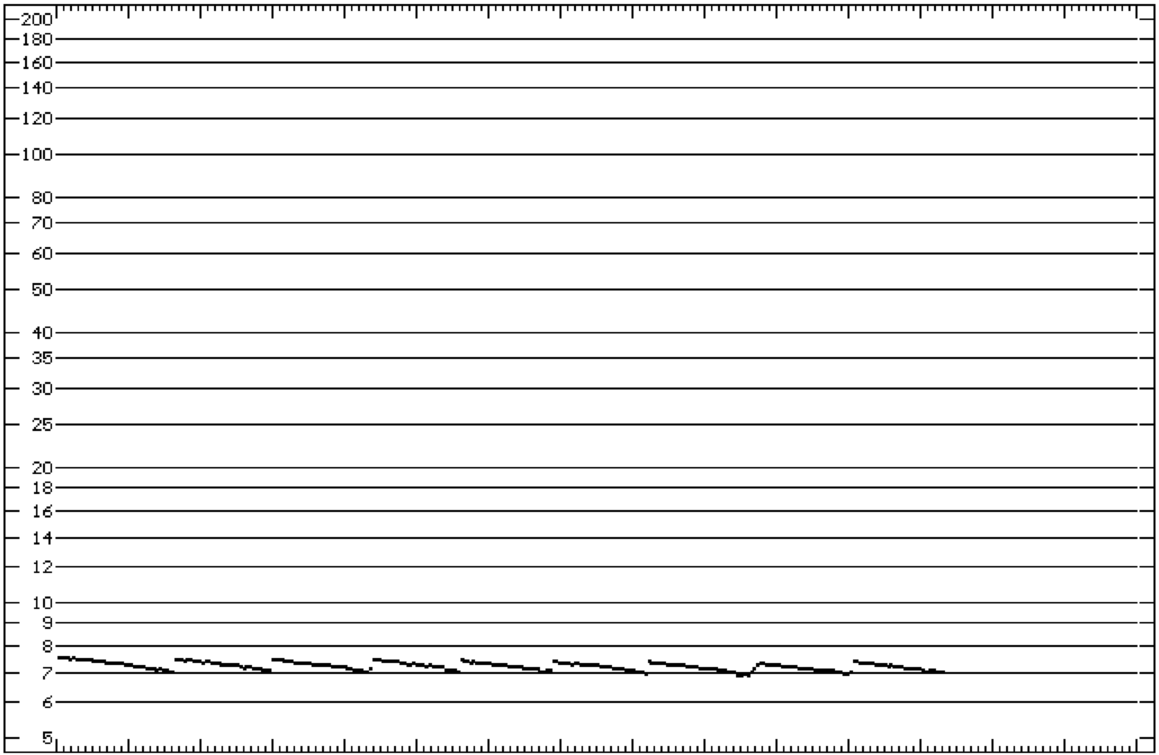
There are five museum records for this species from Yosemite National Park, all from Yosemite Valley (YNP), collected between 1924 and 1941. Recent studies in the park have documented that *E. perotis* is relatively abundant, especially at lower elevations in areas with the combination of exfoliating granite (for roosting) and nearby meadows (for foraging), as is found in Yosemite Valley and Wawona.

This Study

E. perotis was detected only acoustically, but there were significant differences in the relative frequency with which it was detected in the three groves. It was relatively rare in both the Mariposa and Merced Groves, constituting 0.98% and 2.00% respectively of all acoustic detections.

In the Tuolumne Grove it was the second most commonly detected species. This actually may be an artifact of the extremely limited sampling in this grove, since there was a large pulse of *E. perotis* on one night of sampling in September 2001. They were detected most prevalently in a clearing below the road, and it may be that this grove, which is in general more open than the other two, may provide a foraging corridor for this species.

In the Mariposa Grove, it was detected most frequently in association with an open rock outcrop, at Wawona Junction (a gap that may be a flyway), and in the meadow in the Upper Grove (Figure 45).



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Note:  37N..... 119W....., ....m;WFF;1955-2300PDT;B1327 8.3gn lmk;wx:clr,clm,
warm;at first tree in grove facing over trail. as bfr in june
B8292045.53#   Div 16     Type  132   2001/08/29 2045:53
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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Figure 44. Echolocation call of western mastiff bat, Tuolumne Grove, 29 August 2001.

3.5.5. *Lasionycteris noctivagans*, Silver-haired Bat

Lasionysteris noctivagans has a broad distribution from southern Alaska, throughout southern Canada, most of the United States, and into the San Carlos Mountains of northeastern Mexico (Kunz 1982). Its distribution in California is generally thought to be concentrated in the northern half of the state, with most of the breeding records occurring in the upper Sacramento drainage (Rainey and Pierson 1996), the Trinity Mountains and northern coast ranges (Pierson and Rainey 1998b), and the northern Sierra Nevada. S. Sweet (personal communication) reports, however, finding breeding females on Mt. Pinos in Ventura County. Although there are relatively few records for southern California (Constantine 1998), they are concentrated in the winter, suggesting that some individuals of this migratory species may over-winter in southern California.

L. noctivagans is a forest bat, associated primarily with north temperate zone conifer and mixed conifer/hardwood forests. A netting study in Oregon showed a strong association with old growth forest (Perkins and Cross 1988). It has been found in winter and during seasonal migrations in low elevation, more xeric habitats.

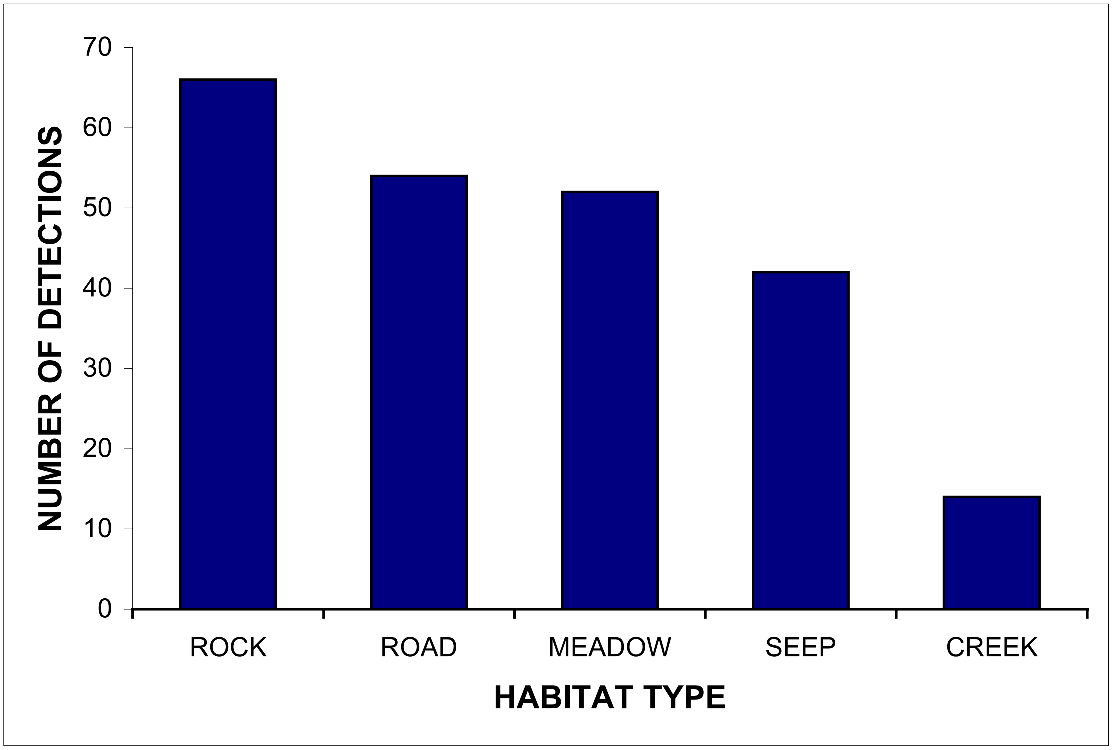


Figure 45. Acoustic activity (number of detections) for western mastiff bats by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

Several radio-tracking studies have documented that this species roosts in warm seasons almost exclusively in trees -- both in woodpecker and other cavities and under flaking bark (Barbour and Davis 1969, Betts 1996 & 1998, Campbell *et al*. 1996, Rainey and Pierson 1996, Vonhof 1996). Roosts are generally in large diameter dead or dying trees, in locations that are high (> 15 m) and uncluttered. This species has been found hibernating in hollow trees, under sloughing bark, in rock crevices, and occasionally in buildings, mines and caves (Barbour and Davis 1969, Kunz 1982a). There is a record of silver-haired bat hibernating in leaf litter (Sanborn 1953), a pattern that is likely poorly detected and, like similar behavior in western red bats (see below), is probably more common than is realized.

L. noctivagans forages above the canopy, in forest clearings, and in the riparian zone along water courses (Barclay 1985 & 1986, Kunz 1982, Rainey and Pierson 1996). Radio-tracking has shown that it travels considerable distances from roost sites to foraging areas (Rainey and Pierson 1996). Although the species is known to take a wide variety of insects, including Diptera, Homoptera, Hemiptera, Hymenoptera and Coleoptera, moths appear to be a major portion of dietary prey (Barclay 1985 & 1986, Kunz 1982, van Zyll de Jong 1985, Whitaker *et al.* 1981b). In a study in the upper Sacramento River drainage the diet of this species was dominated by Lepidoptera and Trichoptera (Rainey and Pierson 1996).

This is a medium-sized bat with a forearm of 37-44 mm. Its fur is generally black (sometimes dark brown) with silver-tips. The interfemoral membrane is furred. Its ears are short and rounded. Its size, along with its frosted fur, distinguish it from all other species. The only other species with frosted fur are either larger (*Lasiurus cinereus*) or red (*Lasiurus blossevillii*). Its echolocation calls, while sometimes distinctive, overlap in frequency with those of other 25 kHz species, especially *Eptesicus fuscus* and *Tadarida brasiliensis*.

Records from Yosemite Prior to This Study

There are no museum records for this species from Yosemite National Park. Recent studies have provided the first records for this species from the park, with the first animal being captured in Yosemite Valley on 21 July 1993 (Pierson and Rainey 1993). Since then this species has also been captured over the South Fork of the Merced River in Wawona (Pierson *et al.* 2001).

This Study

Seven *L. noctivagans* were captured at Kiosk Creek in the Mariposa Grove on three different occasions, and one individual was captured in the Merced Grove. One animal escaped before it could be sexed, but all others were adult males. Two individuals were radio-tracked. Each one was followed for two to three days before both disappeared. One individual roosted in two different ponderosa pines, and the other in two sugar pine snags. While neither of these individuals roosted in giant sequoias, the sample size was very small. We were able to document that this species both roosted and foraged in the Mariposa Grove.

3.5.6. *Lasiurus blossevillii*, Western Red Bat

Until recently the western red bat was considered a subspecies of *Lasiurus borealis*, and was known as *L. b. teliotis* (Shump and Shump 1982a). Based on two recent phylogenetic studies (Baker *et al.*, 1988; Morales and Bickham, 1995), however, this taxon is now recognized as a separate species, *L. blossevillii*, with a distribution that extends from southern British Columbia (Nagorsen and Brigham 1993) through the western U.S., Mexico, Central America, and South America, although the work of Morales and Bickham (1995) suggests that the South American populations should be treated as a separate species.

In California, the majority of records are from the coastal areas from the San Francisco Bay area south, plus the Central Valley and bordering foothills, with a limited number of records from southern California, extending as far east as western Riverside and central San Diego Counties. There are a few records from higher elevations and the east side of the Sierra Nevada (Constantine 1998, Pierson *et al.* 2000, J. Szewczak personal communication). Breeding females for this foliage-roosting species appear to be highly associated with lower elevation riparian habitats, particularly relatively intact stands of cottonwood and sycamore in the Central Valley and southern coastal areas (Pierson *et al.* 2000). Winter populations of both sexes are concentrated along the central and southern coast (Pierson *et al.* 1999). Grinnell (1918) suggested that red bats in California were sexually segregated in summer, with males moving to higher elevations, a pattern more recently noted in other species (*e.g.*, Cryan *et al.* 2000). There are records for red bats (most likely males or non-reproductive females) up to 2,500 m in the Sierras (Pierson *et al.* 2000 & 2001).

L. blossevillii roosts on the underside of overhanging leaves. Recent studies in the Central Valley found that summering populations are substantially more abundant in remnant stands of cottonwood/sycamore riparian that extend >50 m back from the river than they are in younger, less extensive stands (Pierson *et al.* 1999). Red bats have been observed emerging near canopy level in mature cottonwood stands. This species also roosts extensively in orchards. Constantine (1959) found the species roosting in fruit trees (apricot, fig, and orange) in the Central Valley of California. In an analysis of these roosts Constantine (1959) suggested the bats selected trees that were well-pruned and 4.5-6.0 m in height, with roost sites typically located 2.6 m above the ground. The trees had rigid branches and short stems that resisted the wind, a spreading canopy, and lacked lower limbs that might provide perches for predatory birds. The roosting site was usually dark, well sheltered from above, with open exposure for free flight below. Dalquest (1945) noted daytime roosting sites for *L. blossevillii* in tamarisk windbreaks along irrigation ditches in California's Central Valley. They also have been found in peach orchards (Grinnell 1918), and detected at emergence time in stands of eucalyptus and adjacent to almond, apricot, fig, and walnut orchards (Pierson *et al.* 1999). Other roosts in non-native vegetation include mulberry (Grinnell 1918) and china berry (Constantine 1959).

Animals discovered in winter in Golden Gate Park in San Francisco were roosting in *Sparmannia africana*, a large-leafed, exotic, evergreen plant commonly planted in gardens in the Bay area (Orr 1950). Winter behavior of this species is not well understood. Saugey *et al.* (1998) recently documented, through a radio-tracking study in Arkansas, that when temperatures dropped, some individuals of the closely related *L. borealis* moved from trees to hibernate in the leaf letter. Red bats apparently arouse from hibernation on warm days to feed (Shump and Shump 1982a), and Orr's observations suggest that this species forages periodically during the winter in the San Francisco Bay area (Orr 1950).

Red bats forage on a number of insect taxa, flying at both canopy height and low over the ground (Shump and Shump 1982a). One diet sample from California suggests this species feeds primarily on small moths, but takes a variety of other insects, particularly orthopterans (Ross 1961). Other dietary information has come from *L. borealis* in the eastern U.S. In a study conducted in Indiana, Whitaker (1972) found that red bats ate 26% moths. Other studies (summarized in Shump and Shump 1982a) have also found Homoptera, Coleoptera, Hymenoptera, Diptera in the diet.

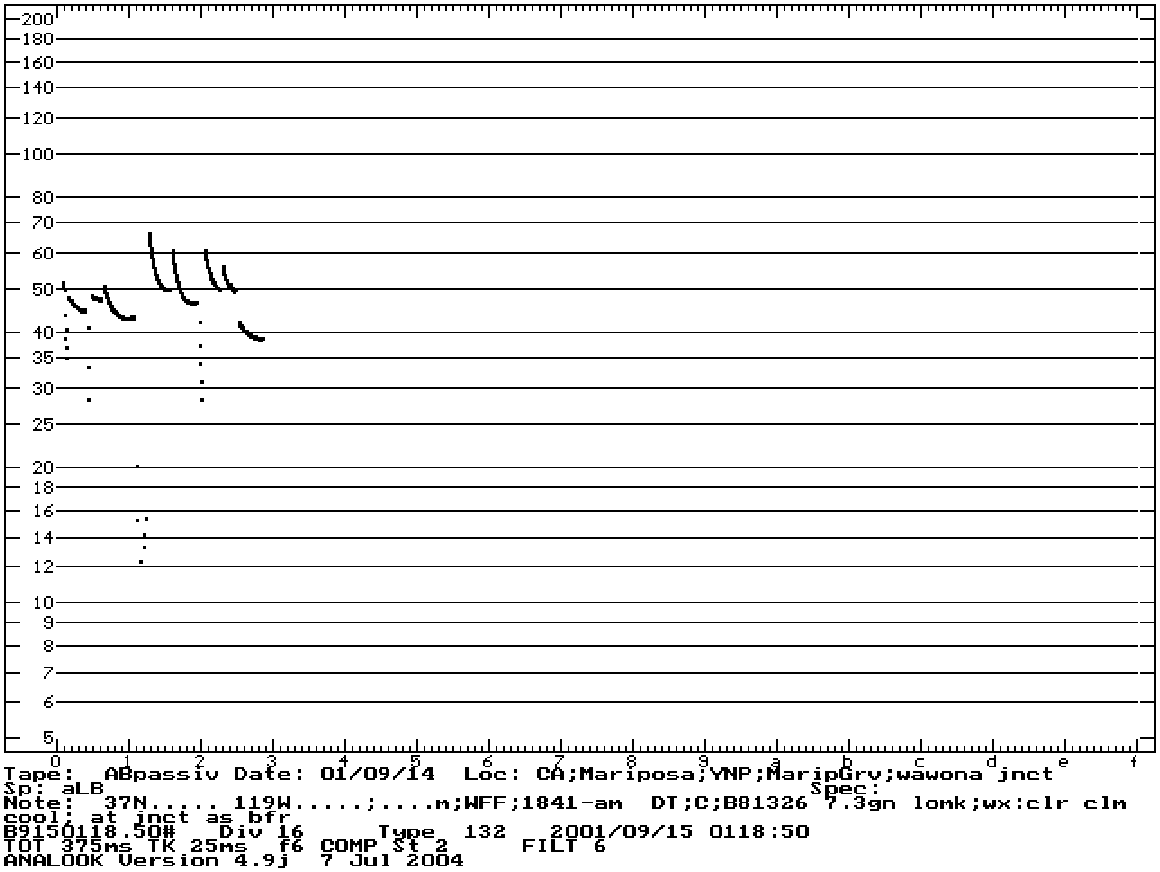
L. blossevillii is a medium sized bat with a short rostrum, short rounded ears, and a heavily furred interfemoral membrane (Barbour and Davis 1969, Shump and Shump 1982a). It can generally be distinguished by the brick-red color of its fur. The color, however, can vary from intense red to yellow-brown. It can, nevertheless, be distinguished from *Lasiurus cinereus* based on size. *L. blossevillii* has a forearm of 35-45 mm; *Lasiurus cinereus* is larger, with a forearm of 46-58 mm. This species also has a distinctive echolocation call, which is typified by a porpoising pattern from pulse to pulse, and has a characteristic frequency of ca. 45 kHz (Figure 46).

Records from Yosemite Prior to This Study

There are no museum records for this species from Yosemite National Park. Recent studies in the park have provided the first records for this species, with the capture of three individuals (2 adult males and one nulliparous female) over the South Fork Merced River on 16 September 1998

(Pierson *et al.* 2001). Since that time this species has been documented acoustically at multiple localities up as high as Siesta Lake at 2433 m (Pierson *et al.* 2001).

At low elevation sites (*e.g.*, in the Central Valley), *L. blossevillii* roosts in fruit orchards, mature cottonwood and sycamore trees, and willow riparian. Acoustic detections have been obtained in association with black cottonwood in both Yosemite and Sequoia National Parks. Other potential roosting sites have not been identified.



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cool; at jnct as bfr
B9150118.50#   Div 16     Type  132   2001/09/15 0118:50
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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Figure 46. Echolocation call of western red bat, Upper Mariposa Grove, 15 September 2001.

This Study

L. blossevillii was detected only acoustically, and only in the Mariposa Grove. We had a total of 25 detections during the entire study. It was detected during 11.28% of the sessions, and at 29.27% of the sites. The majority of the detections were either in an open rock setting at Rattlesnake Dome, or on the road at Wawona Junction (Figure 47). The latter site was located in a saddle and may have been a flyway for bats to enter the grove. *L. blossevillii* was also detected from the balloon, at 63 m above the meadow. The absence of detections in the Merced and Tuolumne Groves may reflect the much lower sampling effort.

Whether or not this species roosts in the giant sequoia groves is unknown.

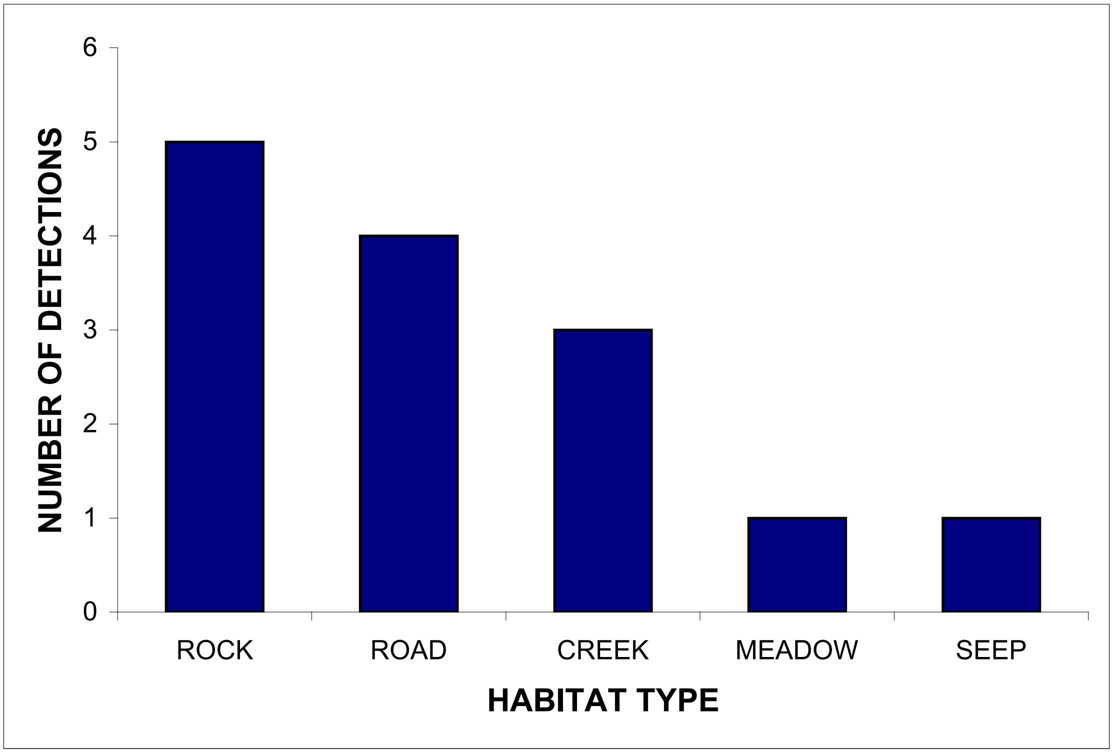


Figure 47. Acoustic activity (number of detections) for western red bats by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

3.5.7. *Lasiurus cinereus*, Hoary Bat

L. cinereus is the most widespread of all North American bats (Shump and Shump 1982b). It ranges from near tree line in Canada, southward at least to Guatemala, and from Brazil to Argentina and Chile in South America. Hoary bats are uncommon throughout most of the eastern U.S. and in the northern Rocky Mountains, but are more common in the prairie states and Pacific Northwest. Breeding females are distributed primarily in southern Canada and the central portion (Great Plains) of the United States (Findley and Jones 1964).

No breeding females have been found in California, and the majority of records (and all mid-summer records) are males. This species is found throughout California, with records from the Central Valley to > 2,500 m in the Sierra Nevada. It is highly associated with cottonwood riparian habitat, and is also found in forested areas. A netting study in Oregon showed a strong association with old growth Douglas fir forest (Perkins and Cross 1988). This species is known to undergo long distance seasonal migrations (Cryan 2003), with increased numbers of animals appearing along the California coast in the fall (Dalquest 1943, Tenaza 1966) and in southern California in the winter (Vaughan and Krutzsch 1954). Data obtained recently in the Central Valley and the Sierra foothills (Pierson *et al.* 2000) suggest that this species migrates through the Central Valley and adjacent foothills in the spring and the fall. We obtained six records from the shore of the largest lake in Dusy Basin at 3,425 m, possibly a high elevation record for this species (E.D. Pierson and W.E. Rainey unpublished data).

L. cinereus roosts primarily in foliage in both coniferous and deciduous trees. Some unusual roosting situations have been reported in caves, beneath a rock ledge, in a woodpecker hole, and in a squirrel's nest (Tenaza 1966, Shump and Shump 1982b, van Zyll de Jong 1985), but the species is generally found in trees. In a radiotracking study in Alberta (Barclay 1984), family groups, consisting of an adult female and two young, roosted high in trees (8-12 m. above the ground), predominantly in green ash (*Fraxinus pennsylvanicus*). Roosts were generally near the tips of branches, in locations offering an unobstructed flight path. One family group used the same roost for 41 days, while another moved between two trees that were 10 m apart. In the southwestern U.S. this species is frequently associated with riparian habitats (Hoffmeister 1986, Pierson *et al.* 2000), and is presumed to roost in trees such as cottonwood, sycamore and mature willow.

L. cinereus forages along river and stream corridors, over open bodies of water, over meadows, in open forest habitat, and above forest canopies (Kalcounis *et al.*1999). In a radio-tracking study conducted in southern Canada, this species traveled up to 40 km and foraged in four habitats: lakeshore, forested ridge, meadows and marsh, with highest activity in the lee of a forested ridge (Barclay 1984). It feeds primarily on 6-30 mm moths (Black 1974, Ross 1967), but is also known to consume Coleoptera, Hymenoptera, Isoptera, and Odonata (Barclay 1985, Barclay 1986, Ross 1967, van Zyll de Jong 1985). Rolseth *et al.* (1994) found that newly volant juveniles foraged primarily on smaller insects like chironomids. In a study in the upper Sacramento River drainage the diet of this species was dominated by Lepidoptera (Rainey and Pierson 1996).

L. cinereus is a large bat (forearm of 46-58 mm.) with a short rostrum, short rounded ears, and a heavily furred interfemoral membrane (Barbour and Davis 1969, Shump and Shump 1982b). It can generally be distinguished by its distinctive coloration -- dark grey fur, with frosted white tips, a yellow face, and ears rimmed in black. This species has a distinctive echolocation call that has a characteristic frequency that varies from 16 to 25 kHz. A call sequence is typified by a porpoising pattern from pulse to pulse (Figure 48).

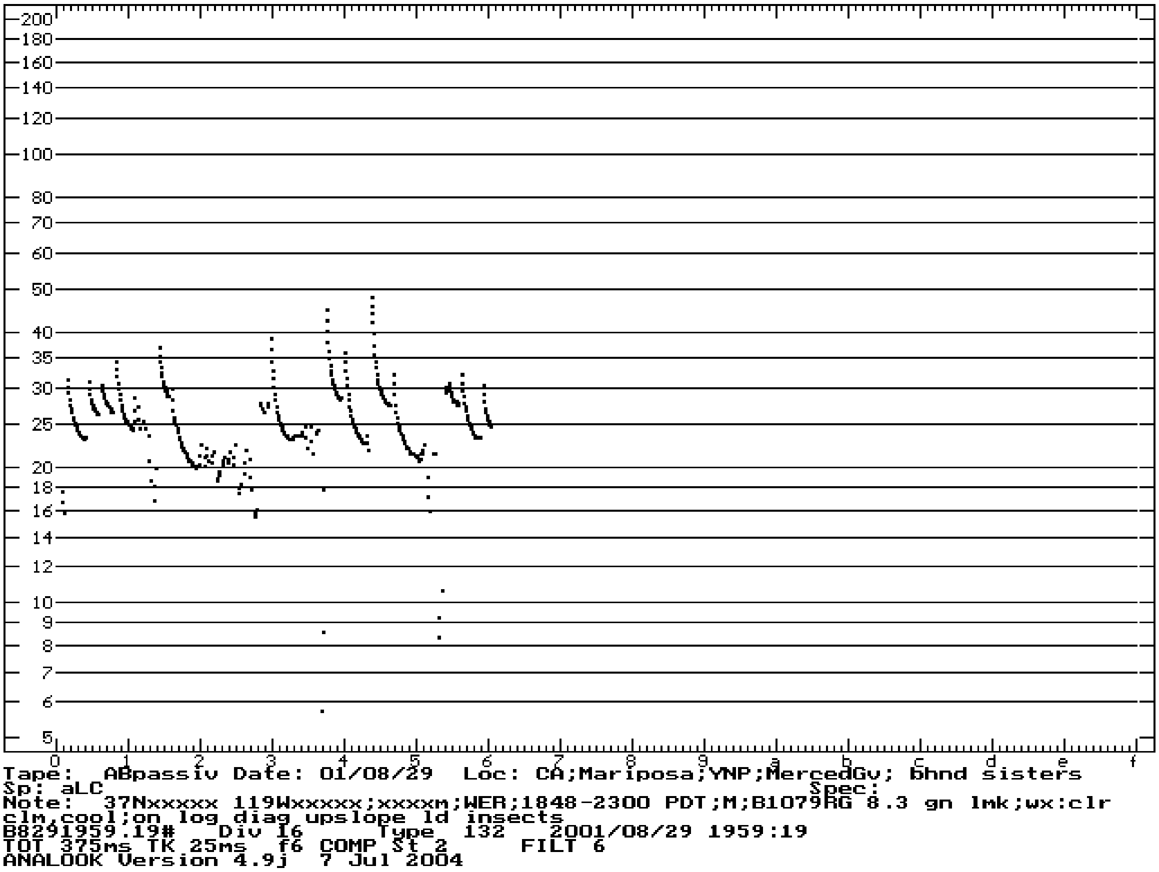
Records from Yosemite Prior to This Study

There are two museum records for this species from Yosemite National Park, one collected in 1939 in Yosemite Valley (YNP), and one collected in 1915 from one mile east of Merced Lake (MVZ). In more recent studies individuals of this species have been captured at a number of localities from Yosemite Valley and Wawona (1,000-1,200 m) to Tenaya Lake (2,488 m) (Pierson *et al.* 2001). It also has been documented acoustically at numerous sites throughout the park. No roost sites for this species are known in the park.

This Study

L. cinereus was detected acoustically in all three giant sequoia groves. It was among the rarest species in both the Mariposa and Merced Groves, constituting 1.5 % and 1.1% respectively of all detections. It was relatively more frequently detected in the Tuolumne Grove, where it constituted 3.3 % of all detections. The vast majority of these (25 out of 27) occurred, however, at one site on one night. In the Mariposa Grove, it was detected predominantly over the meadow in the Upper Grove (Figure 49).

Although nothing is known regarding the roosting habits of this species in the Sierra Nevada, it is thought to be foliage roosting. Whether it roosts in giant sequoias is unknown.



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clm,cool;on log diag upslope ld insects
B8291959.19#   Div 16     Type  132   2001/08/29 1959:19
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
ANALOOK Version 4.9j  7 Jul 2004
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Figure 48. Echolocation call of hoary bat, Merced Grove, 29 August 2001.

3.5.8. *Myotis californicus*, California Myotis

M. californicus has a broad distribution in the North American west, ranging from southeastern Alaska, through southern British Columbia, most western United States to Baja California and Mexico (Simpson 1993). It is found throughout California, and while it is most abundant at lower and mid-elevations, it does occur above 2,000 m in the Sierra Nevada (Pierson *et al.* 2001). This versatile species is found in almost every habitat.

M. californicus is a crevice roosting species that uses a wide variety of both natural and anthropogenic roosts. In natural settings it is found in rock crevices (including boulders close to the ground), in crevices inside caves, inside hollow trees, and beneath loose bark. It is also frequently associated with man-made structures, being found in buildings, bridges, and mine tunnels. It is sometimes even found under signboards (Barbour and Davis 1969, Brigham *et al.* 1997, van Zyll de Jong 1985). Solitary individuals and small groups have been found in caves, mines, and buildings in the winter in southern California (Krutzsch 1954).
M. californicus emerges prior to dark. Its diet is dominated by Lepidoptera, but also includes Diptera, Hemiptera, Trichoptera, and Coleoptera (Simpson 1993, Whitaker *et al.* 1977 & 1981a).

In a study in the upper Sacramento River drainage the diet of this species was dominated by Hymenoptera, Lepidoptera and Trichoptera (Rainey and Pierson 1996). It is often detected feeding around the canopy of oak trees or along riparian corridors in association with cottonwood, sycamore and willow. Individuals are known to be active periodically in the winter, even at temperatures below freezing (O'Farrell and Bradley 1970).

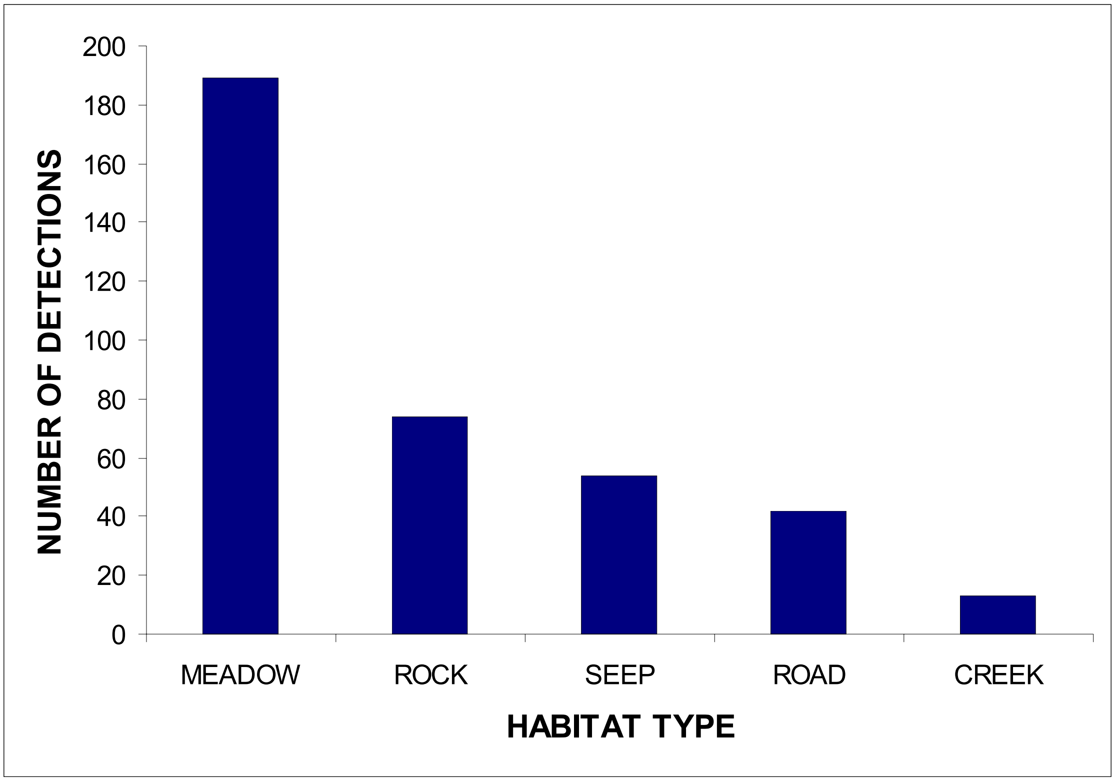


Figure 49. Acoustic activity (number of detections) for hoary bats by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

M. californicus is a small bat (forearm 29-36 mm) with a pointed tragus, a keeled calcar, and a tiny foot (Barbour and Davis 1969). Although its pelage color is highly variable throughout its range, in the Sierra Nevada it tends to be dark brown. It is most readily confused with *M. ciliolabrum*, which tends to be slightly bigger, have the last 1.5-2.5 mm of its tail exposed (Constantine 1998), and have a dark mask that contrasts with somewhat lighter pelage. The safest way, however, to distinguish the two is to record echolocation calls upon release, since *M. ciliolabrum* is a 40 kHz bat and *M. californicus* is a 50 kHz bat. Its echolocation call is difficult to distinguish from that of the other 50 kHz species, *M. yumanensis*.

<u>Records from Yosemite Prior to This Study</u>

There are seven museum records for this species from Yosemite National Park (KU, MVZ, YNP). All are from lower elevation sites – Yosemite Valley or Hetch Hetchy. In recent studies this species has been relatively common in net captures at the lower elevation sites (Pierson *et al.* 2001).

This Study

M. californicus is one of the dominant species in the giant sequoia groves. It was found using the basal fire scars for both day-roosting and night-roosting. It was the second most abundant species in net captures in both the Mariposa and Merced Groves. Lactating females and juveniles were captured in the Mariposa Grove; post-lactating females and juveniles in the Merced Grove. Thus, we deduce that this species has reproductive populations in both groves. *M. californicus* was captured roosting in four of the basal fire scars that were being monitored for guano deposition (Tree #'s 42, 280, 285, and 474).

We made no attempt to distinguish this species acoustically from *M. yumanensis*, the other 50 kHz *Myotis*. We presume, however, based on the placement of the acoustic detectors and capture records, that the majority of the 50 kHz calls were attributable to *M. californicus*. This was the most abundant class of calls in both the Merced and Tuolumne Groves, and second most abundant in the Mariposa Grove.

3.5.9. *Myotis evotis*, Long-eared Myotis

Myotis evotis ranges across western North America from southwestern Canada (British Columbia, Alberta and Saskatchewan) to Baja California and eastward in the United States to the western Great Plains (Manning and Jones 1989). In California, it is found from the foothills to high elevation in all the mountain ranges. An altitudinal transect in the central Sierras documented this species from the foothills to 2,900 m (Pierson *et al.* 2001). *M. evotis* occurs in a wide variety of habitats, but is generally forest-associated, occurring in both mixed deciduous and predominantly coniferous forest.

This species roosts in hollow trees, behind loose bark, in caves, mines, and other man-made structures (bridges, buildings), and sometimes in cliff fissures and sink holes (Manning and Jones 1989, Marcot 1984, Pierson *et al.* 1996). In a radio-tracking study on the upper Sacramento River, it roosted in black oak and in highway rip-rap (Pierson and Rainey 1997). Another radiotracking study identified roosts under loose bark in tree stumps (Vonhof and Barclay 1997). It was one of the species most commonly encountered in giant sequoias in Giant Forest, Sequoia National Park (Pierson and Heady 1996). It is also found in red fir-lodgepole habitat (Ingles 1949). A study on the Plumas National Forest suggested it was ubiquitous, and found in most habitats (P.A. Heady and W.F. Frick personal communication). It forms relatively small maternity colonies, generally 20-30 females.

This species is a slow flier that often forages in cluttered under-storey, along streams and among trees. It feeds both by aerial hawking and substrate gleaning (Faure and Barclay 1994). It feeds primarily on Lepidoptera, but also takes Coleoptera, Diptera, Hymenoptera and Hemiptera (Black 1974, Whitaker *et al.* 1977 & 1981a). In a study in the upper Sacramento River drainage the diet of this species was dominated by Coleoptera, Hymenoptera, Lepidoptera and Trichoptera (Rainey and Pierson 1996).

M. evotis is a medium-sized myotis with a forearm of 36-41 mm. It is generally recognizable by its very long ears (22-25 mm), which are longer than those of any other myotis species (Barbour and Davis 1969). Its ear and wing membranes are generally black, and contrast sharply with relatively light brown fur.

Records from Yosemite Prior to This Study
There are four museum records for this species from Yosemite National Park (MVZ, YNP), collected between 1923 and 1941. Three are from Yosemite Valley, and one is from near Foresta. In more recent studies in the Park, this species has been documented up to 2,484 m, with breeding females up to 2,196 m. The majority of records are from lower elevations in Wawona and Yosemite Valley (Pierson *et al.* 2001).

This Study
M. evotis was the fourth most abundant species in net captures in the Mariposa Grove. Reproductive females were captured in both the Mariposa and Merced Groves. Also, we have evidence that this species used the fire-scar hollows as nursery sites. We captured a lactating female exiting Tree #19 in the Merced Grove, and in the Mariposa Grove we captured pregnant females near Tree #311 and emerging from Tree #314, plus two individuals (a male and a post-lactating female) at Tree #39. All these trees were being monitored for guano deposition. Also, on several occasions we observed (using night vision equipment and a bat detector) a small group (10-15 animals) that was most likely a nursery colony exiting from the Clothespin Tree.

Due to difficulties with positive identification of acoustic calls, it is likely under-represented in our acoustic data, where calls attributable to this species comprised 1.48% of all calls in the Mariposa Grove, 1.26% in the Merced Grove, and 11.44% in the Tuolumne Grove.

3.5.10. *Myotis thysanodes*, Fringed Myotis

M. thysanodes is widely distributed across the western third of the United States, is found in most of Mexico, and reaches into southern British Columbia. In California, the species is found the length of the state, from the coast (including Santa Cruz Island) to >1,900 m in the Sierra Nevada. It has been found in mixed deciduous/coniferous forest, Douglas fir forest, and in both redwood and giant sequoia habitat (Pierson and Heady 1996, Pierson and Rainey unpublished observation, Weller and Zabel 2001). In mist-netting surveys it is often found on secondary streams. Although records exist for the high desert and east of the Sierra Nevada (P. Brown personal communication), the majority of known localities are from the west side of the Sierra Nevada, ranging from the southern and central coast (Miner *et al.* 1996, Orr 1956), the transverse range in southern California (Dalquest and Ramage 1946, Miller 1897, P. Brown personal communication), to the upper Sacramento River (Rainey and Pierson 1996), the Trinity Mountains (Pierson and Rainey 1998b, Weller and Zabel 2001) and the Sierra Nevada (Pierson and Heady 1996, Pierson *et al.* 2001). Although nowhere common, the species occurs as one of the rarer taxa in netting records from sea level to at least 1,950 m in the Sierra Nevada.

This species is known to use a wide variety of roost sites, including rock crevices, caves, mines, and buildings (Barbour and Davis 1969, O'Farrell and Studier 1980). Recent radio-tracking studies in the forested regions of northern California have shown that this species also forms nursery colonies in predominantly early to mid-stage, large diameter snags (Weller and Zabel 2001). Likewise, studies conducted in Oregon and Arizona have also documented that *M. thysanodes* roosts in tree hollows, particularly in large conifer snags (Cross and Clayton 1995, Chung-MacCoubrey 1996). In California, a small colony was located in a hollow redwood tree in the Carmel Valley (Pierson and Rainey unpublished observation). It is also one of the species thought to be most reliant on abandoned mines (Altenbach and Pierson 1995).

This species often forages along secondary streams, in fairly cluttered habitat. It also has been captured over meadows (Pierson *et al.* 2001). Only limited information is available on diet in *M. thysanodes*. In a study conducted in New Mexico, Black (1974) concluded the species appeared to be a beetle strategist. In western Oregon (Whitaker *et al.* 1977), the dominant prey item in the diet of three out of four animals examined was lepidopterans (moths). The diet also included phalangids (harvestmen), gryllids (crickets), tipulids (crane flies), and araneids (spiders). The feces of one individual captured on the upper Sacramento River in California contained predominantly coleopterans (beetles) and hemipterans (bugs) (Rainey and Pierson 1996). Relatively heavy tooth wear on animals examined in a five year study on the Sacramento River would suggest that in this area the species feeds primarily on heavy bodied insects, such as coleopterans and hemipterans. The presence of non-flying taxa in the diet of the Oregon animals suggests a foraging style that relies at least partially on gleaning.

This is a medium-sized myotis with a forearm of 39-48 mm, and relatively long ears (16-20 mm). It can be distinguished from all other myotis species by a conspicuous fringe of hair of the posterior edge of the interfemoral membrane (Barbour and Davis 1969). Its pelage is often a cinnamon brown. It has a distinctive, very steep (slope > 250 o/s) echolocation call with a characteristic frequency of ca. 25 kHz (Figure 50).

Records from Yosemite Prior to This Study

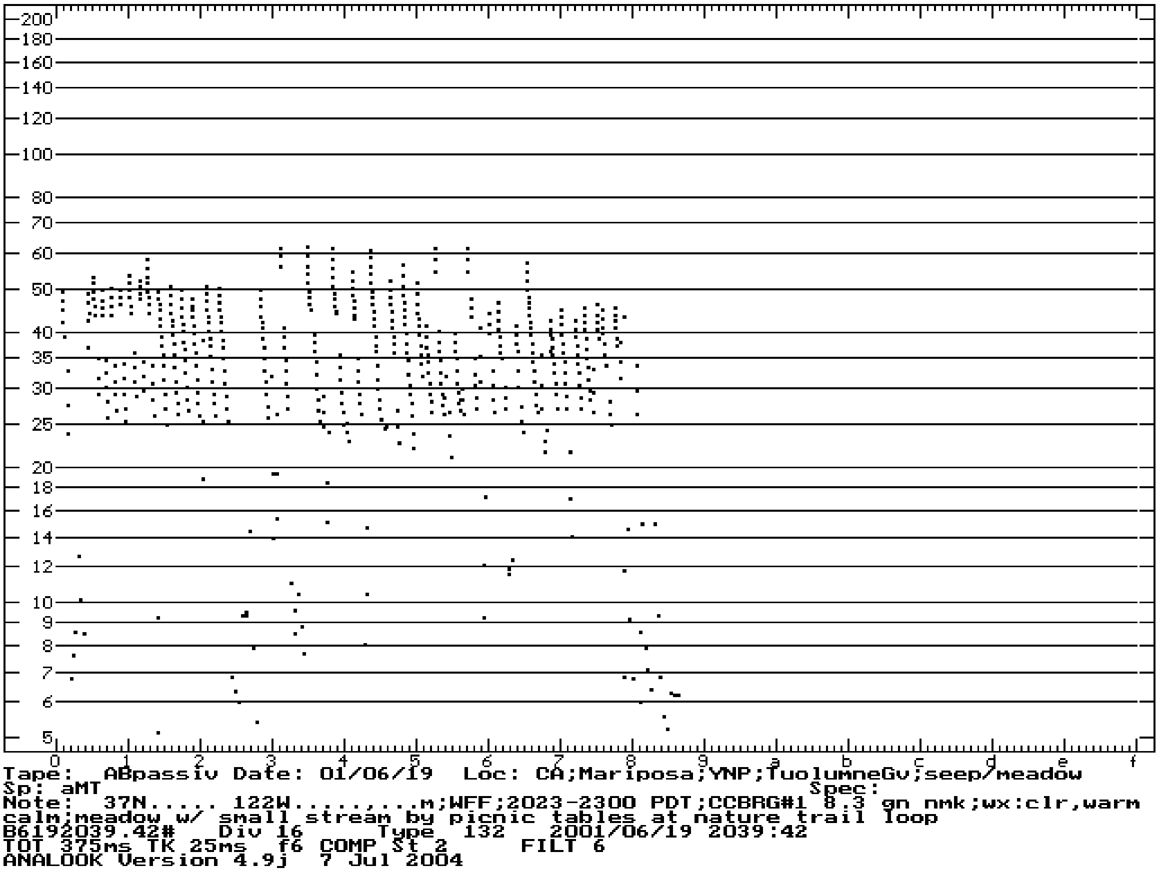
There are three museum records for this species from Yosemite National Park (KU, YNP), collected between 1951 and 1952. Two are from Hetch Hetchy Dam (KU) and one is from Crane Flat (YNP). Recent studies have indicted that this species may be limited to elevations below 2,250 m, and that it is relatively rare in most habitats (Pierson *et al.* 2001).

Recent studies conducted in Yosemite National Park suggest that this species, while everywhere rare, is most common at mid-elevations (1,000-2,000 m).

This Study

M. thysanodes was the most abundant species in net captures in the Merced Grove, and the third most abundant in the Mariposa Grove. Given its apparent rarity in most habitats, these data suggest a high association with the giant sequoia groves. In the Merced Grove we captured five lactating females at the basal hollow of one giant sequoia (Tree #19), and five other lactating females on the creek adjacent to another giant sequoia (Tree #44) that appeared to have a colony of this species resident in its basal hollow). In the Mariposa Grove, we captured lactating females on three occasions at Kiosk Creek. Adult male *M. thysanodes* were captured roosting in two giant sequoia basal hollows that we were monitoring for guano deposition (Tree #124 and Tree #285) and in the upper meadow.

One post-lactating female that was radio-tracked in the Mariposa Grove roosted in four different snags, two ponderosa pines and two sugar pines. One of the ponderosa pines housed a maternity colony of up to 44 individuals under flaking bark.



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calm;meadow w/ small stream by picnic tables at nature trail loop
B6192039.42#   Div 16    Type  132   2001/06/19 2039:42
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
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Figure 50. Echolocation call of fringed myotis, Tuolumne Grove, 19 June 2001.

This species represented 4.00% of all acoustic records in the Mariposa Grove, 14.65% in the Merced Grove, and 3.16% in the Tuolumne Grove. It was detected during 55.39% of all sessions and at 63.42% of all sites in the Mariposa Grove, 84.00% of all sessions and 88.89% of all sites in the Merced Grove, and 33.33% of all sessions and 75.00% of all sites in the Tuolumne Grove. In the Mariposa Grove the vast majority of the detections were at creek sites (Figure 51).

3.5.11. *Myotis volans*, Long-legged Myotis

M. volans is widely distributed across the western third of the United States, reaching the northern limits of its range in northern British Columbia and the southern limits in central Mexico (Hall 1981, Warner and Czaplewski 1984).

In California, *M. volans* occurs in a variety of habitats throughout most of the state, and has been found from the coast, to high elevation in the Sierra Nevada and White Mountains. Records are absent for the low desert areas of southeastern California, but occur in the mountains of the Mojave Desert, central San Diego County, the Coast Range, and the transverse ranges between the Los Angeles basin and the Central Valley (Dalquest and Ramage 1946). A notable percentage of the records (from California and elsewhere in the range) are from relatively high elevations, although there are also records from the Sierran foothills (*e.g.*, P.A. Heady and W.F. Frick personal communication, Pierson and Rainey 2002).

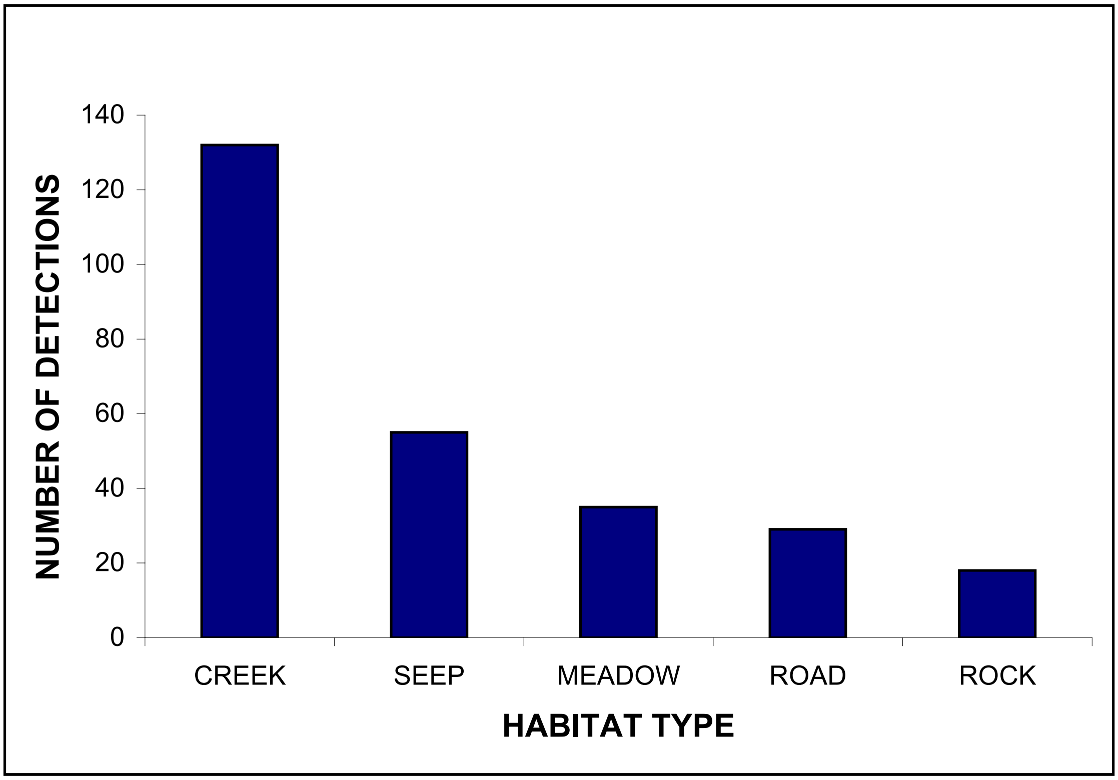


Figure 51. Acoustic activity (number of detections) for fringed myotis by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

Although this species has been found roosting in abandoned buildings, mines, and rock crevices (Barbour and Davis 1969, Warner and Czaplewski 1984), recent research suggests it roosts primarily in trees, particularly large diameter conifer snags, or live trees with lightning scars. Colonies of up to 200 have been found in live and dead ponderosa pine in New Mexico (Chung-MacCoubrey 1996). Radio-tagged females have also been found in *Ponderosa* snags in South Dakota (Cryan 1996) and in large snags and hollow cedar trees in the Central Oregon Cascades (Ormsbee 1996). Ormsbee (1996) found that females used multiple day roosts within a single area. Along the upper Sacramento River in California, a post-lactating female *M. volans* was radio-tracked to a large diameter conifer snag (Rainey and Pierson 1996).

M. volans is an aerial pursuit forager that feeds primarily on moths (Lepidoptera), but it also eats a variety of other soft-bodied invertebrates and small beetles (Warner and Czaplewski 1984). It is known to feed on spruce budworm moths in southern Oregon (M. Perkins, personal communication).

M. volans is a medium-sized myotis with a forearm of 35-41 mm. It is the only relatively large western myotis with a keeled calcar (Barbour and Davis 1969). It also has somewhat rounded ears and relatively long tibia (17.4-18.9 mm) (Grinnell 1918).

Records from Yosemite Prior to This Study

There are no museum records for this species from Yosemite National Park. The first record for this species in the Park was an animal captured under the bridge over Yosemite Creek on Tioga Road (Pierson *et al.* 2001). In the context of the same study, multiple individuals were captured under bridges on Route 120, very close to the park boundary.

This Study

M. volans was tied with *E. fuscus* as the third most abundant species in net captures in the Merced Grove, and fifth in the Mariposa Grove. All individuals captured in the Mariposa Grove were adult males; the two individuals captured in the Merced Grove were an adult male and a nulliparous female. Net captures indicated an association with giant sequoia trees. Two of the individuals captured in the Mariposa Grove were in association with two of the giant sequoias we were monitoring with guano traps (Tree #311 and #426). An adult male was roosting in Tree #19 in the Merced Grove.

Although this species cannot be separated acoustically from two other species that echolocate at 40 kHz, we have no evidence that the two potentially confusing species, *M. ciliolabrum* and *M. lucifugus*, occur in the giant sequoia groves. If we presume that the majority of the 40 kHz acoustic records are *M. volans*, then it is more abundant in the groves than our capture records would indicate. In the Mariposa Grove, bats echolocating at 40 kHz accounted for 6.40% of acoustic detections, and they were detected in during 87.18% of the sessions at 87.81% of the sites. In the Merced Grove 40 kHz *Myotis* accounted for 11.78% of the detections, and were detected during 88% of the sessions at 100% of the sites. In the Tuolumne Grove they accounted to 6.81% of detections, were detected during 91.67% of the sessions at 100% of the sites.

3.5.12. *Myotis yumanensis*, Yuma Myotis

M. yumanensis, is widely distributed throughout western North America, from Mexico to southern Canada. The Yuma myotis is widely distributed throughout much of California. While it occurs from sea level to >2,500 m in the Sierras, its maternity colonies (which are typically comprised of 300-1,000 females) are generally confined to elevations below 1,000 m.

M. yumanensis is predominantly a crevice dwelling species, although it is also frequently found roosting on open surfaces. It forms large, conspicuous maternity colonies, in a wide variety of roost sites. It is one of the species most commonly associated with anthropogenic structures, including barns and bridges, although it will also roost in caves, mines, abandoned swallow nests, and under flaking bark of large snags (Barbour and Davis 1969, Dalquest 1947, Evelyn *et al*. 2004, Rainey and Pierson 1996). Some of the largest known colonies of *M. yumanensis* are found in buildings and bridges. In northern California, maternity colonies are known from fire scarred coast redwoods and sugar pine snags (Pierson and Rainey 1997, Rainey and Pierson 1996, Rainey *et al.* 1992).

M. yumanensis is more highly associated with water than any other species. It flies low over relatively calm water (reservoirs, ponds, or slowly flowing reaches and pools of rivers and streams), feeding primarily on small, emergent aquatic insects, such as midges, mayflies and caddis flies (Barbour and Davis 1969, Dalquest 1947b, Rainey and Pierson 1996, van Zyll de Jong 1985). *M. yumanensis* is often found in association with reservoirs in California (*e.g.*, Pierson and Rainey 2002, Pierson *et al.* 2001). Studies in Oregon found this species feeding on a wide variety of taxa, including Lepidoptera, Coleoptera, Trichoptera, Homoptera, Isoptera and Diptera (Whitaker 1977 & 1981a). In a study in the upper Sacramento River drainage the diet of this species was dominated by Trichoptera (Rainey and Pierson 1996). It is also known to forage over fields, and some diet samples from orchard roosts are composed largely of moth remains (Brigham *et al.* 1992, Rainey and Pierson 1996).

M. yumanensis is a small myotis species with a forearm of 32-38 mm. It has large feet (10 mm), and an unkeeled calcar (Barbour and Davis 1969). Although its color can vary, in the Sierra Nevada it tends to be a grey brown. It is most readily confused with *M. lucifugus*, and can be most confidently distinguished from this species by its echolocation call. *M. yumanensis* is a 50 kHz species, and *M. lucifugus* is a 40 kHz species. It is, however, difficult to distinguish acoustically from *M. californicus*.

Records from Yosemite Prior to This Study
There are ten museum records for this species from Yosemite National Park, collected between 1931 and 1952 (KU,MVZ, YNP). Eight are from Hetch Hetchy Dam (KU, YNP), and two are from Yosemite Valley (MVZ,YNP). Recent studies have documented that this species is widely distributed in Yosemite (Pierson *et al.* 2001). While reproductive females appear to be confined to lower elevations, males have been captured as high as Tenaya Lake (2,488 m).

This Study
Capture records suggest that *M. yumanensis* is relatively rare in the giant sequoia groves. Only two adult males were captured in the Mariposa Grove, and one juvenile male in the Merced Grove. Because this species forages primarily over open water, there is little suitable foraging habitat for it in the groves. It is, for example, the species most commonly netted in association with the more open water of the South Fork Merced River in Wawona. No attempt was made to identify this 50 kHz species acoustically. It was assumed, based on capture records and placement of acoustic detectors, that the majority of bats echolocating at 50 kHz were *M. californicus.*

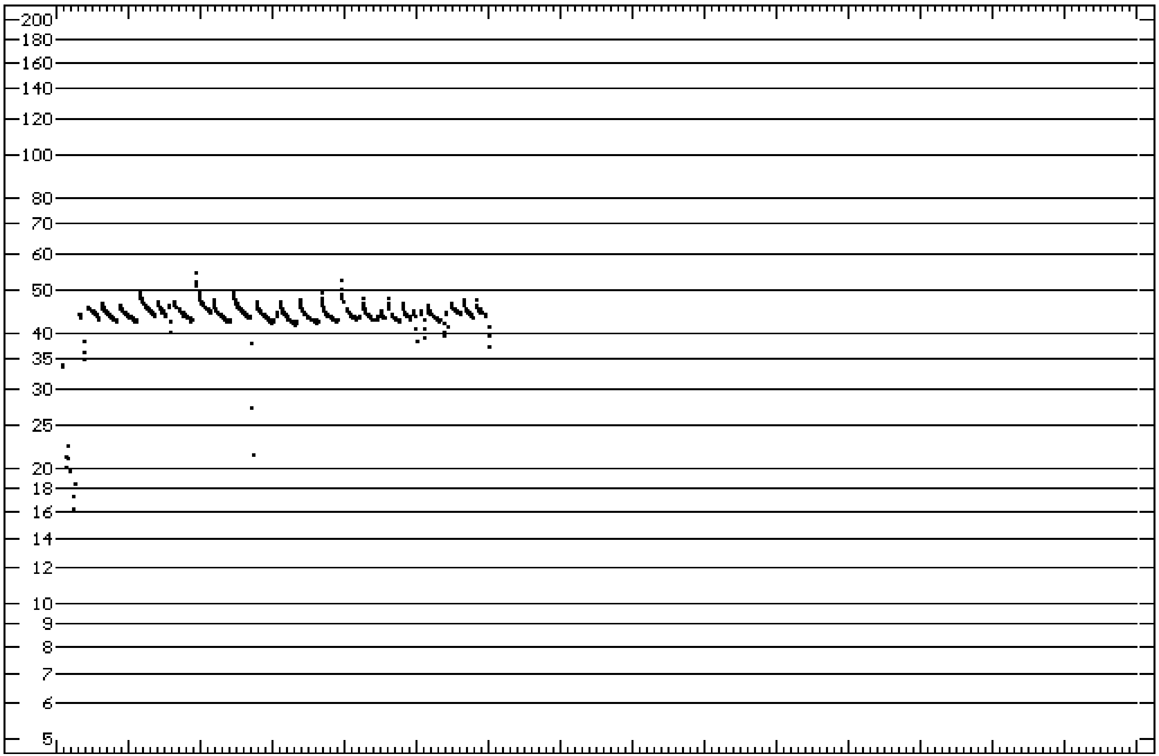
3.5.13. *Pipistrellus hesperus*, Western Pipistrelle

Pipistrellus hesperus occurs from the desert lowlands of the southwestern United States to southern Washington. While most commonly associated with arid, desert landscapes, it also occurs in mixed conifer forest in mountain ranges in California and up to fir-spruce forest in Arizona. Recent surveys in the Sierra Nevada suggest it is more widespread in this mountain range than was previously realized (Pierson *et al.* 2001), occurring as far north as Shasta and Siskiyou counties (Constantine 1982, Pierson and Rainey 1998b, Pierson *et al.* 2001, Rainey and Pierson 1996).

This species, which roosts primarily in cliffs or rock outcrops, is often regarded as a bat of desert waterholes and canyons (Barbour and Davis 1969, Hayward and Cross 1979). Yet it is locally common in river canyons along the western slope of the Sierra Nevada, and occurs in Shasta and Siskiyou Counties at isolated river canyon rock features in mixed conifer forest (Constantine 1982, Pierson and Rainey 1998b, Rainey and Pierson 1996). It has also been reported roosting in crevices in buildings and mine tunnels (Hayward and Cross 1979, Stager 1943), and very occasionally in expansion joints in bridges (G. Erickson, California Department of Transportation, personal observation).

Western pipistrelles are usually described as non-colonial, though aggregations up to twelve have been reported (Koford and Koford 1948). This is smallest North American bat, but, in contrast to the single offspring produced annually by many local species, females typically give birth to twins.

Pipistrelles often emerge to hunt before dark, flying seemingly erratically, while pursuing small insects in open air. Diet analyses indicate an opportunistic generalist aerial hunter. Moths dominate in the diet (Black 1974), but other groups include homopterans, hymenopterans, and some coleopterans (Ross 1967, Whitaker 1981a).



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B7020454.27#   Div 16     Type  132   2001/07/02 0454:27
TOT 375ms TK 25ms  f6 COMP St 2     FILT 6
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Figure 52. Echolocation call of the western pipistrelle, Mariposa Grove, 02 July 2001.

P. hesperus is the smallest bat in California, with a forearm of 27-33 mm. While it has a keeled calcar, and could be confused with *M. californicus* or *M. ciliolabrum*, it has a blunt tragus (Barbour and Davis 1969). Also it has a very distinct dark mask and dark ears, which contrast with a light brown, sometimes blondish pelage. It is readily identifiable acoustically (Figure 52).

Records from Yosemite Prior to This Study

There are six museum records for this species from Yosemite National Park, collected between 1915 and 1938 (MVZ, YNP). Five are from Yosemite Valley (MVZ) and one is from Hetch Hetchy (YNP). In recent studies this species has been captured both in Yosemite Valley and Wawona (Pierson *et al.* 2001).

This Study

P. hesperus was detected only acoustically, and only in the Mariposa Grove. We had 253 detections during the course of the study, which constituted 0.79% of all detections. The records for this species are concentrated in two areas: at Wawona Point, where the species was detected at emergence time strongly suggesting that it roosts in this rock feature, and in the nearby meadow, close to Sunset Point (Figure 53). Wawona Point, at 2,075 m, is the highest elevation locality known for this species in Sierra Nevada.

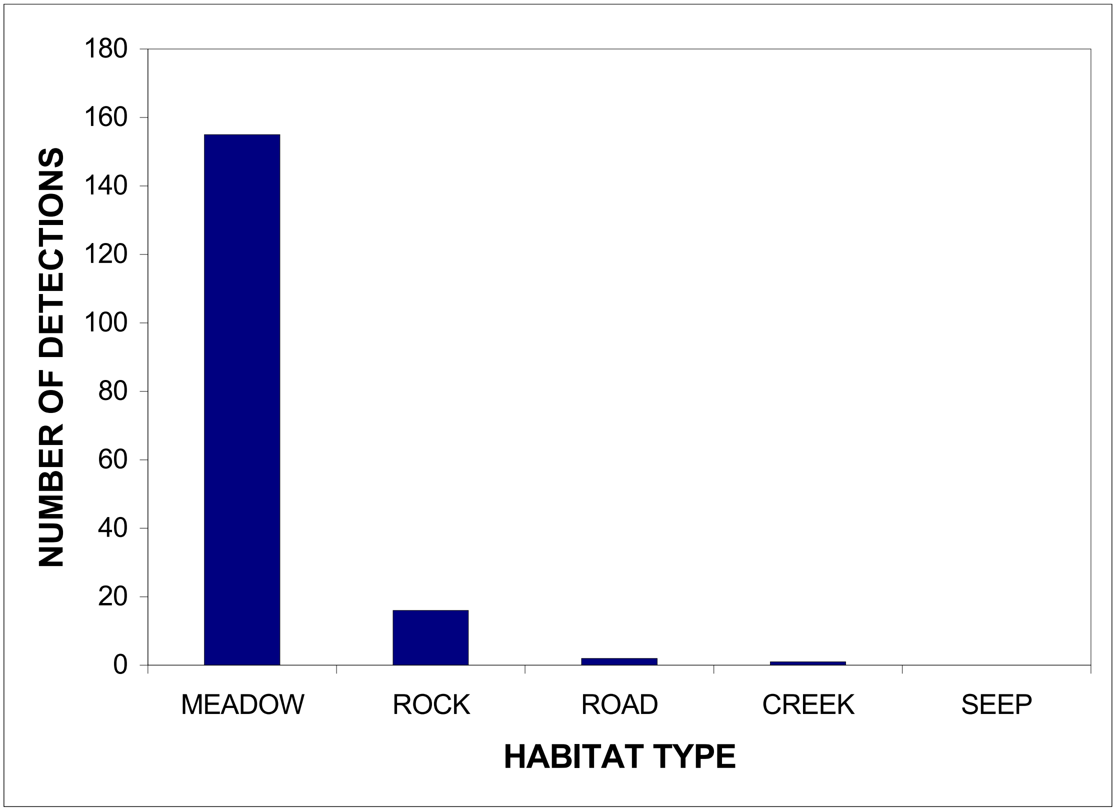


Figure 53. Acoustic activity (number of detections) for western pipistrelles by habitat type in the Mariposa Grove on 18 nights (between 6 May and 14 September 2001). All habitat types were sampled simultaneously.

3.5.14. *Tadarida brasiliensis*, Mexican Free-tailed Bat

This is one of the most widely distributed and commonly encountered species in California. While breeding populations occur primarily at low to mid-elevations, this species is found all the way to the crest of the Sierra Nevada (Pierson *et al.* 2001). *T. brasiliensis* is found in a range of habitats, and is the species most tolerant of urbanization.

Mexican free-tailed bats form maternity colonies of up to several million in some caves in Texas, but in California, with the exception of one population of about 250,000 (in a lava cave in northern California), most colonies in California range in size from a few hundred to a few thousand. Although some populations of Mexican free-tailed bats migrate large distances (*e.g.*, Texas populations over-winter in Mexico), seasonal movement patterns and population structure within California are poorly understood. Free-tailed bats can tolerate torpor during cold weather, but do not hibernate.

Mexican free-tailed bats are crevice or cavity dwellers, and can fit in cracks smaller than one inch wide. While this species roosts in a number of natural features (rock crevices, caves, and abandoned swallow nests), it is also the species most often found in man-made structures, including buildings, bridges, and mines (Barbour and Davis 1969, Wilkins 1989). Colonies also appear to be more mobile than many bat species, apparently displaying less loyalty to particular roost sites, with the exception of major maternity sites which are occupied year to year.

Mexican free-tailed bats are aerial foragers, and feed on a wide variety of flying insects (Whitaker et. al. 1996). This is the species most likely to include a variety of agricultural pests in its diet, including the corn earworm moth (*Heliothis zea*) (McCracken 1996), and most likely the codling moth (*Cydia pomonella* L.) (Hogan 2000). Year-round diet studies conducted at Lemoore Naval Air Station showed that this species foraged primarily over cotton fields and other agricultural areas, and included flies, moths, true bugs (mostly plant hoppers) and beetles in their diet (Johnston 1998).

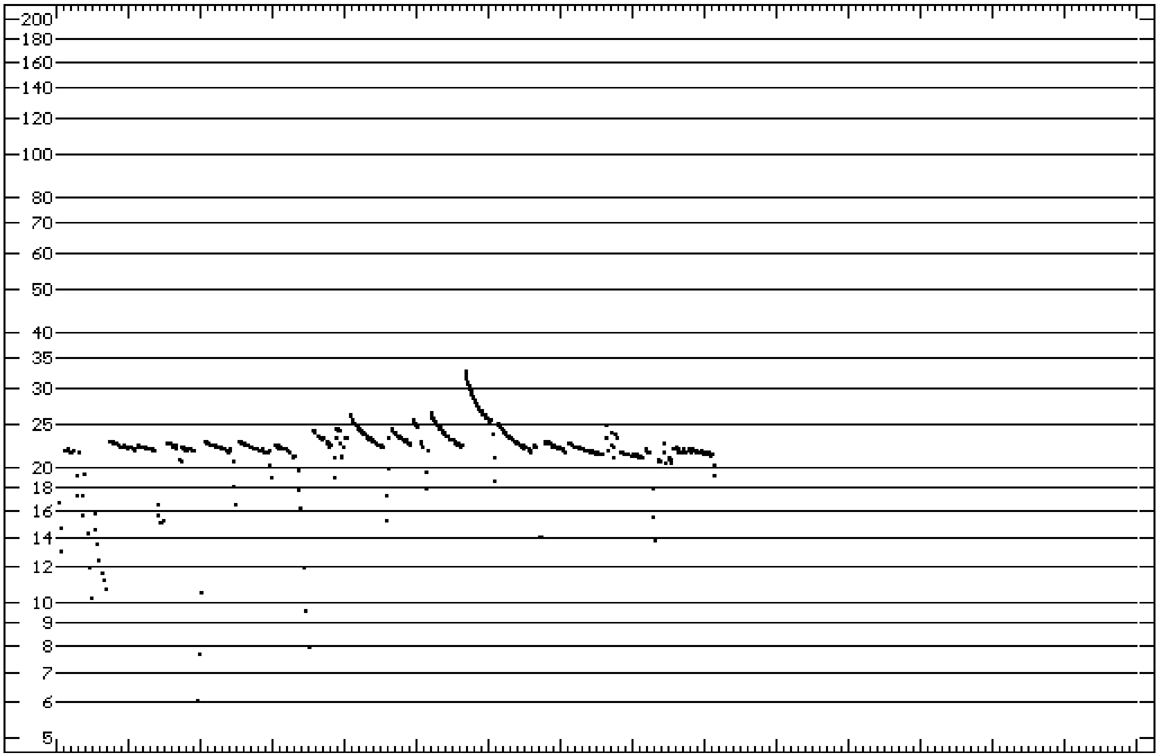
T. brasiliensis is a medium-sized bat (forearm of 36-46 mm), with long narrow wings, a tail that extends about half its length beyond the back of the inter-femoral membrane. The ears are rounded and almost meet at the mid-line (Barbour and Davis 1969), and it has hairy toes. Its pelage is generally grey. The only other molossids (free-tailed bats) known to occur in Yosemite are considerably larger. A subset of its echolocation calls is diagnostic for this species (Figure 54).

Records from Yosemite Prior to This Study

There are two museum records for this species from Yosemite National Park, both collected at the Ahwahnee Hotel in August 1937 (YNP). Recent studies have shown that *T. brasiliensis* is widely distributed and relatively common throughout the park, up to greater than 3,000 m elevation at Tioga Pass (Pierson *et al.* 2001). Its abundance in Yosemite suggests a greater association with cliff habitat than has previously been recognized.

This Study

We had no capture records for this species in the giant sequoia groves, and no evidence that this predominantly cliff-dwelling species is using the giant sequoia trees. It was detected foraging, particularly high above the meadow, in the Mariposa Grove



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warm; at base of tree with trap in swamp near creek
B6192235.43#   Div 16     Type  132   2001/06/19 2235:43
TOT 375ms TK 25ms  f6 COMP St 2      FILT 6
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Figure 54. Echolocation call of Mexican free-tailed bat, Merced Grove, 19 June 2001.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1. Species Diversity in the Giant Sequoia Groves

Bat species diversity in the giant sequoia groves is comparable to that of non-sequoia forest at comparable elevation in Yosemite. Fourteen of the 18 bat species known from the park were encountered in the giant sequoia groves. Of the four species not found, two (*Corynorhinus townsendii* and *Myotis ciliolabrum*) might have been expected to occur. *C. townsendii* is known to roost (and form maternity colonies) in coast redwood cavities (Fellers and Pierson 2002, Mazurek 2004), but low intensity echolocation calls make it difficult to detect acoustically. It is also notably sensitive to roost disturbance and appears to have been displaced from many Sierra foothill caves by recreational visitors. Of the other two species not observed, *Myotis lucifugus* occurs primarily at higher elevation and *Nyctinomops macrotis* is a rare cliff dweller that has only been identified at only one locality in Yosemite Valley.

Of the fourteen species identified as occurring in the groves, eight were confirmed as roosting there (*Antrozous pallidus*, *Eptesicus fuscus*, *Lasionycteris noctivagans*, *Myotis californicus*, *M. evotis*, *M. thysanodes*, *M. volans*, *M. yumanensis*). Two other species (*Lasiurus blossevillii* and *L. cinereus*), were detected only acoustically, but are likely to roost locally as well.

Four of the species detected acoustically are unlikely to be roosting in the groves because tree-roosting for them is either rare (*Tadarida brasiliensis*) or unknown (*Euderma maculatum*, *Eumops perotis*, *Pipistrellus hesperus*) (Barbour and Davis 1969, Hayward and Cross 1979, Pierson and Rainey 1996b, Wai-Ping and Fenton 1989). In Yosemite, recent work has shown that all these species roost primarily in rock crevices (Pierson and Rainey 1996b, E.D. Pierson and W. E. Rainey personal observation). *E. maculatum*, *E. perotis*, and *T. brasiliensis* are all known to travel considerable distances from their roost sites to forage (Chambers *et al.* 2005, McCracken 1996, Pierson and Rainey 1996b, Rabe *et al.* 1998), and likely have roost sites on Wawona Dome, or in cliffs farther up the South Fork Merced drainage. Acoustic surveys documented *P. hesperus* in the vicinity of Wawona Point at emergence time, strongly suggesting that this species was roosting locally in fractured rock, and foraging primarily over the nearby meadow near Sunset Point.

4.2. Bat Use of Giant Sequoias and Other Tree Species

Bat use of giant sequoia trees was investigated by a number of methods, including guano traps, mist-nets, acoustic detectors, direct observation with night vision devices, and radio-telemetry. Synthesizing the results of all these approaches we can conclude that at least six species roost in giant sequoia trees, including the five species known to have reproductive populations in the groves. Day roosts include cavities inside the burned basal hollows, deep bark crevices, and cavities and/or crevices in damaged/anomalous areas of the trees, *e.g.,* lightning strikes (generally at the apex, as in the Sunset Tree), elevated bole cavities, or broken limbs. Additionally, the burned basal hollows are used extensively as night roosts, particularly by the pallid bat.

The giant sequoia groves are likely to be most important to the eight tree-dwelling species that roost in giant sequoias and/or associated tree species. Of greatest interest are those species that are rare or have a somewhat limited distribution within the park, but appear to be relatively more common in the groves, particularly *Antrozous pallidus*, *Myotis evotis*, *Myotis thysanodes*, and *Myotis volans*. All these species also appear to be significant members of the bat community in giant sequoia groves in Sequoia and Kings Canyon National Parks (Pierson and Heady 1996, E.D. Pierson and W.E. Rainey unpublished data).

One of the most significant findings of this study was that the large basal hollows of the giant sequoias maintained relatively stable, above freezing temperatures throughout the winter, giving them a thermal profile characteristic of hibernating sites (Davis 1970, Fenton 1983, Whitaker and Gummer 1992 & 2000). While very large aggregations of hibernating bats are well documented for several cave-dwelling species in central and eastern North America, few such sites are known in the west. Large aggregations have been identified for only one species, *Corynorhinus townsendii* (Pearson *et al.* 1952, Pierson *et al.* 1999). Most species appear to hibernate either individually or in small groups (*e.g.*, Marcot 1984, Rainey *et al*. 1992, Szewczak *et al*. 1998). While some hibernating sites have been identified in mines in the White and Inyo Mountains (Szewczak *et al.* 1998), and caves in the northern part of the state (Marcot 1984, Pearson *et al.* 1952), we are not aware of any documented hibernating sites in the Sierra Nevada. Research conducted in the Rocky Mountains in Colorado has shown that *Eptesicus fuscus*, one of the species most likely to be hibernating in the giant sequoia groves, moved upslope in the fall and hibernated at higher elevations (Neubaum *et al.* 2004).

Radio-tracking revealed that the bats resident in the giant sequoia groves roost preferentially in large diameter, mid- to late stage snags of both sugar pine and ponderosa pine in addition to the giant sequoias. Preferences shown by the bats for the largest snags on the landscape are consistent with results of other studies on tree-dwelling bats in the western United States (*e.g.*, Brigham and Barclay 1996, Waldien *et al.* 2000, Weller and Zabel 2001). Large, dead trees with characteristics preferred by the bats, if located in proximity to visitor areas, may be identified as “hazard trees” and recommended for selective removal. The findings of this study suggest that such trees should be evaluated for bat occupancy and an effort made to avoid bat mortality during removal.

4.3. Bat Use of Habitat Elements in the Giant Sequoia Groves

The acoustic surveys demonstrated that other features in the giant sequoia forest are important to bats in addition to the trees themselves. Foraging behavior, as assessed by acoustic monitoring, was highest in association with water, which in these groves meant primarily secondary streams *(e.g.,* several creeks in the Mariposa Grove, Moss Creek in the Merced Grove, and North Crane Creek in the Tuolumne Grove). It was also evident, however, that other habitat elements such as wet meadows and rock outcrops were used preferentially by some of the rarer species.

The overall character of the three groves differed somewhat. The Upper Mariposa Grove, for example, is more open and in places drier than any portion of the Merced Grove. Also, with an extensive wet meadow running through the center and several significant rock features around the periphery, it offers a more complex local habitat than either of the other groves. Some or all of these features would favor certain species, and may explain the dominance of *E. fuscus* and exclusive occurrence of *P. hesperus* in the Mariposa Grove. The more enclosed and wet habitat of the Merced Grove, with the close proximity of a perennial creek to all the trees, favors the tree-dwelling *Myotis* species (Waldien and Hayes 2001, Weller and Zabel 2001).

4.4. Management Implications and Recommendations

4.4.1. Roosting Ecology of Bats

<u>Giant Sequoias</u>
The most obvious question is whether visitor activity in the groves, particularly the Mariposa Grove has any direct or indirect impact on bats and their use of the giant sequoia trees.

Many bat species are very sensitive to human activity in or around their nursery roosts. It is well documented that some species will move or abandon a roost if disturbed when raising their young (*e.g.*, Pierson *et al.* 1999). Fortunately, many potential roosts in the giant sequoias are clearly out of human reach (*e.g.*, the lightning scar at the top of the Sunset Tree). Many basal fire-scars have interior heights of > 7.0 m, with crevices that extend higher, thus offering bats dark and cryptic roost day sites not readily accessible to humans or potential native predators such as squirrels. A colony of *Myotis evotis* roosts diurnally the extensive basal hollow of the Clothespin Tree, a tree that is visited many times every day in summer. While it is not likely that roost sites are limiting in this forest, it is possible that relatively frequent visitor exploration of lower height basal hollows along trails leads bats to avoid roosting in these trees during the day.

Wildlife activity in the basal hollows includes other species besides bats. We observed small terrestrial mammals (most often squirrels), and several bird species (most commonly ravens and white-faced woodpeckers) using the hollows. Winter damage to temperature monitors in the basal hollows indicates winter rodent activity, possibly by *Peromyscus* sp.

A significant finding of this study was the potential suitability of the giant sequoias as hibernating sites for bats. The accessibility of the basal hollows, and improvements in acoustic monitoring technology since the field work for this study was conducted, would make it possible to investigate the hibernation issue more thoroughly with relatively low effort. For example, acoustic detectors could be installed inside trees and run continually all winter, providing a direct assessment of winter use of giant sequoias and cold season patterns of flight activity. Given how little is known regarding over-wintering behavior and habitat of bats in the Sierra Nevada, this study would potentially make a significant contribution.

<u>Recommendations</u>

1. Visitor guidelines that discourage entry into the basal hollows would lessen tree perimeter trampling and likely provide long-term benefit to bats and other wildlife.

2. A more focused study of the use of giant sequoias as hibernation sites.

Other Tree Species

From a management perspective the most significant finding of this study was that radio-tagged bats roosted preferentially in three large tree species – the giant sequoias, sugar pine and ponderosa pine. Additionally, they selected trees that were among the largest available, and for the pines, mostly trees that were dead and in mid to late stages of decay. Any one of these roost trees, had they been located on a trail or in a visitor area, would likely have been identified as "hazard trees." The key importance of large snags to bats has been demonstrated in study after study for tree-dwelling bats of the western United States. Because, in addition to specific tree characteristics, the location of the tree on the landscape (*e.g.*, its proximity to water, it position on the slope) may be significant, it should not be assumed that an individual tree is not important, even in an area with an apparently abundant supply of snags.

Recommendations:

1. Any tree recommended for removal should be evaluated for its potential as a bat roost. This would include not only the obvious "hazard" trees, but any tree of moderate size that might have features suitable as roost sites (*e.g.*, many live black oaks have flaws that bats use as roosts). Given the obvious importance of mid to late stage snags as roost trees for bats, removal should be done only when considered absolutely necessary for human safety reasons.

2. Additional studies should be conducted elsewhere in the park to gain a better understanding of bat roosting behavior in other forest types. Of particular interest would be bats living at high elevation (particularly *Myotis lucifugus*, the only species known to raise its young above 8,000 ft). Yosemite Valley also offers a unique opportunity to learn a great deal regarding roosting preferences for bats in a setting that offers abundant roosting opportunities in both cliffs and old growth forest. A number of species have been documented roosting in both cliffs and trees, but most studies have been conducted in highly managed forests where snag availability may be limited.

4.4.2. Foraging Ecology of Bats

This study provided information on the complexity of foraging habitat preferences for the bat assemblage. While the greatest amount of bat activity, as assessed by acoustic detectors, occurred in association with water, individual species showed quite different preferences. It was evident that meadows and rock outcrops were also highly favored as foraging areas by some species. Trampling of meadows, streams and wetland areas by humans likely alters the invertebrate fauna of these delicate habitats, and thus the prey base for bats. The board walks that the Park has installed in various places throughout the grove, most notably near the parking area and museum, helps greatly in channeling human traffic.

Recommendations:

1. Visitor guidelines that minimize damage to the landscape around the giant sequoia trees, particularly sources of water and delicate meadows.

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Appendix 1. Localities for guano trap sampling in the Mariposa and Merced groves, 2000 and 2001

Locality	Tree Number	Latitude	Longitude	Elevation (m)	Quad	DBH (cm)	Notes
MARIPOSA GROVE							
Lower and Middle Groves							
	39	37.50191	119.60791	1761	Mariposa Grove	565	Near Parking, on old logging trail
	42	37.50649	119.60854	1800	Mariposa Grove	339	Near junction of trails from Grizzly Giant and Faithful Couple
	43	37.50638	119.60811	1800	Mariposa Grove	322	Next to #42
	91	37.50231	119.60673	1735	Mariposa Grove	460	Upslope from #39
	121	37.51061	119.60324	1875	Mariposa Grove	605	Above road, above curve after Faithful Couple
	124	37.51008	119.60305	1865	Mariposa Grove	268	Across road from Faithful Couple
	127	37.51019	119.60186	1874	Mariposa Grove	643	On trail to Clothespin from Faithful Couple
	146	37.50390	119.60073	1785	Mariposa Grove	590	On creek behind Grizzly Giant; has raven nest
Upper Grove							
	211	37.51458	119.60399	1952	Mariposa Grove	403	Near Mariposa Tree
	225	37.51524	119.60399	1950	Mariposa Grove	320	In Sunset Grove, NE of Mariposa Tree
	276	37.51521	119.60081	1958	Mariposa Grove	627	Upslope, near road, just past Sunset area
	280	37.51535	119.59952	1982	Mariposa Grove	446	Upslope of #276 and #285
	285	37.51492	119.60034	1957	Mariposa Grove	471	SE of #276, on upslope side of road
	311	37.51308	119.60014	1960	Mariposa Grove	590	close to trail junction, west of bathroom, at corner loop in road
	312	37.51282	119.60133	1961	Mariposa Grove	556	SW of #311, just north of trail
	314	37.51286	119.59924	1965	Mariposa Grove	523	Across road from bathrooms
	329	37.51518	119.59776	1981	Mariposa Grove	580	Upslope, north side of loop
	345	37.51478	119.59792	1975	Mariposa Grove	603	just north of road, north of loop, near junction with road to museum
	411	37.51542	119.59661	1975	Mariposa Grove	365	NW of road, north side of loop
	426	37.5153	119.59537	1989	Mariposa Grove	599	Charcoal tree, east of road near seep, N side of loop
	447	37.51397	119.59602	1994	Mariposa Grove	427	In center of loop, east of museum
	474	37.51306	119.59528	2007	Mariposa Grove	607	Center of loop, SE of museum
	507	37.51606	119.59308	2038	Mariposa Grove	344	NE junction of loop and Wawona Point Rd
	508	37.51571	119.59358	2032	Mariposa Grove	515	just E of loop road, just S of junction with Wawona Point Rd.
	524	37.51442	119.59466	2008	Mariposa Grove	451	W of loop road, just S of Tunnel Tree
	574	37.51228	119.59375	2014	Mariposa Grove	711	W of loop road, near SE corner of Loop
	588	37.51102	119.59432	2032	Mariposa Grove	624	On slope above Telecope Tree, S side of Loop
MERCED GROVE							
	9	37.74986	119.84046	1666	El Portal	610	Uphill from road, down road from 6 Sisters
	13	37.74981	119.83967	1643	El Portal	281	On road, below 6 sisters
	17	37.75052	119.83852	1632	El Portal	370	East of creek, across creek from #19, across large SEGI log
	19	37.75127	119.83926	1651	El Portal	451	East of road, east of 6 Sisters
	44	37.75166	119.83864	1646	El Portal	581	N most SEGI in grove, at creek.
	49	37.74918	119.83893	1635	El Portal	464	On road, across road from cabin
	51	37.74849	119.83969	1660	El Portal	491	SW and uphill from cabin
	53	37.74823	119.83812	1623	El Portal	508	Down road from cabin, on creek, roots in swamp
	200	37.74849	119.83769	1623	El Portal	166	Incense cedar, directly across creek from #53

Appendix II. List of all net sites, showing netting effort and netting success.

Date	Locality	Latitude	Longitude	# of bats	Net Area (M^2)	Time (Hr)	M^2*Hr	Bats*10^2/M^2*Hr
Mariposa Grove								
20-Jun-01	Boardwalk, Upper Grove	37.51334	119.59890	2	278.59	3.50	975.07	0.21
20-Jun-01	nr. Tree 311	37.51308	119.60014	3	37.18	2.50	92.95	3.23
20-Jun-01	Tree 314	37.51305	119.59917	1	12.78	3.16	40.38	2.48
20-Jun-01	Tree 311	37.51308	119.60014	0	13.52	2.75	37.18	0.00
2-Jul-01	Sunset Loop Trail	37.51701	119.60360	1	37.18	3.00	111.54	0.90
2-Jul-01	Hollow Cedar	37.51589	119.60193	0	13.52	3.00	40.56	0.00
3-Jul-01	Kiosk Creek	37.50026	119.60944	41	50.63	3.50	177.21	23.14
4-Jul-01	Tree 124	37.50998	119.60382	1	6.76	3.00	20.28	4.93
4-Jul-01	Faithful Couple Meadow	37.50900	119.60681	0	74.36	3.00	223.08	0.00
4-Jul-01	Tree 94	37.51030	119.60459	0	6.76	3.00	20.28	0.00
4-Jul-01	Tree 121	37.51040	119.60437	0	13.52	3.00	40.56	0.00
6-Jul-01	Tree 280	37.51535	119.59952	1	11.69	1.50	17.54	5.70
6-Jul-01	Tree 285	37.51492	119.60034	1	13.52	1.50	20.28	4.93
13-Jul-01	Tree 311	37.51308	119.60014	0	20.28	2.25	45.63	0.00
13-Jul-01	nr. 311	37.51308	119.60014	0	37.18	2.00	74.36	0.00
26-Jul-01	Tree 426	37.51537	119.59544	1	62.39	3.50	218.37	0.46
27-Jul-01	Kiosk Creek	37.50026	119.60944	24	31.16	1.25	38.95	61.62
31-Jul-01	Tree 285	37.51492	119.60034	1	4.2	4.00	16.80	5.95
31-Jul-01	Meadow, Upper Grove	37.51360	119.60052	9	358.91	3.00	1076.73	0.84
1-Aug-01	Tree 42	37.50647	119.60728	1	23.38	2.50	58.45	1.71
1-Aug-01	Rattlesnake Dome	37.51423	119.60557	1	82.76	2.75	227.59	0.44
2-Aug-01	Loop/Wawona Pt. Jct	37.51567	119.59413	1	315.77	3.50	1105.20	0.09
2-Aug-01	Tree 426	37.51537	119.59544	0	4.2	3.50	14.70	0.00
2-Aug-01	Tree 505	37.51570	199.59386	0	13.52	3.50	47.32	0.00
2-Aug-01	Tree 508	37.51570	119.59359	0	11.69	3.50	40.92	0.00

Appendix II. (cont'd)

Date	Locality	Latitude	Longitude	# of bats	Net Area (M^2)	Time (Hr)	M^2*Hr	Bats*10^2/M^2*Hr
3-Aug-01	Boundary Creek	37.49964	119.59832	9	94.45	3.50	330.58	2.72
3-Aug-01	Kiosk Creek	37.50026	119.60944	16	31.16	3.50	109.06	14.67
8-Aug-01	Tree 474	37.51306	119.59527	2	34.34	3.50	120.19	1.66
9-Aug-01	Tree 39	37.50191	119.60791	3	75.92	2.75	208.78	1.44
27-Aug-01	Kiosk Creek	37.50026	119.60944	15	31.16	3.25	101.27	14.81
27-Aug-01	Nr. Tree 39	37.50163	119.60768	3	140.46	4.00	561.84	0.53
28-Aug-01	Boundary Creek	37.49964	119.59832	5	111.54	3.50	390.39	1.28
28-Aug-01	Boardwalk, Upper Grove	37.51334	119.59890	1	133.78	3.50	468.23	0.21
28-Aug-01	Tree 314	37.51305	119.59917		11.69	3.50	40.92	0.00
31-Aug-01	Rattlesnake Dome	37.51423	119.60557	1	128.76	3.00	386.28	0.26
	Subtotals			**144**			**7499.43**	**1.92**
Merced Grove								
5-Jul-01	Tree 19	37.75169	119.83728	8	13.52	2.50	33.80	23.67
5-Jul-01	nr. Tree 44	37.75097	119.83879	15	18.45	2.50	46.13	32.52
5-Jul-01	nr. Six Sisters	**??**	**??**	2	19.47	2.50	48.68	4.11
24-Jul-01	Tree 13	37.74981	119.83967	0	6.76	2.00	13.52	0.00
24-Jul-01	Tree 44	37.75097	119.83879	0	13.52	2.00	27.04	0.00
29-Aug-01	Creek Crossing blw grove	37.73954	119.83384	2	31.21	3.00	93.63	2.14
29-Aug-01	Nr. Tree 44	37.75097	119.83879	12	11.69	3.00	35.07	34.22
	Subtotals			**39**			**297.86**	**13.09**
Tuolumne Grove								
29-Aug-01	Picnic Area	37.76909	119.80574	0	48.87	3.50	171.05	0.00
South Fork Merced, Wawona								
25-Jul-01	River, E. end of golf course	**??**	**??**	67	385.02	3.50	1347.57	4.97
30-Aug-01	River, E. end of golf course	**??**	**??**	14	117.05	3.50	409.68	3.42
30-Aug-01	Usptream of Campground	37.54320	118.67108	20	133.78	3.50	468.23	4.27
	Subtotals			**101**			**2225.48**	**4.54**

Appendix III. Acoustic sampling effort, listed chronologically by site.

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
Mariposa Grove										
10-Aug-00	2000	J	19:42	23:30		Clearing abv Telescope		37. 51526	119.58696	
31-Aug-00	2000	F	20:20	22:13	113	Museum, Balloon	BLLN	37.51318	119.59795	
11-Aug-00	2000	J	19:34	0:14		Boundary Ck	CRK	37.49952	119.59823	1806
27-Jul-01	2001	Q	pm	2:00		Boundary CK	CRK	37.49952	119.59823	1806
7-Aug-01	2001	I	pm	21:15		Boundary CK	CRK	37.49952	119.59823	1806
27-Aug-01	2001	D	pm	am		Boundary CK	CRK	37.49952	119.59823	1806
13-Sep-01	2001	B	pm	am		Boundary CK	CRK	37.49952	119.59823	1806
25-Aug-00	2000	C	18:57	23:00	183	Boundary Creek	CRK	37.39969	119.59761	
27-Aug-00	2000	F	19:35	AM		Boundary Creek	CRK	37.39969	119.59761	
26-Aug-00	2000	D	19:36	23:14	218	Boundary Creek, Down	CRK	37.49943	119.59899	1787
30-Aug-00	2000	I	19:46	22:53	187	Boundary Creek, Down	CRK	37.49943	119.59899	1787
26-Aug-00	2000	E	19:16	23:25	234	Boundary Creek, Up	CRK	37.50037	119.59717	
30-Aug-00	2000	G	19:24	22:43	180	Boundary Creek, Up	CRK	37.50037	119.59717	1769
10-Aug-00	2000	B	19:21	23:30		Creek blw Sunset	CRK	37.51384	119.60554	
26-Aug-00	2000	I	18:04	23:24	230	Kiosk Ck	CRK	37.50026	119.60944	1684
13-Oct-00	2000	H	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
23-Oct-00	2000	F	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
29-Dec-00	2000	B	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
5-May-01	2001	A	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
6-May-01	2001	A	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
7-May-01	2001	A	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
18-Jun-01	2001	E	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
2-Jul-01	2001	E	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
3-Jul-01	2001	I	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
4-Jul-01	2001	B	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
13-Jul-01	2001	B	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
24-Jul-01	2001	D	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
27-Jul-01	2001	B	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
3-Aug-01	2001	I	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
6-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
7-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
8-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
9-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
27-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
28-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
30-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
31-Aug-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
10-Sep-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
11-Sep-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
13-Sep-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
14-Sep-01	2001	G	pm	am	All night	Kiosk Ck	CRK	37.50026	119.60944	1684
3-Jul-01	2001	C	pm	am	All night	Mariposa Tree Creek	CRK	37.51309	119.60416	1978
27-Aug-01	2001	N	pm	am	All night	Mariposa Tree Creek	CRK	37.51309	119.60416	1978
13-Sep-01	2001	I	pm	am	All night	Mariposa Tree Creek	CRK	37.51309	119.60416	1978
27-Aug-01	2001	I	pm	am	All night	Rattlesnake Ck , Entrance	CRK	37.50102	119.61160	1738
4-Jul-00	2000		18:53	23:22		Rattlesnake Ck, Entrance	CRK	37.50084	119.61194	1702
5-Jul-00	2000		18:04	23:00		Rattlesnake Ck, Entrance	CRK	37.50084	119.61194	1702
3-Jul-01	2001	E	pm	am	All night	Raven Tree Creek	CRK	37.50386	119.60061	1792
9-Aug-00	2000		21:48	23:00		Wawona Pt Pkg East	FOR	37.51871	119.59994	2085
28-Aug-01	2001	I	pm	am	All night	Bachelor Meadow	MDW	37.50407	119.60621	1746
10-Sep-01	2001	N	pm	am	All night	Bachelor Meadow	MDW	37.50407	119.60621	1746
25-Aug-00	2000	F	21:12	21:42	30	Boardwalk, Upper Mdw	MDW	37.51411	119.59896	1969
11-Aug-00	2000	G	18:06	23:10		Faithful Couple Mdw	MDW	37.50914	119.60655	1855
25-Aug-00	2000	H	19:22	23:24	242	Faithful Couple Mdw	MDW	37.50914	119.60655	1855
23-Oct-00	2000	D	pm	am	All night	Faithful Couple Mdw	MDW	37.50914	119.60655	1855
4-Jul-01	2001	E	pm	am	All night	Faithful Couple Mdw	MDW	37.50914	119.60655	1855
28-Aug-01	2001	D	pm	am	All night	Faithful Couple Mdw	MDW	37.50914	119.60655	1855
10-Sep-01	2001	B	pm	am	All night	Faithful Couple Mdw	MDW	37.50914	119.60655	1855
5-Jul-00	2000		19:03	22:36		Mdw nr Sunset Pt	MDW	37.51457	119.60235	
18-May-01	2001	NA	20:55	22:08	73	Meadow Boardwalk	MDW	37.51647	119.59807	?
31-Jul-01	2001	D				Meadow Boardwalk	MDW	37.51647	119.59807	?
3-Jul-01	2001	M	20:09	0:12		Museum Mdw, Balloon	MDW	37.51311	119.59809	1908
26-Jul-01	2001	I	21:09	0:19		Museum Mdw, Balloon	MDW	37.51311	119.59809	1908
20-Jun-01	2001	B	20:30	23:26		Museum Mdw, Balloon log	MDW	37.51311	119.59809	1908
3-Jul-01	2001	B	20:08	23:50		Museum Mdw, Balloon log	MDW	37.51311	119.59809	1908
26-Jul-01	2001	G	pm	0:17		Museum Mdw, Balloon log	MDW	37.51311	119.59809	1908
28-Aug-01	2001	N	pm	am	All night	Museum Mdw, Balloon log	MDW	37.51311	119.59809	1908
10-Sep-01	2001	D	pm	am	All night	Museum Mdw, Balloon log	MDW	37.51311	119.59809	1908
11-Aug-00	2000	C	21:10	22:40		Museum Meadow	MDW	37.51344	119.59880	1969

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
31-Aug-00	2000	G	19:44	22:30	174	Museum, Meadow	MDW	37.51318	119.59795	1964
23-Oct-00	2000	I	pm	am	All night	Museum, Meadow	MDW	37.51318	119.59795	1964
20-Jun-01	2001	E	20:15	0:00		UpGrv, mid-MDW	MDW	37.51360	119.60052	1782
5-May-01	2001	I	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
6-May-01	2001	I	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
7-May-01	2001	I	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
18-Jun-01	2001	I			All night	Upper Meadow	MDW	37.51442	119.60258	1976
20-Jun-01	2001	I	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
2-Jul-01	2001	D	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
3-Jul-01	2001	D	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
4-Jul-01	2001	D	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
13-Jul-01	2001	C	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
24-Jul-01	2001	H	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
27-Jul-01	2001	G	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
31-Jul-01	2001	I	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
6-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
7-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
8-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
9-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
27-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
28-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
30-Aug-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
1-Sep-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
11-Sep-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
13-Sep-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
14-Sep-01	2001	E	pm	am	All night	Upper Meadow	MDW	37.51442	119.60258	1976
4-Jul-00	2000		18:34	23:04		abv Tree #91	PILA	37.50205	119.60657	1780
6-Aug-01	2001	D	19:35	21:00		EPFU 119A Roost	PILA	37.50084	119.61010	1848
7-Aug-01	2001	D	19:44	22:00		EPFU 119A Roost	PILA	37.50084	119.61010	1848
4-Aug-01	2001	I				EPFU 244A	PILA	37.50144	119.60925	1848
2-Aug-01	2001	I				EPFU 652B	PILA	37.51140	119.60419	1906
4-Aug-01	2001	D				EPFU 932A	PILA	37.49839	119.59584	1843
4-Aug-01	2001	H				LANO 44A Roost	PILA	37.50928	119.60167	1962
30-Jul-01	2001	I				MYTH 574C Roost	PILA	37.50162	119.60571	1764
5-Aug-01	2001	D				MYTH 574C Roost	PILA	37.50162	119.60571	1764

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
2-Sep-01	2001	D	pm	am	All night	MYTH 574C Roost	PILA	37.50162	119.60571	1764
28-Aug-01	2001	Q	pm	am	All night	Nr. Tree #219, Sunset Tree	PILA			
27-Aug-01	2001	B	pm	am	All night	Boundary Ck Tree	PIPO	37.49950	119.59772	1806
28-Aug-01	2001	B	pm	am	All night	Boundary Ck Tree	PIPO	37.49950	119.59772	1806
30-Aug-01	2001	B	pm	20:33		Boundary Ck Tree	PIPO	37.49950	119.59772	1806
31-Aug-01	2001	B	pm	am	All night	Boundary Ck Tree	PIPO	37.49950	119.59772	1806
13-Sep-01	2001	D	pm	am	All night	Boundary Ck Tree	PIPO	37.49950	119.59772	1806
1-Aug-01	2001	I	20:05	23:26		EPFU 652A	PIPO	37.51141	119.60516	1913
7-Aug-01	2001	B	19:52	21:00		EPFU 652C Roost	PIPO	37.51141	119.60516	1913
28-Jul-01	2001	D				MYTH 574A Roost	PIPO	37.50196	119.60340	xx
5-Aug-01	2001	H				MYTH 574A Roost	PIPO	37.50196	119.60340	xx
2-Sep-01	2001	I	pm	am	All night	MYTH 574A Roost	PIPO	37.50196	119.60340	1805
30-Jul-01	2001	E				MYTH 574B Roost	PIPO	37.50316	119.60360	1845
5-Aug-01	2001	E				MYTH 574B Roost	PIPO	37.50316	119.60360	1845
6-Aug-01	2001	Q	20:07	21:24		MYTH 574B Roost	PIPO	37.50316	119.60360	1845
8-Aug-01	2001	B	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
30-Aug-01	2001	Q	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
31-Aug-01	2001	Q	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
1-Sep-01	2001	Q	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
2-Sep-01	2001	Q	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
4-Sep-01	2001	Q	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
12-Sep-01	2001	M	pm	am	All night	MYTH 574B Roost	PIPO	37.50316	119.60360	1845
10-Aug-00	2000	C	19:17	23:00		Rattlesnake Dome	ROCK	37.51403	119.60578	1984
9-Aug-00	2000		21:12	21:45		Wawona Pt Pkg West	ROCK	37.51871	119.59994	2085
9-Aug-00	2000		20:40	23:00		Wawona Pt West	ROCK	37.51915	119.60008	2075
5-Jul-00	2000		18:36	22:24		Wawona Pt.	ROCK	37.51828	119.60047	2076
25-Aug-00	2000	I	19:48	22:00	132	Outer Sunset Point	ROCK	37.51801	119.60366	2000
24-Jul-01	2001	Q	pm	21:00		SFK Merced, Wawona	RIVER	xx	xx	
2-Jul-01	2001	N	20:41	22:10		Sunset Loop Trail	ROAD	NET??		
11-Aug-00	2000	D	21:25	22:05		Wawona Jct	ROAD	37.51567	119.59413	2018
25-Aug-00	2000	F	20:16	21:00	45	Wawona Jct	ROAD	37.51567	119.59413	2018
26-Aug-00	2000	C	19:34	22:24	170	Wawona Jct	ROAD	37.51567	119.59413	2018
27-Aug-00	2000	B	19:29	am		Wawona Jct	ROAD	37.51567	119.59413	2018
29-Aug-00	2000	I	19:46	20:42	56	Wawona Jct	ROAD	37.51567	119.59413	2018
31-Aug-00	2000	B	19:26	22:22	168	Wawona Jct	ROAD	37.51567	119.59413	2018

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
5-May-01	2001	H	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
6-May-01	2001	H	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
7-May-01	2001	H	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
18-Jun-01	2001	C			All night	Wawona Jct	ROAD	37.51567	119.59413	2018
20-Jun-01	2001	M	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
2-Jul-01	2001	B	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
3-Jul-01	2001	G	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
4-Jul-01	2001	G	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
24-Jul-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
27-Jul-01	2001	N	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
2-Aug-01	2001	D			All night	Wawona Jct	ROAD	37.51567	119.59413	2018
6-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
7-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
8-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
9-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
27-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
28-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
30-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
31-Aug-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
10-Sep-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
11-Sep-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
13-Sep-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
14-Sep-01	2001	C	pm	am	All night	Wawona Jct	ROAD	37.51567	119.59413	2018
11-Aug-00	2000	D	22:15	22:30		Wawona Pt. Road	ROAD	37.51735	119.59614	
26-Aug-00	2000	A	19:40	21:11	91	Wawona Pt. Road, 100m Jct	ROAD	37.51686	119.59455	
31-Aug-01	2001	N	pm	am		Boundary Creek Rocks	ROCK	37.49968	119.59931	1740
14-Sep-01	2001	N	pm	am		Boundary Creek Rocks	ROCK	37.49968	119.59931	1740
31-Aug-01	2001	I	pm	am		Faithful Couple Mdw Rocks	ROCK	37.50840	119.60678	1869
14-Sep-01	2001	B	pm	am		Faithful Couple Mdw Rocks	ROCK	37.50840	119.60678	1869
5-May-01	2001	C	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
6-May-01	2001	C	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
7-May-01	2001	C	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
18-Jun-01	2001	D			ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
20-Jun-01	2001	C	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
2-Jul-01	2001	C	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
3-Jul-01	2001	N	pm	am	ALL	Rattlesnake Dome	ROCK	37.51441	119.60571	1950
4-Jul-01	2001	N	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
13-Jul-01	2001	Q	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
24-Jul-01	2001	N	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
27-Jul-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
6-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
7-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
8-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
9-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
27-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
28-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
30-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
31-Aug-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
10-Sep-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
11-Sep-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
13-Sep-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
14-Sep-01	2001	M	pm	am		Rattlesnake Dome	ROCK	37.51441	119.60571	1950
2-Jan-01	2001	B	pm	am	ALL	Sunset Rocks	ROCK			
31-Aug-01	2001	D	pm	am		Wawona Point	ROCK	37.51823	119.60046	2060
14-Sep-01	2001	I	pm	am		Wawona Point	ROCK	37.51823	119.60046	2060
4-Jul-01	2001	M	pm	am		Bachelor Tree Seep	SEEP	37.49969	119.59766	
27-Aug-00	2000	I	19:57	am		Bachelor Tree Seep, #73	SEEP	37.49969	119.59766	
20-Jun-01	2001	H	pm	am	ALL	Charcoal Seep	SEEP	37.51542	119.05952	2050
4-Jul-01	2001	C	pm	am		Charcoal Seep	SEEP	37.51542	119.05952	2050
11-Aug-00	2000	C	20:06	20:56		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
25-Aug-00	2000	F	19:42	20:10	28	Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
27-Aug-00	2000	H	19:39	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
28-Aug-00	2000	A	pm	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
31-Aug-00	2000	E	19:31	22:28	177	Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
5-Oct-00	2000	C	18:35	20:45		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
13-Oct-00	2000	D	pm	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
14-Oct-00	2000	D	pm	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
23-Oct-00	2000	B	pm	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
30-Dec-00	2000	E	pm	am		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
18-May-01	2001	NA	20:10	20:44	34	Charcoal Seep, #426	SEEP	37.51542	119.05952	2050

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
18-Jun-01	2001	H	22:10	DAWN		Charcoal Seep, #426	SEEP	37.51542	119.05952	2050
11-Aug-00	2000	H	18:52	0:05		Grizzly Giant Seep, nr. #101	SEEP	37.50478	119.60260	1755
26-Aug-00	2000	G	18:20	23:09	217	Seep, nr. #68 & 69	SEEP	37.50416	119.60627	1692
5-May-01	2001	B	pm	am	ALL	Telescope Seep	SEEP	37.51205	119.59514	1997
26-Aug-00	2000	B	19:36	22:36	180	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
27-Aug-00	2000	C	19:19	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
5-Oct-00	2000	A	18:30	20:55		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
13-Oct-00	2000	B	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	
14-Oct-00	2000	B	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	
23-Oct-00	2000	A	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
30-Dec-00	2000	B	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
6-May-01	2001	B	pm	am	ALL	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
7-May-01	2001	B	pm	am	ALL	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
20-Jun-01	2001	N	pm	am	ALL	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
2-Jul-01	2001	I	pm	am	ALL	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
3-Jul-01	2001	H	pm	am	ALL	Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
4-Jul-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
13-Jul-01	2001	G	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
24-Jul-01	2001	M	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
27-Jul-01	2001	D	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
6-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
7-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
8-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
9-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
27-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
28-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
30-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
31-Aug-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
10-Sep-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
11-Sep-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
13-Sep-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
14-Sep-01	2001	H	pm	am		Telescope Seep, nr. #484	SEEP	37.51174	119.59580	1987
3-Jul-00	2000		20:15	Dawn			SEGI	37.50647	119.60728	1823
5-Jul-00	2000		20:04	22:05		Clothespin Tree, #153	SEGI	37.51090	119.60141	1898
9-Aug-00	2000	C	20:07	23:19		Clothespin Tree, #153	SEGI	37.51090	119.60141	1898

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
25-Aug-00	2000	F	22:20	23:10	50	Clothespin Tree, #153	SEGI	37.51090	119.60141	1898
5-Oct-00	2000	DAT	18:30	20:30		Clothespin Tree, #153	SEGI	37.51090	119.60141	1898
15-Sep-01	2001	I				Clothespin Tree, #153	SEGI	37.51090	119.60141	1898
9-Aug-00	2000	F	20:01	23:13		Clothespin Tree, dwnhill	SEGI	**xxx**	**xxx**	
10-Aug-00	2000	I	20:09	23:18		Fallen Tree nr #316	SEGI	37.51644	119.59692	2010
10-Aug-00	2000	D	20:10	23:00		Inside Telescope Tree #584	SEGI	37.51161	119.59452	2036
25-Aug-00	2000	B	19:56	22:04	128	Nr. Sunset Tree, #219	SEGI	37.51635	119.60768	1920
9-Aug-01	2001	D	pm	am		Sunset Tree - east side	SEGI	37.51578	119.60348	1920
9-Aug-01	2001	B	pm	20:31		Sunset Tree - west side	SEGI	37.51605	119.60377	1920
3-Jul-00	2000	D980	20:27	ca. 21:45		Sunset Tree, East	SEGI	37.51578	119.60348	1920
2-Jan-01	2001	E	pm	am	ALL	Three Graces	SEGI			
11-Sep-01	2001	D	pm	am		Tree #146	SEGI	37.50390	119.60073	1828
18-Jun-01	2001	H	20:46	21:46	60	Tree #211	SEGI			
23-Oct-00	2000	H	pm	am		Tree #211 (or #212??)	SEGI			
29-Aug-00	2000	A	pm	am		Tree #211, inside	SEGI			
3-Jul-00	2000		19:32	Dawn		Tree #219, Sunset Tree	SEGI	37.51605	119.60377	1920
2-Aug-01	2001	H				Tree #219, Sunset Tree	SEGI	37.51605	119.60377	
10-Aug-01	2001	Q	pm	21:30		Tree #219, Sunset Tree	SEGI	37.51605	119.60377	1920
6-Jul-01	2001	E	20:12	21:18		Tree #280	SEGI	xxx	xxx	
28-Aug-00	2000	F	pm	am		Tree #285	SEGI	37.51513	119.60081	
6-Jul-01	2001	I	19:52	21:37		Tree #285	SEGI	xxx	xxx	
11-Sep-01	2001	N	pm	am		Tree #311	SEGI	37.51308	119.60014	2009
10-Sep-01	2001	Q	pm	am		Tree #312	SEGI	37.51301	119.60108	1993
11-Sep-01	2001	I	pm	am		Tree #312	SEGI	37.51315	119.60138	2005
29-Aug-00	2000	D	pm	am		Tree #314, inside	SEGI			
3-Jul-00	2000		20:34	22:53	139	Tree #316	SEGI			
4-Jul-00	2000		20:05	22:00		Tree #345	SEGI	37.51477	119.59793	1988
10-Sep-01	2001	I	pm	am		Tree #345	SEGI	37.51477	119.59793	1988
29-Aug-00	2000	B	pm	am		Tree #360, inside	SEGI			
4-Jul-00	2000		20:12	23:29		Tree #39	SEGI	37.50191	119.60791	1761
23-Oct-00	2000	E	pm	am		Tree #39	SEGI	37.50191	119.60791	1761
2-Jul-01	2001	H	20:15	22:50		Tree #39	SEGI	37.50191	119.60791	1761
27-Jul-01	2001	E	pm	am		Tree #39	SEGI	37.50191	119.60791	1761
3-Aug-01	2001	D	19:50	0:33		Tree #39	SEGI	37.50191	119.60791	1761
9-Aug-01	2001	Q	pm	22:50		Tree #39	SEGI	37.50191	119.60791	1761

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
14-Sep-01	2001	Q	pm	am		Tree #39	SEGI	37.50191	119.60791	1761
28-Aug-00	2000	G	pm	am		Tree #39, inside	SEGI	37.50191	119.60791	1761
28-Aug-00	2000	I	pm	am		Tree #42	SEGI	37.50647	119.60728	1823
1-Aug-01	2001	E	20:00	23:10		Tree #42	SEGI	37.50647	119.60728	1823
11-Sep-01	2001	Q	pm	am		Tree #42	SEGI	37.50647	119.60728	1823
14-Sep-01	2001	D	pm	am		Tree #42	SEGI	37.50647	119.60728	1823
15-Sep-01	2001	D				Tree #42	SEGI	37.50647	119.60728	1823
10-Aug-00	2000	H	20:18	23:00		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
11-Aug-00	2000	D	20:03	20:46		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
23-Oct-00	2000	M	pm	am		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
6-Jul-01	2001	H	20:00	21:31		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
26-Jul-01	2001	E	pm	0:33		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
27-Jul-01	2001	C	pm	am		Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
28-Jul-01	2001	E				Tree #426, Charcoal Tree	SEGI	37.51537	119.59544	2054
4-Jul-01	2001	I	pm	23:12		Tree #43	SEGI	37.50647	119.60728	1823
27-Jul-01	2001	I	pm	am		Tree #43	SEGI	37.50647	119.60728	1823
27-Jul-01	2001	H	pm	am		Tree #474	SEGI			
8-Aug-01	2001	D	pm	22:38		Tree #474	SEGI			
29-Aug-00	2000	F	pm	am		Tree #505, inside	SEGI			
18-Jun-01	2001		21:02	22:20		Tree #508	SEGI			
11-Sep-01	2001	B	pm	am		Tree #508	SEGI	37.51570	119.59359	2041
29-Aug-00	2000	E	pm	am		Tree #508, inside	SEGI			
10-Aug-00	2000	F	20:06	23:00		Tree #524	SEGI	37.51408	119.59399	2066
4-Jul-00	2000		18:26	23:04		Tree #91	SEGI	37.50231	119.60673	1770
11-Aug-00	2000	I	18:27	23:28		Trees #42 and #43	SEGI	37.50647	119.60728	1823
10-Aug-00	2000	E	20:20	23:00		Tunnel Tree, portal	SEGI	37.51257	119.59909	2002
10-Aug-00	2000	A	20:10	23:00	170	Tunnel Tree	SEGI	37.52888	119.59581	2022
4-Aug-01	2001	E				UpGrv Restrm	SEGI	37.51286	119.59924	1965
20-Jun-01	2001	D	20:30	23:30		UpGrv Restrm, net	SEGI	37.51286	119.59924	1965
30-Aug-00	2000	A	19:34	23:00	204	Calling Tree, Boundary CK	TREE	37.49945	119.59756	1825
5-Oct-00	2000	B				Calling Tree, Boundary CK	TREE	37.49945	119.59756	1825
31-Aug-00	2000	CJC				AT Ballon site				
10-Aug-00	2000	G	FAILED			At ridge top				
26-Aug-00	2000	H	21:22	22:27	65	Driving Transect				
29-Aug-00	2000	CJC				Driving Transect				

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
27-Aug-00	2000	CJC				Merced R. Wawona				
30-Aug-01	2001	P	pm	am		SFK Releases				
28-Aug-00	2000					Wawona Mdw balloon test				
Merced Grove										
17-Oct-00	2000	H	pm	21:00		South end of grove				
29-Aug-01	2001	C	pm	22:30		Creek, 0.5 km below grove	CRK	37.73954	119.83384	1584
19-Jun-01	2001	C	pm	23:55		Top of grove by gate	PILA			
5-Jul-01	2001	D	pm	0:00		Top of grove by gate	PILA			
19-Jun-01	2001	D	pm	23:00		Six Sisters, on trail	SEGI			
5-Jul-01	2001	I	pm	23:48		Six Sisters, upslope behind	SEGI			
29-Aug-01	2001	M	pm	22:57		Six Sisters, upslope behind	SEGI			
12-Sep-01	2001	N	pm	22:45		Six Sisters, upslope behind	SEGI			
24-Jul-01	2001	I	pm	22:14		Tree #09, facing scar	SEGI			
12-Sep-01	2001	C	pm	22:40		Tree #09, facing scar	SEGI			
17-Oct-00	2000	D	pm	am		Tree #17, adjacent log	SEGI			
5-Jul-01	2001	E	pm	23:21		Tree #17, adjacent log	SEGI			
17-Oct-00	2000	C	pm	am		Tree #19, at opening	SEGI	37.75169	119.83728	1630
5-Jul-01	2001	B	pm	23:03		Tree #19, at opening	SEGI	37.75169	119.83728	1630
24-Jul-01	2001	B	pm	22:23		Tree #19, at opening	SEGI	37.75169	119.83728	1630
29-Aug-01	2001	G	pm	22:42		Tree #19, at opening	SEGI	37.75169	119.83728	1630
24-Jul-01	2001	E	pm	22:30		Tree #44, creek portal	SEGI			
12-Sep-01	2001	E	pm	22:30		Tree #44, creek portal	SEGI			
5-Jul-01	2001	H	pm	22:30		Tree #44, upstream bank	SEGI			
29-Aug-01	2001	Q	pm	22:35		Tree #44, upstream bank	SEGI			
29-Aug-01	2001	N	pm	23:00		**Tree #51???**	SEGI			
17-Oct-00	2000	B	pm	am		Tree #53, at opening	SEGI	37.74853	119.83783	1615
19-Jun-01	2001	H	pm	23:00		Tree #53, swamp tree	SEGI	37.74853	119.83783	1615
12-Sep-01	2001	I	pm	22:51		Tree #53, swamp tree	SEGI	37.74853	119.83783	1615
29-Aug-01	2001	H	pm	22:45		Road, just below grove		37.74699	119.83770	

Appendix III. (cont'd)

Date	Year	Detector ID	Start	Finish	Total Min	Specific Locality	Habitat	Lat	Long	Elev (m)
Tuolumne Grove										
19-Jun-01	2001	B	pm	23:00		Clearing, below curve in rd.	MDW	37.77130	119.80714	1706
29-Aug-01	2001	B	pm	23:00		Clearing, below curve in rd.	MDW	37.77130	119.80714	1706
12-Sep-01	2001	H	pm	22:37		Clearing, below curve in rd.	MDW	37.77130	119.80714	1706
19-Jun-01	2001	M	pm	23:10		Seep, picnic at nature loop	SEEP	37.76909	119.80574	1812
29-Aug-01	2001	D	pm	23:09		Seep, picnic at nature loop	SEEP	37.76909	119.80574	1812
12-Sep-01	2001	G	pm	22:35		Seep, picnic at nature loop	SEEP	37.76909	119.80574	1812
19-Jun-01	2001	E	pm	23:22		Tree #10, on road	SEGI			
29-Aug-01	2001	E	pm	23:38		Tree #10, on road	SEGI			
12-Sep-01	2001	D	pm	22:39		Tree #10, on road	SEGI			
19-Jun-01	2001	I	pm	22:50		Tree #19, stream below	SEGI			
29-Aug-01	2001	I	pm	23:09		Tree #19, stream below	SEGI			
12-Sep-01	2001	P	pm	22:46		Tree #19, stream below	SEGI			

Appendix IV. Sampling sites for different habitat types. Primary sites were used in all sampling sessions. Secondary sites were sampled on a rotating basis, with all sites in any one category being sampled simultaneously.

HABITAT TYPE	LOCALITY	DESCRIPTION	LATITUDE	LONGITUD
PRIMARY SITES				
Creek	Kiosk Creek	Behind Entrance Kiosk	37.50026	119.60944
Meadow	Upper Grove Meadow	Near Sunset pullout	37.51442	119.60258
Road	Wawona Point Junction	Junction with Upper Grove Loop	37.51567	119.59413
Rock Outcrop	Rattlesnake Dome	Outcrop below Mariposa Tree	37.51441	119.60571
Seep	Telescope Seep	Near Tree #484	37.51174	119.59580
SECONDARY SITES				
Creek	Boundary Ck	Rd. crossing, E. Grizzly Giant	37.49952	119.59823
	Mariposa Tree Creek	Below Mariposa Tree	37.51309	119.60416
	Rattlesnake Ck	Nr. Entrance to grove	37.50084	119.61194
	Creek blw Sunset	Below Sunset Point	37.51384	119.60554
	Raven Tree Creek	Behind Tree #146	37.50386	119.60061
Meadow	Bachelor Meadow	Near Bachelor trees	37.50407	119.60621
	Faithful Couple Mdw	Below Faithful Couple trees	37.50914	119.60655
	Mdw nr Sunset Pt	near Sunset Point	37.51457	119.60235
	Museum Mdw, Balloon	Adjacent to museum	37.51311	119.59809
Road	Sunset Loop Trail	Near end of Sunset Pt	37.51663	119.60347
	Wawona Pt. Road		37.51735	119.59614
	Wawona Pt. Road, 100m Jct		37.51686	119.59455

Appendix IV. (cont'd)

HABITAT TYPE	LOCALITY	DESCRIPTION	LATITUDE	LONGITUD
Rock Outcrop	Faithful Couple Mdw Rocks	Below meadow	37.50840	119.60678
	Wawona Point	Near outlook point	37.51823	119.60046
	Boundary Creek Rocks	outcrop to north of creek	37.49968	119.59931
Seep	Bachelor Tree Seep	Near Bachelor Trees	37.49969	119.59766
	Charcoal Seep	Near Tree #426	37.51542	119.05952
	Grizzly Giant Seep	Near Tree #101	37.50478	119.60260
	Seep, nr. #68 & 69	Near #68 & 69	37.50416	119.60627

Appendix V. List of insects, identified by insect parts, collected from guano traps in 2000 and 2001 in the Mariposa and Merced Groves.

MARIPOSA GROVE 2000

Order: **Araneida**
  Spiders

Order: **Coleoptera**
  Unknown black elytra

Order: **Coleoptera**
  Suborder: **Adephaga**
    Family: **Carabidae**
      Common Carabids
      Predaceous Ground Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Bostrichoidea**
      Family: **Bostrichidae**
        Polycaon confertus
          California Branch Borer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Cerambycinae*
          Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Lepturinae*
         Anoplodera
          Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Prioninae*
          Ergates spiculatus
            Spined Woodboorer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cucujoidea**
      Family: **Coccinellidae**
        Ladybird Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cucujoidea**
      Family: **Coccinellidae**
        Hippodamia convergens
          Convergent Ladybird Beetle

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Curculionoidea**
      Unknown Weevil elytra

Order: **Coleopter**
  Suborder: **Polyphaga**
    Superfamily: **Elateroidea**
      Family: **Buprestidae**
        Chalcophora.
          Metallic Wood-Boring Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Elateroidea**
      Family: **Buprestidae**
        Chalcophora angulicollis
          Sculptured Pine Borer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Elateroidea**
      Family: **Elateridae**
        Common Click Beetle

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Scarabaeoidea**
   Family: **Scarabaeidae**
    Subfamily: *Melolonthinae*
     Chafer Beetle

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Scarabaeoidea**
   Family: **Scarabaeidae**
    Subfamily: *Pleocominae*
     Pleocoma
      Rain Beetles

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Tenebrionoidea**
   Family: **Tenebrionidae**
    Darkling Beetles

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Tenebrionoidea**
   Family: **Tenebrionidae**
    Eleodes
     Stink Beetle

Order: **Dermaptera**
 Family: **Forficulidae**
  Forficula auricularia
   European Earwig

Order: **Hemiptera**
 Suborder: **Gymnocerata**
  Superfamily: **Scutelleroidea**
   Family: **Pentatomidae**
    Stink Bugs

Order: **Hemiptera**
 Suborder: **Gymnocerata**
  Superfamily: **Scutelleroidea**
   Family: **Scutelleridae**
    Shield Bugs

Order: **Homoptera**
  Suborder: **Auchenorrhyncha**
    Superfamily: **Cicadoidea**
      Family: **Membracidae**
        Platycotis vittata
          Oak Treehopper

Order: **Hymenoptera**
  Suborder: **Apocrita**
    Superfamily: **Scolioidea**
      Family: **Formicidae**
        Camponotus
          Carpenter ant

Order: **Isoptera**
  Family: **Hodotermitidae**
    Zootermopsis nevadensis
      Sierran Dampwood Termite

Order: **Lepidoptera**
  Unknown wings

Order: **Lepidoptera**
  Suborder: **Frenatae**
    Division: **Macrolepidoptera**
      Superfamily: **Papilionoidea**
        Family: **Nymphalidae**
          Nymphalis californica
            California Tortoise-shell

Order: **Lepidoptera**
  Suborder: **Frenatae**
    Division: **Macrolepidoptera**
      Superfamily: **Sphingoidea**
        Family: **Sphingidae**
          Hyles lineata
            White-lined Sphinx Moth

Order: **Neuroptera**
  Suborder: **Planipennia**
    Superfamily: **Hemerobioidea**
      Family: **Chrysopidae**
        Chrysopa carnea
          Common Green Lacewing

Order: **Neuroptera**
  Suborder: **Planipennia**
    Superfamily: **Hemerobioidea**
      Family: **Polystoechotidae**
        Polystoechotes punctatus
          Spotted Large Lacewing

Order: **Neuroptera**
  Suborder: **Raphidioptera**
    Family: **Raphidiidae**
      Agulla
        Common Snakeflies

Order: **Odonata**
  Suborder: **Anisoptera**
    Unknown Dragonfly wing

Order: **Orthoptera**
  Suborder: **Ensifera**
    Family: **Gryllacrididae**
      Subfamily: *Stenopelmatinae*
        Jerusalem Cricket

Order: **Scorpionida**
  Scorpions

MARIPOSA GROVE 2001

Order: **Araneida**
  Spiders

Class: **Chilopoda**
  Centipedes

Order: **Coleoptera**
  Unknown black elytra

Order: **Coleoptera**
  Suborder: **Adephaga**
    Family: **Carabidae**
      Common Carabids
      Predaceous Ground Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Bostrichoidea**
      Family: **Bostrichidae**
        Polycaon confertus
          California Branch Borer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Cerambycinae*
          Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Lepturinae*
          Anoplodera
            Long-Horned Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Prioninae*
          Ergates spiculatus
            Spined Woodboorer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cleroidea**
      Family: **Ostomidae**
        Ostomatid
          Bark-Gnawing Beetles

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Cucujoidea**
   Family: **Coccinellidae**
    Ladybird Beetles

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Cucujoidea**
   Family: **Coccinellidae**
    Hippodamia convergens
     Convergent Ladybird Beetle

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Curculionoidea**
   Unknown Weevil elytra

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Curculionoidea**
   Family: **Curculionidae**
    Subfamily: *Brachyrhininae*
     Broad-nosed Weevils

Order: **Coleopter**
 Suborder: **Polyphaga**
  Superfamily: **Elateroidea**
   Family: **Buprestidae**
    Chalcophora.
     Metallic Wood-Boring Beetles

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Elateroidea**
   Family: **Buprestidae**
    Chalcophora angulicollis
     Sculptured Pine Borer

Order: **Coleoptera**
 Suborder: **Polyphaga**
  Superfamily: **Elateroidea**
   Family: **Elateridae**
    Common Click Beetle

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Scarabaeoidea**
      Family: **Scarabaeidae**
        Unknown Scarab Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Scarabaeoidea**
      Family: **Scarabaeidae**
        Subfamily: *Melolonthinae*
          Chafer Beetle

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Scarabaeoidea**
      Family: **Scarabaeidae**
        Subfamily: *Pleocominae*
          Pleocoma
            Rain Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Tenebrionoidea**
      Family: **Tenebrionidae**
        Darkling Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Tenebrionoidea**
      Family: **Tenebrionidae**
        Eleodes
          Stink Beetle

Order: **Dermaptera**
  Family: **Forficulidae**
    Forficula auricularia
      European Earwig

Class: **Diplopoda**
  Millipedes

Order: **Diptera**
  Suborder: **Nematocera**
    Family: **Tipulidae**
      Crane Flies

Order: **Hemiptera**
  Suborder: **Gymnocerata**
    Superfamily: **Scutelleroidea**
      Family: **Pentatomidae**
        Stink Bugs

Order: **Hemiptera**
  Suborder: **Gymnocerata**
    Superfamily: **Scutelleroidea**
      Family: **Scutelleridae**
        Shield Bugs

Order: **Homoptera**
  Suborder: **Auchenorrhyncha**
    Superfamily: **Cicadoidea**
      Family: **Membracidae**
        Platycotis vittata
          Oak Treehopper

Order: **Hymenoptera**
  Unknown wings

Order: **Hymenoptera**
  Suborder: **Apocrita**
    Superfamily: **Ichneumonoidea**
      Family: **Ichneumonidae**
        Common Ichneumonids

Order: **Hymenoptera**
  Suborder: **Apocrita**
    Superfamily: **Scolioidea**
      Family: **Formicidae**
        Camponotus
          Carpenter ant

Order: **Isoptera**
  Family: **Hodotermitidae**
    Zootermopsis nevadensis
      Sierran Dampwood Termite

Order: **Lepidoptera**
  Unknown wings

Order: **Neuroptera**
  Unknown wings

Order: **Neuroptera**
  Suborder: **Planipennia**
    Superfamily: **Hemerobioidea**
      Family: **Chrysopidae**
        Chrysopa carnea
          Common Green Lacewing

Order: **Neuroptera**
  Suborder: **Planipennia**
    Superfamily: **Hemerobioidea**
      Family: **Polystoechotidae**
        Polystoechotes punctatus
          Spotted Large Lacewing

Order: **Orthoptera**
  Suborder: **Coelifera**
    Family: **Acrididae**
      Subfamily: *Oedipodinae*
        Band-Winged Grasshopper

Order: **Orthoptera**
  Suborder: **Ensifera**
    Family: **Gryllacrididae**
      Subfamily: *Stenopelmatinae*
        Jerusalem Cricket

Order: **Orthoptera**
  Suborder: **Ensifera**
    Family: **Tettigoniidae**
      Katydids

Order: **Scorpionida**
  Scorpions

MERCED GROVE 2000

Order: **Araneida**
  Spiders

Order: **Coleoptera**
  Family: **Bostrichidae**
    Polycaon confertus
      California Branch Borer

Order: **Coleoptera**
  Family: **Cerambycidae**
    Subfamily: *Cerambycinae*
      Long-Horned Beetles

Order: **Coleoptera**
  Family: **Coccinellidae**
    Hippodamia convergens
      Convergent Ladybird Beetle

Order: **Coleoptera**
  Family: **Elateridae**
    Common Click Beetle

Order: **Coleoptera**
  Family: **Scarabaeidae**
    Subfamily: *Melolonthinae*
      Chafer Beetle

Order: **Hymenoptera**
  Family: **Formicidae**
    Camponotus
      Carpenter ant

Order: **Hymenoptera**
  Family: **Ichneumonidae**
    Parasitic Wasps

Order: **Isoptera**
  Family: **Hodotermitidae**
    Zootermopsis angusticollis
      Pacific Dampwood Termite

Order: **Lepidoptera**
  Unknown wings

Order: **Neuroptera**
  Suborder: **Nematocera**
    Family: **Tipulidae**
      Crane Flies

Order: **Neuroptera**
  Suborder: **Planipennia**
    Family: **Polystoechotidae**
      Polystoachotes punctatus
        Spotted Large Lacewing

Order: **Odonata**
  Suborder: **Anisoptera**
    Family: **Aeshnidae**
      Aeshna (palmata?)
        Common Blue Darner

Order: **Orthoptera**
  Family: **Tettigoniidae**
    Katydid

MERCED GROVE 2001

Order: **Araneida**
  Spiders

Class: **Chilopoda**
  Centipedes

Order: **Coleoptera**
  Black pronotum with red and black wing covers

Order: **Coleoptera**
  Suborder: **Adephaga**
    Family: **Carabidae**
      Common Carabids
      Predaceous Ground Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Bostrichoidea**
      Family: **Bostrichidae**
        Polycaon confertus
          California Branch Borer

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Cerambycoidea**
      Family: **Cerambycidae**
        Subfamily: *Lepturinae*
          Anoplodera
            Long-Horned Beetles

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Cucujoidea**
Family: **Coccinellidae**
Ladybird Beetles

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Cucujoidea**
Family: **Coccinellidae**
Hippodamia convergens
Convergent Ladybird Beetle

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Curculionoidea**
Family: **Curculionidae**
Subfamily: *Brachyrhininae*
Broad-nosed Weevils

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Elateroidea**
Family: **Buprestidae**
Agrilus?
Twig Girdlers?
Dark metallic purplish elytra

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Elateroidea**
Family: **Buprestidae**
Chalcophora.
Metallic Wood-Boring Beetles

Order: **Coleoptera**
Suborder: **Polyphaga**
Superfamily: **Elateroidea**
Family: **Elateridae**
Common Click Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Scarabaeoidea**
      Family: **Scarabaeidae**
        Subfamily: *Melolonthinae*
          Chafer Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Tenebrionoidea**
      Family: **Tenebrionidae**
        Darkling Beetles

Order: **Coleoptera**
  Suborder: **Polyphaga**
    Superfamily: **Tenebrionoidea**
      Family: **Tenebrionidae**
        Eleodes
          Stink Beetles

Class: **Diplopoda**
  Millipede

Order: **Diptera**
  Suborder: **Nematocera**
    Family: **Tipulidae**
      Crane Flies

Order: **Hemiptera**
  Suborder: **Gymnocerata**
    Superfamily: **Scutelleroidea**
      Family: **Scutelleridae**
        Shield Bugs

Order: **Homoptera**
  Suborder: **Auchenorrhyncha**
    Superfamily: **Cicadoidea**
      Family: **Membracidae**
        Platycotis vittata
        Oak Treehopper

Order: **Hymenoptera**
  Suborder: **Apocrita**
    Superfamily: **Scolioidea**
      Family: **Formicidae**
        Camponotus
          Carpenter ant

Order: **Hymenoptera**
  Suborder: **Symphyta**
    Superfamily: **Tenthredinoidea**
      Family: Tenthredinidae?
        Sawflies?

Order: **Isoptera**
  Family: **Hodotermitidae**
    Zootermopsis nevadensis
      Sierran Dampwood Termite

Order: **Lepidoptera**
  Unknown wings

Order: **Neuroptera**
  Suborder: **Raphidioptera**
    Family: **Raphidiidae**
      Agulla
        Common Snakeflies

Order: **Neuroptera**
  Suborder: **Planipennia**
    Superfamily: **Hemerobioidea**
      Family: **Polystoechotidae**
        Polystoachotes punctatus
          Spotted Large Lacewing

Order: **Odonata**
  Unknown head